Validity of Sensory Systems as Distinct Constructs

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MeSH TERMS
- child development
- developmental disabilities
- sensation
- sensation disorders

This study investigated the validity of sensory systems as distinct measurable constructs as part of a larger project examining Ayres's theory of sensory integration. Confirmatory factor analysis (CFA) was conducted to test whether sensory questionnaire items represent distinct sensory system constructs. Data were obtained from clinical records of two age groups, 2- to 5-yr-olds ($n = 231$) and 6- to 10-yr-olds ($n = 223$). With each group, we tested several CFA models for goodness of fit with the data. The accepted model was identical for each group and indicated that tactile, vestibular–proprioceptive, visual, and auditory systems form distinct, valid factors that are not age dependent. In contrast, alternative models that grouped items according to sensory processing problems (e.g., over- or underresponsiveness within or across sensory systems) did not yield valid factors. Results indicate that distinct sensory system constructs can be measured validly using questionnaire data.

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Theoretical constructs and therapeutic strategies from the Ayres Sensory Integration® (ASI) conceptual framework (Ayres, 1972, 1979) are widely used by occupational therapy practitioners who provide services for children. In this framework, *sensory integration* (i.e., the brain's organization of sensation for use) is viewed as integral to the child's successful performance of daily occupations (Ayres, 1979; Parham, 2002). Problems with sensory integration (SI) may affect not only a child's physical enactment of activities, but also his or her feelings of competency in the context of social participation.

One of the most fundamental ideas in the ASI conceptual framework is that the early developing, body-centered senses (tactile, vestibular, and proprioceptive) provide a foundation for the development of later maturing visual and auditory systems (Ayres, 1972, 1979). In her synthesis of neurobiological and developmental research, Ayres theorized that early development and integration of the tactile, vestibular, and proprioceptive systems allow for the formation of body scheme, object concepts, and body-centered spatial mapping of the environment. These elementary functions eventually become automatized and serve as a platform for the layering of more complex auditory and visual functions (Ayres, 1972, 1979; Smith Roley, 2005). The proposition that the tactile, vestibular, and proprioceptive sensory systems provide a foundation for more complex auditory and visual processing could be tested in research, but this testing would require the use of valid measures of discrete sensory system functioning.

This study was designed specifically to test the discreteness of sensory system measures in preparation for further research examining whether functions of the tactile, vestibular, and proprioceptive systems serve as a foundation for visual and auditory functioning, as Ayres's theory proposes. In past research, exploratory factor analysis methods were used with Sensory Profile questionnaire items (Dunn & Brown, 1997). Results did not depict sensory systems as discrete constructs. Instead, Sensory Profile items formed factors that incorporated multiple sensory systems into different types of patterns, such as sensory avoiding or sensory seeking. In contrast, exploratory factor analysis of data from a different questionnaire, the Sensory Processing Measure, suggested that items represented sensory systems as distinct constructs (Parham, Ecker, Miller Kuhaneck, Henry, & Glennon, 2007). However, the exploratory factor analytic techniques used in past research on the Sensory Profile and Sensory Processing Measure are not designed to rigorously test whether item data support a particular theoretical model.

In contrast to previous research, the current study used confirmatory factor analysis (CFA), a statistical technique specifically designed to test whether measures are consistent with a particular theoretical perspective (Jöreskog, 1969). We used CFA to test whether sensory questionnaire items form factors that represent sensory systems as distinct theoretical constructs in order to determine the feasibility of future research to test Ayres's premise that some sensory systems form a foundation for other sensory system functions. In the current study, if CFA showed that items did not cohere within distinct sensory systems, it would not be feasible to test this premise. However, if CFA confirmed that items fit a measurement model of distinct sensory systems, future research could be conducted to examine Ayres's premise that tactile, vestibular, and proprioceptive systems provide a foundation for auditory and visual system functioning.

Purpose

The primary purpose of this study was to evaluate the validity of sensory system measures as distinct constructs. This purpose was important because strong evidence of the validity of sensory system measures must be ascertained before future research can examine the theoretical interrelationships among sensory systems Ayres proposed.

