
Performance Challenges for Children and Adolescents With Difficulty Processing and Integrating Sensory Information: A Systematic Review

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KEY WORDS

- activities of daily living
- human activities
- pediatrics
- review
- sensory integrative dysfunction
- sensory processing

A systematic review of the literature related to performance difficulties for children and adolescents with difficulty processing and integrating sensory information was completed as part of the Evidence-Based Literature Review Project of the American Occupational Therapy Association. The review focused on functional performance difficulties that these children may exhibit in areas of occupation including play and leisure, social participation, activities of daily living, instrumental activities of daily living, rest and sleep, education, and work. The results suggest that children and adolescents with difficulty processing and integrating sensory information do exhibit functional performance difficulties in key areas of occupation. However, further descriptive studies are needed to tie these difficulties to their specific sensory and motor issues. Researchers are encouraged to include functional performance measures and measures of social participation in their studies to further elucidate these relationships.

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Occupational therapy practitioners focus on performance issues that affect their clients' ability to engage in meaningful occupations (American Occupational Therapy Association [AOTA], 2008). (The term *occupational therapy practitioner* in this article refers to both occupational therapists and occupational therapy assistants; AOTA, 2006.) Practitioners are increasingly being asked to provide evidence of the effectiveness of their interventions. To do so, it is critical to clearly identify the performance difficulties presented by interventions. For people with difficulty processing and integrating sensory information, identification of performance difficulties will help target occupational therapy interventions. These data will be useful to (1) guide assessment and intervention, (2) assist occupational therapists in choosing relevant outcome measures, and (3) guide research design and efficacy trials in areas of occupation that have relevance for children and adolescents with difficulty processing and integrating sensory information. Thus, the goal of this review was to identify the performance difficulties that children and adolescents with difficulty processing and integrating sensory information demonstrate in activities of daily living (ADLs), instrumental activities of daily living (IADLs), rest and sleep, education, work, play, leisure, and social participation.

Background Literature

One important step in the process of identifying the performance difficulties observed in a clinical population is to clearly define the target population. Given the heterogeneity of the children and adolescents with difficulties processing and integrating sensory information, this task is challenging; therefore, for this

review, performance difficulties that children and adolescents with sensory issues may demonstrate were grouped according to difficulties in the following areas of occupation: play and leisure, social participation, ADLs, IADLs, rest and sleep, education, and work. Although current research has attempted to identify the comorbidity of difficulties processing and integrating sensory information in different diagnostic groups using a variety of measures, the literature often then does not link their sensory issues to actual performance difficulties. Studies may discuss sensory processing issues associated with diagnostic conditions, including fragile X (Baranek et al., 2002), Asperger syndrome (Blakemore et al., 2006; Dunn, Smith-Myles, & Orr, 2002; Pfeiffer, Kinnealey, Reed, & Herzberg, 2005), autism (Baranek, David, Poe, Stone, & Watson, 2006; Ben-Sasson et al., 2009; Kern et al., 2006; Liss, Saulnier, Fein, & Kinsbourne, 2006), and attention deficit hyperactivity disorder (ADHD; Dunn & Bennett, 2002; Mangeot et al., 2001; Parush, Sohmer, Steinberg, & Kaitz, 2007), but fail to link sensory issues to actual performance deficits in the areas of occupation. Additional studies investigating difficulties processing and integrating sensory information with no other diagnostic classifications also do not focus on evaluation of participation difficulties (Davies & Gavin, 2007; Goldsmith, Van Hulle, Arneson, Schreiber, & Gernsbacher, 2006; Reynolds & Lane, 2008).

To further complicate this issue, the population of children with difficulties processing and integrating sensory information often includes children with motor issues as well. For example, Ayres (1985) showed that children with dyspraxia and developmental coordination disorder (DCD) who have motor execution difficulties also have an underlying sensory deficit. Ayres hypothesized that motor planning deficits, which she termed *developmental dyspraxia*, were another significant manifestation of sensory integration dysfunction. Similarly, in a nosology proposed by Miller, Anzalone, Lane, Cermak, and Osten (2007), sensory-based motor disorders are used to describe children who have difficulty with the praxis and postural requirements of a motor task but who may have underlying sensory deficits that contribute to motor coordination problems. Thus, studies addressing these groups were included in the review.

Studies that do include descriptors of functional performance deficits include anecdotal reports and case reviews that describe difficulty with performance of daily routines (e.g., dressing, brushing hair and teeth) and the behavioral outbursts accompanying those routines (Kinnealey, 1998; Reeves, 1998). Studies that use sensory histories and interviews include responses to sensory

input and its impact on performance but in a non-standardized format. With the development of more psychometrically sound sensory measures such as the Sensory Profile (Dunn, 1999) and the Sensory Processing Measure (Parham, Ecker, Kuhaneck, Henry, & Glennon, 2006), more systematic, standardized information can be obtained on the impact that difficulties processing and integrating sensory information have on functional performance.

At this stage, to fully understand the performance challenges experienced by children and adolescents who have difficulty processing and integrating sensory information, we must be inclusive of all clinical groups who may have these problems but pose questions specific to their sensory issues. For example, we might pose questions such as, How do underresponsive or overresponsive sensory patterns affect daily routines and ADLs? What impact do difficulties processing and integrating sensory information have on school performance? Do atypical sensory processing patterns have a direct impact on play and social participation? Do children with dyspraxia and DCD have more difficulty with the task demands of the environment and with everyday participation, and are these related to their sensory or motor problems or some combination of both? This systematic review contributes to the identification of performance deficits in children and adolescents with difficulties processing and integrating sensory information and provide recommendations for future research to include demonstrated performance measures that are relevant to performance in areas of occupation that are critical to successful participation.

Method for the Evidence-Based Review

The portion of the Evidence-Based Literature Review of Occupational Therapy for Children and Adolescents With Sensory Processing Disorder/Sensory Integrative Dysfunction reported in this article addresses the challenges for children and adolescents with difficulty processing and integrating sensory information in areas of occupation. Detailed information about the methodology for the entire literature review can be found in the article "Methodology for the Systematic Reviews of Occupational Therapy for Children and Adolescents With Difficulty Processing and Integrating Sensory Information" in this issue (Arbesman & Lieberman, 2010). An exception to the methodology listed in Arbesman and Lieberman is that several studies were added that were published after 2007 because of their particular relevance to the question of performance difficulties.

Also of note is the inclusion of articles on participants with DCD. As stated previously, DCD is frequently used

as a synonym for dyspraxia. It is a relevant diagnostic group to include in this systematic review because some evidence indicates a sensory component to the motor difficulties of people with DCD. Finally, although an extensive body of literature exists as to how autism spectrum disorders affect social, educational, and functional outcomes, inclusion was limited to research that included a measure of sensory behaviors in addition to demonstrated performance deficits to identify potential relationships.

Results

Thirty-five studies met the inclusion criteria for the following question: What are the demonstrated performance difficulties for children and adolescents with difficulties processing and integrating sensory information in the areas of play, leisure, and social participation; ADLs and IADLs; rest and sleep; and education and work? There were 19 Level II studies, 11 Level III studies, 2 Level IV studies, 2 Level V studies, and 1 qualitative study. No Level I studies were found that were relevant to the topic. The articles in the review were divided into four areas of occupational performance: (1) play, leisure, and social participation; (2) ADLs and IADLs; (3) rest and sleep; and (4) education, transition, and work. An evidence table including all articles reviewed in this systematic review is available at www.ajot.ajotpress.net (navigate to this article, and click on “supplemental materials”).

Play, Leisure, and Social Participation

Seventeen articles related to the areas of play, leisure, and social participation were reviewed. Thirteen were Level II studies, and 4 were Level III studies relevant to social skill development, play, and physical activity. All but one of the studies were nonintervention observational studies using various tools and measures to describe performance and areas of difficulty for children and adolescents with difficulty processing and integrating sensory information or related conditions, such as DCD. One intervention study (Lloyd, Reid, & Bouffard, 2006) was included because of the descriptive nature of the measures taken at baseline that give information relevant to functional performance deficits. Table 1 presents sample articles that are most representative of the 17 articles reviewed for this area of occupation and includes information about the objectives, design, procedures, findings, and limitations of the reviewed studies.