A secondary purpose of this study was to identify whether sensory systems operate as distinct constructs in a consistent manner across age groups spanning early through middle childhood. Past research has indicated that rapid development of SI occurs between the preschool and elementary school ages (Ayres, 1989), raising the possibility that developmental changes may influence relationships among sensory systems. No previous research has examined this possibility. If developmental changes in sensory constructs are found, such changes would need to be addressed in future research examining Ayres's proposition that tactile, vestibular, and proprioceptive sensory systems provide a foundation for auditory and visual processing.

Method

We used CFA to test whether five sensory systems—tactile, proprioceptive, vestibular, auditory, and visual—form valid, distinct factors. We created CFA models independently for two age groups because of the possibility that developmental changes might affect interrelationships among sensory systems. CFA is designed to test the hypothesized linkages between observed variables (in this study, sensory questionnaire item ratings) and their underlying constructs, called *latent variables* (in this study, underlying sensory processes). CFA also computes correlations among latent variables. In CFA, relationships among variables are hypothesized before statistical procedures are conducted on the basis of a theory being tested, empirical research, or both (Bentler & Chou, 1987; Byrne, 1994).

Data Collection Procedures

Data came from the clinical records of children whose parents had filled out a questionnaire, the Evaluation of Sensory Processing (ESP)–Research Version 4 (Parham & Ecker, 2002), as part of routine clinical assessment procedures at sites in California, Colorado, and Texas, where the children received occupational therapy for their sensory integration problems. Staff at these sites identified children who met eligibility criteria and sent photocopies of their completed ESP forms to the researchers after blocking out any information that might identify the children. A research university institutional review board deemed the study exempt from review because all data were anonymous.

Participants

ESP questionnaires for 454 children with SI problems were analyzed. Occupational therapists with formal training and experience in ASI theory and practice, including assessment using the Sensory Integration and Praxis Tests (Ayres, 1989), identified children with SI problems at their clinical sites. Children were excluded if they had cerebral palsy, hearing loss, or severe visual impairments because their parents' responses would reflect the effects of significant motor disorders or sensory losses rather than SI functioning. We analyzed two age groups separately. The younger group consisted of 231 children ages 2 yr, 0 mo, to 5 yr, 11 mo, with a mean age of 3 yr, 9 mo (SD = 13.42 mo). The older group consisted of 223 children ages 6 yr, 0 mo, to 10 yr, 11 mo, with a mean age of 7 yr, 8 mo (SD = 16.35 mo). No other demographic information was available.

Instrument

The ESP–Research Version 4 (Parham & Ecker, 2002) contains 76 items divided into six sensory system categories: (1) tactile (21 items), (2) proprioceptive (12 items), (3) vestibular (15 items), (4) auditory (10 items), (5) gustatory/olfactory (5 items), and (6) visual (13 items). A total sensory score represents the sum of all item ratings. Each item describes the child's behavioral response to some sensory experience in a natural situation. For example, an auditory item is "Is your child bothered by any household or ordinary sounds, such as the vacuum, hair dryer, or toilet flushing?" The parent is asked to rate his or her child's behavioral responses on an ordinal scale with five levels of frequency: *always, often, sometimes, rarely,* or *never.*

Past research has indicated that the ESP has strong content validity (LaCroix, 1993) and strong discriminant validity (a type of construct validity) in distinguishing children with and without clinical problems such as SI dysfunction or autism spectrum disorder (Johnson-Ecker & Parham, 2000; Lee, 1999). The current study adds to the evidence regarding construct validity of the ESP. Interrater reliability using mother and father ratings is adequate (Chang, 1999), and internal consistency coefficients for most sensory scales are high across studies (Chang, 1999; Lee, 1999). Normative data are not available for the ESP. However, the ESP contributed to the development of a nationally normed questionnaire for clinical use, the Sensory Processing Measure Home Form (Ecker & Parham, 2010; Parham & Ecker, 2007).

ESP items that were both psychometrically strong and clinically valuable were assembled to create Research Version 4 of the ESP (Parham & Ecker, 2002), which we used in the current study. Additionally, the ESP authors categorized items within each sensory system of ESP–Research Version 4 (except the gustatory/olfactory system) into subdomains reflecting various types of sensory processing and sensory–motor problems. These subdomains within each sensory system, along with the number of items in each subdomain, are summarized in Table 1.