The studies provide evidence to suggest that children with difficulty processing and integrating sensory information show decreased quality and quantity of play

skills and social participation. In terms of social participation, a Level III study that directly linked sensory processing symptoms and social competence (Hilton, Graver, & LaVesser, 2007) found statistically significant correlations between sensory processing and social competence. In this study of 36 children with high-functioning autism ages 6–10, patterns of sensory avoiding and sensory sensitivity, as measured by the Sensory Profile, displayed the strongest correlations between social performance and sensory processing. Children who had high sensory overresponsivity demonstrated the poorest social performance. A direct link between sensory overresponsiveness and social performance may exist, but cross-sectional studies are unable to infer that one variable is causally related to the other, and it has not been established, beyond anecdotal information, how sensory issues affect social participation.

For children with DCD, a Level II study of 39 children with and without DCD by Cummins, Piek, and Dyck (2005) showed that scores on tests of neuromotor coordination were significant predictors of social problems in children. In addition, Cummins et al. (2005) found a significant relationship between motor coordination and social problems.

In terms of play skill development, Smyth and Anderson (2000) found that children with DCD spent more time alone and were more often onlookers in social play, indicating that play involvement is affected by poor coordination. In addition, physical social play was decreased in children with DCD but varied among people with DCD; some boys with DCD took part in team games, but others did not. No differences were found between children with and without DCD in social fantasy play, suggesting that coordination disorders have more impact on motor-based play.

In a cross-sectional, Level III study by Cairney et al. (2005), the authors attempted to determine whether a link exists between DCD and reduced physical activity. Results showed that DCD is associated with decreased variation in physical activity level. Poulsen, Ziviani, Cuskelly, and Smith (2007) found that boys with DCD recorded significantly lower participation rates in both structured and unstructured physical activities than boys without DCD. In addition, physical coordination difficulties were significantly related to loneliness. The authors did, however, find an inverse relationship between physical coordination ability and loneliness when mediated by participation in team sports. The social participation appeared to act as a protective factor for boys with DCD when compared with boys with DCD who did not participate in team sports.

Table 1. Evidence for Functional Performance Difficulties in Children and Adolescents With Difficulty Processing and Integrating Sensory Information: Play–Leisure and Social Participation (Sample Articles)

Author/Year	Study Objectives	Level/Design/Participants	Intervention and Outcome Measures	Results	Study Limitations
Cairney et al. (2005)	The objective was to study a theoretical model determining whether there is a link between DCD and reduced physical activity, with generalized self-efficacy as a mediating influence	Level III <i>Design</i> Nonrandomized, cross-sectional 564 children in Grades 4–8	Nonintervention; observational study <i>Outcome Measures</i> • Bruininks–Oseretsky Test of Motor Proficiency, Short Form • Children’s Self-Perceptions Toward Physical Activity • Participation Questionnaire	7.5% of the study population met the requirements for probable DCD. 28% of the variance in children’s activity level was predicted by both generalized self-efficacy and DCD.	Study was unable to test causal ordering between variables of self-efficacy and DCD. Data were not derived from a random sample of students. Many factors other than those examined in this study are involved in a child’s play.
Hilton, Graver, & LaVesser (2007)	The study examined the relationship between social competence and sensory processing in children with high-functioning ASD.	Level III <i>Design</i> Nonrandomized, cross-sectional 36 participants, ages 6–10, with high-functioning ASD	Nonintervention; observational study <i>Outcome Measures</i> • SRS • Sensory Profile	All the relationships between the SRS <i>t</i> scores and the Sensory Profile quadrant scores were statistically significant. The quadrants of sensation seeking and low registration had a moderately negative correlation, whereas the quadrants of sensory sensitivity and sensation avoiding had strongly negative correlations.	The use of questionnaire format assessments limited. The accuracy of these assessments is based on a parent’s ability to understand and answer the questions accurately. Participants used were a convenience sample, recruited from a limited section of the country with limited ethnic diversity.
Smyth & Anderson (2000)	The objective was to determine whether children with poor coordination were fully involved across the range of play activities or spent time by themselves or in very small groups; whether they engaged in social but not physical play, and whether this activity changed with age; and whether they engaged in skill mastery that could be physical but not social.	Level II <i>Design</i> Case-control 2 groups: 55 children were assigned to a DCD group and 55 to a control group on the basis of their scores on the M–ABC.	Nonintervention; observational study <i>Outcome Measures</i> Play and social skills were coded using a coding scheme that was developed in 2 schools that were not part of the main study.	Children in the DCD group spent more time alone, were onlookers more often, and played formal games in large groups less often if they were boys and informal games in large groups less often if they were girls. Social fantasy play did not differentiate between the 2 groups, but social physical play did, particularly in the older age groups.	Difficult to determine whether children initially did not participate in group playground games or if they did not participate because they had been excluded in the past. Coding scheme developed to measure play and social skills had not had formal reliability (with the exception of interrater reliability) and validity measures performed.