Table 1. Subdomains of the Evaluation of Sensory Processing

Sensory System	Subdomain	No. of Items
Auditory	Perception	2
	Overresponsiveness	6
	Underresponsiveness	2
Proprioceptive	Proprioception seeking	5
	Regulation of muscle tone and force	5
	Postural control	2
Tactile	Overresponsiveness	16
	Underresponsiveness	3
	Pain modulation	2
Vestibular	Overresponsiveness	5
	Underresponsiveness or seeking	6
	Balance/postural control	4
Visual	Perception	5
	Modulation	3
	Visual–motor attention and control	5

Data Analysis

Higher ESP scores indicate fewer sensory problems. The response of *always* for an ESP item usually indicates relatively greater behavioral difficulty. Therefore, for most of the items, the response of *always* was coded as 1, *often* as 2, *sometimes* as 3, *rarely* as 4, and *never* as 5. Only two items were coded in opposition, with *always* coded 5 and *never* coded 1: vestibular Item 3 ("Does your child have good balance?") and vestibular Item 5 ("Does your child like fast spinning carnival rides, such as merry-go-rounds?"). The coding of Item 5 was based on findings of previous studies that showed that parents of typically developing children tended to rate this item *always* or *often,* in contrast to parents of children with sensory integration problems (Johnson-Ecker & Parham, 2000) or autism (Lee, 1999), who more often answered *never* or *rarely* for this item.

We excluded an ESP questionnaire from the data analysis if all the items within a single sensory system were missing responses or if the total number of answered items across all sensory systems was fewer than half of all the ESP items. Such major omissions usually occurred when an error had been made in printing the questionnaire or when parents had skipped the back side of a page. Questionnaires retained for data analysis ($N = 454$) were coded and entered into a database. Before data analysis, any missing responses were replaced by the average score for that particular item from all the collected questionnaires in the same age group.

Merging the two age groups would have provided a larger sample size, which is desirable in a CFA study. However, we analyzed data obtained from the younger age group separately from data on the older age group to examine whether developmental changes appear to influence the distinctness of sensory systems. ESP data from the older group contained three visual items related to academic tasks that were not completed for the younger group.

Data analysis procedures were identical for each age group. Because ESP ratings produce ordinal data, frequency distributions of all items were tested for normality before further analysis. For both groups, all items in the five sensory systems of interest satisfied statistical criteria for the assumption of normal distribution—that is, absolute value of skewness ≤3 (Glasnapp & Poggio, 1985; Kline, 1998) and absolute value of kurtosis ≤10 (Kline, 1998). Therefore, no transformation of data was necessary before conducting CFA procedures. The normal distributions in these data were consistent with previous research showing that ESP scores of children with SI dysfunction were more variable than those of children without dysfunction, who almost always had highly skewed data because most items were rated as *rarely* or *never* observed (Johnson-Ecker & Parham, 2000); ESP items are designed to be sensitive to SI problem behaviors that are infrequent among typically developing children. The data in the current study were derived entirely from clinically identified children with SI problems, so the heterogeneous nature of SI dysfunction is probably responsible for the wide distribution of ESP scores.

Before conducting the CFA procedures, we computed the internal consistency of each sensory system score and the total ESP score to assess the reliability of the data for each age group. Then we constructed models that depicted the factors being tested and each factor's indicators (i.e., composites of items thought to measure the factor). Next, we tested the hypothesized linkages between the indicators and their underlying factors for each group through CFA. Data were analyzed using EQS (Bentler, 1995), a computer software package that is designed specifically for CFA and structural equation modeling procedures.

We used two kinds of fit indexes, the absolute fit index and the incremental fit index, to judge whether collected data fit each hypothesized CFA model. An absolute fit index evaluates how well a hypothesized model reproduces patterns in the collected data. One widely used absolute fit index is the standardized root-mean-square residual (SRMR). SRMR is more sensitive to misspecified factor covariance or latent structure than any other fit index (Bentler, 1995; Hu & Bentler, 1999). An incremental fit index assesses the proportionate improvement in fit when the data are fit to the studied model versus a more restricted, nested baseline model. One incremental fit index, the comparative fit index (CFI), is highly sensitive to models with misspecified factor loadings (Hu & Bentler, 1999) and is recommended when assessing goodness of fit (Byrne, 1994).

When participants are fewer than 250, experts recommend that researchers use both SRMR and CFI to evaluate the fit between model and data (Hu & Bentler, 1999). Therefore, in this study we used both SRMR and CFI with each group analysis to evaluate the goodness of fit between model and data. According to Hu and Bentler (1999), the value for CFI should ideally be .95 or greater. However, a CFI of .90 is considered acceptable (Byrne, 1994; Kline, 1998; Mulligan, 1998). SRMR should be below .08 to conclude that a good fit exists between the hypothesized model and the collected data (Hu & Bentler, 1999).

Results

Internal Consistency

We computed Cronbach's α for each ESP sensory system score and for the total score (see Table 2). Results indicated adequate to excellent internal consistency for five sensory systems (tactile, proprioceptive, vestibular, auditory, and visual) and excellent internal consistency for the total score in both age groups. Internal consistency for all sensory systems was slightly higher for the older age group. Internal consistency was lowest for the gustatory/olfactory system in both age groups, particularly the younger group, a finding consistent with earlier studies that revealed lower alphas for the gustatory and olfactory systems relative to the other sensory systems (Chang, 1999; Johnson, 1996).

Initially Hypothesized Model

In the initial CFA model tested, we divided ESP items into indicators that represent subdomains (i.e., types of sensory processing problems shown in Table 1) within each of the five sensory systems emphasized in Ayres's theory, which formed the factors. We created this model to examine the hypothesis that types of sensory processing problems might best explain variability within each sensory system. This hypothesis is consistent with the current literature, which emphasizes different types of processing differences or problems (Dunn, 2001; Parham & Mailloux, 2010). Results indicated that in both age groups the CFI was .770, which was too low to be acceptable. Also, factor loadings of indicators (i.e., sensory system subdomains) were too low to be acceptable. Only one factor, visual system, accounted for more than 50% of the variance in

Table 2. Cronbach's α for Sensory System and Total Scores

	Age Group	
Sensory System	2–5 Yr	6–10 Yr
Auditory	.85	.85
Gustatory/olfactory	.57	.65
Proprioceptive	.78	.78
Tactile	.87	.90
Vestibular	.69	.73
Visual	.77	.85
Total	.94	.95

its indicators, which is the criterion for factor validity. The other factors (i.e., sensory systems) accounted for 24%–49% of the variance in their indicators for the younger group and 31%–45% in the older group. Thus, this model was rejected for both groups.

We did not use exploratory factor analysis after the initially hypothesized model was rejected because the overarching purpose of this study was to test specific constructs in SI theory. The rejection of an initially hypothesized model is not unusual. If modified models can be created on the basis of theory, as was the case in this study, researchers often use these modified models in CFA (Byrne, 1994). Thus, to find a better fitting CFA model, we regrouped ESP items to form different sets of indicators. On the basis of these modifications, we created new alternative models and analyzed them for goodness of fit with the data.

Alternative Model With Sensory Processing Problems as Factors

The first alternative CFA model was organized solely around types of sensory processing problems without regard to sensory systems. This approach adopts a perspective that is somewhat similar to the work of Dunn and colleagues (Dunn, 1999; Dunn & Brown, 1997), who addressed sensory difficulties primarily in relation to types of processing patterns rather than sensory systems. However, this alternative CFA model tested the subdomains used by the ESP authors to classify items (see Table 1), which were based on the typology of SI problems described by Parham and Mailloux (2010). The hypothesis underlying this CFA model was that a framework involving types of sensory processing problems, rather than sensory systems, could validly depict SI constructs. In this new model, five sensory processing problems, instead of sensory systems, were denoted as factors (F): overresponsiveness (F1), underresponsiveness (F2), sensation seeking (F3), perception/discrimination (F4), and motor control/regulation (F5). Each of these factors included items across multiple sensory systems, including gustatory/olfactory items. If CFA results indicated that this model was valid, this would indicate that Ayres's framework of distinct sensory system relationships should be rejected in favor of a model emphasizing types of sensory processing problems.

In this model, F1, overresponsiveness, comprised five indicators—V1, V2, V3, V4, and V5—consisting of items representing overresponsive behaviors from the auditory, tactile, vestibular, visual, and gustatory/olfactory systems, respectively. F2, underresponsiveness, contained four indicators—V6, V7, V8, and V9—that included items measuring underresponsive behaviors related to the auditory, tactile, vestibular, and gustatory/olfactory systems, respectively. F3, sensation seeking, was represented by four indicators—V10, V11, V12, and V13—composed of items detecting sensation-seeking behaviors representative of the proprioceptive, vestibular, tactile, and gustatory/olfactory systems, respectively. F4, perception/discrimination, consisted of two indicators—V14, which consisted of perception items from the auditory system, and V15, which contained perception/discrimination items from the visual system. F5, motor control/regulation, comprised three indicators: V16, containing items that measure movement regulation; V17, consisting of items that detect postural control problems; and V18, containing visual–motor control items.

CFA results showed that no factor explained more than 50% of the variance of its indicators in either group. Percentages of explained variance ranged from 36% to 45% in the younger group and 25% to 46% in the older group. In addition, the CFI (.829 in the younger group, .779 in the older group) was below the minimum criterion of .90 for goodness of fit. Therefore, this model was rejected.

Alternative Five-Factor Model With Sensory Systems as Factors

We tested an additional alternative CFA model with five sensory systems as factors, as in the originally hypothesized model, but with items grouped differently to form the indicators within each sensory system factor. In this model, items within each sensory system were grouped in the arbitrary order in which they were presented on the questionnaire instead of being grouped in subdomains reflecting types of sensory processing, such as overresponsiveness.

Each indicator within a sensory system contained the same or a similar number of items. For example, 21 items are in the tactile system. Therefore, in F1, tactile system, V1 consisted of Items 1–7 on the ESP questionnaire, V2 of Items 8–14, and V3 of Items 15–21. As another example, the auditory system includes a total of 10 ESP items, so V10 consisted of auditory Items 1–4, V11 of Items 5–7, and V12 of Items 8–10.

Because items on the ESP questionnaire are presented in arbitrary order within each sensory system, the items grouped together for each indicator in this model reflected a variety of aspects of sensory and sensory–motor processing rather than parsing out distinct kinds of processing problems. For example, the first indicator in the auditory system (V10, comprising Items 1–4) included items thought to measure perceptual difficulty as well as over- and underresponsiveness. The hypothesis for this model rested solely on a sensory system–oriented framework to explain sensory processing issues without taking into account various types of sensory processing problems.

In this alternative sensory systems model, results supported a good fit with the data. The SRMR was .048 in the younger group and .065 in the older group, which met the desired criterion of falling below .08. Furthermore, the CFI was .953 in the younger group and .906 in the older group, satisfying the criterion of CFI ≥.90. Also, four factors (tactile, proprioceptive, auditory, and visual systems) accounted for more than 50% of the variance of their indicators, with percentages ranging from 55% to 68% in the younger group and 55% to 69% in the older group. Only one factor, F3, vestibular system, explained <50% of the variance of its indicators (35% in the younger group and 37% in the older group). Overall, this CFA model provided a much better fit with the data, with more factors that met the validity criterion, compared with either the initially hypothesized model (in which factors represented sensory systems and items were grouped by type of processing problem) or the first alternative model (in which factors represented types of sensory processing problems).

However, in this alternative model, the correlation between the vestibular and the proprioceptive systems was unacceptably high (.87 in the younger group and .95 in the older group). An absolute value greater than .85 for any correlation between factors suggests that the two factors are redundant and should be either combined into one factor or excluded from analysis (Kline, 1998). Because these two systems are often thought to function as one integrated sensory system (referred to as the *vestibular–proprioceptive system;* Fisher, 1991) and play key roles in ASI theory, we deemed it more appropriate to combine them to form one factor than to exclude them from further data analysis. Therefore, we created a modified CFA model with four factors, including a vestibular–proprioceptive factor.

Final Four-Factor Model

The final CFA model contained four factors: tactile system (F1), vestibular–proprioceptive system (F2), auditory system (F3), and visual system (F4; see Figure 1). As in the preceding five-factor model, items were grouped within each sensory factor in the arbitrary order in which they appeared on the ESP questionnaire. However, the original six indicators of the separate vestibular and proprioceptive systems now all fell under one consolidated vestibular–proprioceptive system factor. CFA results supported a good fit between this model and the data, with SRMR of .053 and CFI of .944 for the younger group and SRMR of .069 and CFI of .904 for the older group. Three factors (tactile, auditory, and visual system) explained >50% of the variance of their indicators (percentages ranging from 55% to 68% in the younger group and 55% to 69% in the older group). The vestibular–proprioceptive system accounted for 42% of the variance of its indicators in the younger group and

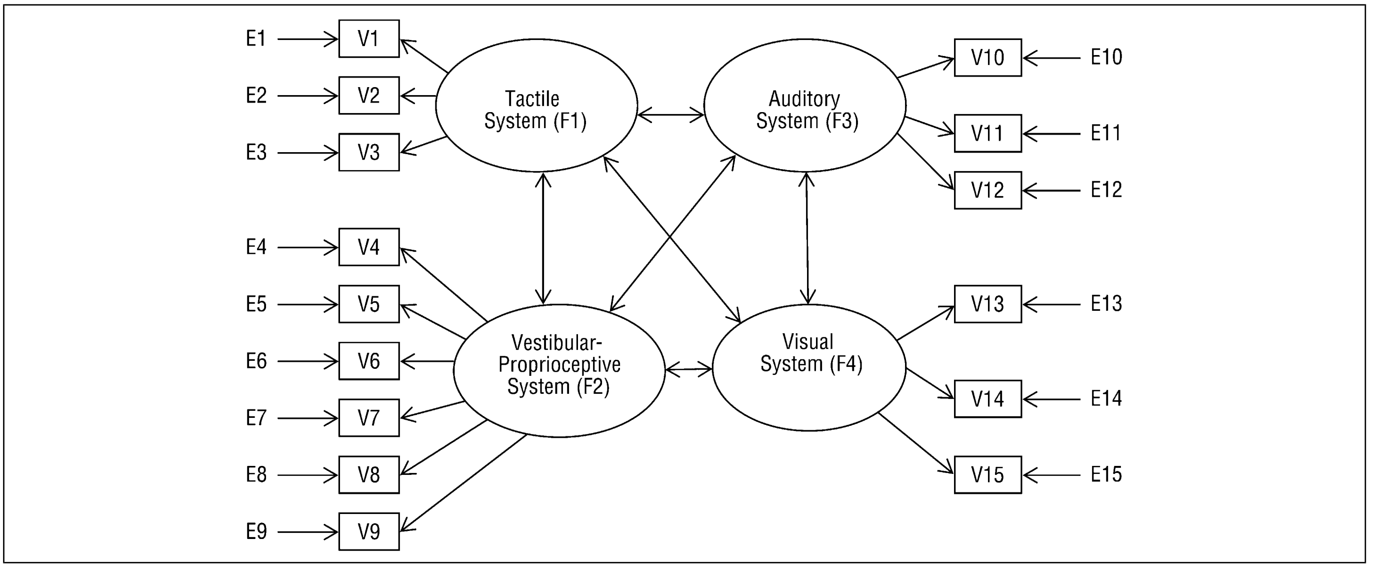

Figure 1. Final four-factor CFA model with sensory systems as factors and items grouped in the order they appear on the Evaluation of Sensory Processing (ESP) instead of by type of sensory processing problem (i.e., overresponsiveness, underresponsiveness, sensation seeking, perception, motor control).

Note. E = measurement error associated with indicators; F = factor; V = indicator (group of ESP items); one-way arrow = hypothesized effect that one variable has on the other; two-way arrow = correlation between pairs of variables. See text for definitions of factors and indicators.

46% in the older group. No factor intercorrelations exceeded the cutoff point (.85) for problems of discriminant validity.

Discussion

Findings confirm that sensory systems are distinct, valid constructs that can be used in future research to test Ayres's proposition that the tactile, proprioceptive, and vestibular systems provide a foundation for auditory and visual functions. Of the four CFA models tested, the only ones that met the criteria for goodness of fit with the data were the two models that used sensory system factors but did not group items into indicators that were linked to types of processing problems (e.g., underresponsiveness, overresponsiveness). Neither of the CFA models containing indicators or factors that represented specific types of processing problems were acceptable. Findings were consistent for both age groups, indicating that sensory systems function as distinct entities across childhood.

Results indicate that problematic sensory processing tends to be expressed most distinctly through individual sensory systems rather than as pervasive patterns of over- or underresponding that cut across sensory systems. Previous research showed that behaviors thought to reflect over- and underresponding are often reported for the same child within the same sensory system (Lai, Parham, & Ecker, 1999; Lee, 1999). The results of the current study suggest that when a particular sensory system is not working well, the child is likely to experience a variety of difficulties involving that sensory system, such as underresponsiveness, overresponsiveness, and problems with perception or sensory–motor control. This finding could explain why the analyses in this study did not generate valid factors representing discrete types of processing problems such as under- and overresponding. Alternatively, perhaps ESP items were not adequate in number or sensitivity to detect different types of sensory processing problems.

Results diverge from those of Dunn and Brown's (1997) factor analysis of Sensory Profile data (Dunn, 1999). Dunn and Brown used an exploratory approach, principal components analysis, whereas this study used CFA. Perhaps an exploratory factor analysis would have produced a different factor structure in this study. The intent here was to empirically test theoretical constructs, however, so CFA was the appropriate technique.

The inclusion of items on the Sensory Profile that are highly sensitive to temperament is another plausible reason why Sensory Profile factors differed from ESP factors in the current study. Although Dunn and Brown (1997) interpreted their factor analysis as identifying mainly types of sensory processing differences, five of the nine factors they identified were not necessarily indicative of sensory processing issues. For example, factors labeled Emotionally Reactive, Inattention/Distractibility, and Sedentary were defined by items that measure behavioral patterns seen in children who may or may not have sensory processing problems (e.g., "Has difficulty tolerating changes in plans and expectations," "Difficulty paying attention," "Prefers sedentary activities"). In regard to this feature, Case-Smith (1997) noted that the Sensory Profile may be providing critical information about the child's temperament.

The sample Dunn and Brown (1997) used also differed from the samples in the current study. All of the data in the Dunn and Brown factor analysis were collected from typically developing children, whose behaviors tend to be far less variable than those of children with SI problems (e.g., see Johnson-Ecker & Parham, 2000). Therefore, it is possible that restriction in the range of item scores may have resulted in low correlations among Sensory Profile items, precluding the detection of sensory system factors that might have emerged if the sample had included a large number of children with SI problems.

Results of this study present compelling evidence for the primacy of sensory systems in clinical assessment of sensory integration, but it would be premature to discard the concept that types of sensory processing problems influence child behavior in important ways. The ESP contains more items reflecting overresponsiveness than any other type of sensory processing problem. Additional items that measure underresponsiveness, sensory seeking, and perceptual functions might lead to detection of valid factors representing different types of processing within particular sensory systems, such as a factor for auditory overresponsiveness.

A limitation of this study is that the modified models were tested with the same samples used in the initially hypothesized models. This limitation is not unique to this study (e.g., see Mulligan, 1998). Still, future research should test the final accepted model with new samples to examine the replicability of findings.

Implications for Occupational Therapy Practice

Results indicate that interpretation of child behaviors using sensory systems as a conceptual framework is a valid approach to clinical assessment. The vestibular and proprioceptive systems are so strongly associated with each other that they might best be interpreted as a single functional system. Findings also indicate that when a specific sensory system is vulnerable to not functioning well, the child's behavioral expressions of that system are likely to represent a variety of difficulties at different times, such as over- and underresponding as well as perceptual and motor problems, rather than consistently presenting one specific type of processing problem. In practice, occupational therapy practitioners might consider the following implications of the evidence produced by this study:

- In clinical assessments of SI, it is appropriate to gather, interpret, and report information on child behaviors in relation to specific sensory systems.
- The vestibular and proprioceptive systems can be addressed as distinct systems but may also be interpreted as one integrated system.
- When assessment findings suggest problems within a particular sensory system, practitioners should identify and analyze the diverse ways that these problems are manifested in child behavior within the routines of daily life. ▲

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