Note. ASD = autism spectrum disorders; DCD = developmental coordination disorder; M–ABC = Movement Assessment Battery for Children; SRS = Social Responsiveness Scale.

Table 2. Evidence for Functional Performance Difficulties in Children and Adolescents With Difficulty Processing and Integrating Sensory Information: ADLs and IADLs (Sample Articles)

Author/Year	Study Objectives	Level/Design/Participants	Intervention and Outcome Measures	Results	Study Limitations
Case-Smith (1995)	The objective was to investigate the relationships among sensorimotor components; standardized measures of fine motor skill; and functional performance in self-care, mobility, and social interaction as well as to examine which sensorimotor components and fine motor skills were predictors of functional performance	Level III <i>Design</i> Nonrandomized cross-sectional 30 preschool children with motor delays	Nonintervention; observational study <i>Outcome Measures</i> • Motor Assessment Outcomes Model (including tests of in-hand manipulation, tactile defensiveness, stereognosis, grasping strength, and fine motor skill) • PEDI	Significant correlations were found among sensorimotor components and discrete fine motor skills as measured on standardized observational tests. Few correlations emerged between foundational components of fine motor skill and functional performance in self-care, mobility, and social function.	Small sample size and narrow age range limit generalizability. Study focused on only 1 aspect of motor function. Sensorimotor components selected for analysis do not represent all of the components that contribute to a child's fine motor skills.
Mandich, Polatajko, & Rodger (2003)	The objective was to explore the impact that DCD has on participation in the typical activities of childhood and the importance of this participation for children with DCD from the perspective of the parent.	Qualitative study 12 participants	<i>Outcome Measures</i> Interviews were conducted with parents of children with DCD who attended a clinic specializing in using the Cognitive Orientation to Daily Occupational Performance approach	Interviews revealed that difficulty in everyday activities had serious negative effects for the children. Intervention that was focused on enablement at the activity and participation levels was found to have a significant positive impact on the children's quality of life. Emerging themes included that performance competency played an important role in being accepted by peers and being able "to be part of the group." Parents reported that successful participation built confidence in their children and allowed them to try other new activities.	Qualitative study is exploratory in nature; as a result, the findings warrant further investigation, but it is difficult to generalize them to other populations.
Reynolds & Lane (2008)	The objective was to present case study reports that identify and describe a set of children who exhibited behaviors of sensory overresponsivity and had no other co-occurring neurological or psychological diagnoses	Level V <i>Design</i> Case reports (3 cases) Participants were 3 children (an 11-yr-old boy, 8-yr-old boy, and 12-yr-old girl), who presented with a profile of sensory overresponsivity without a co-occurring diagnosis.	Nonintervention; observational study <i>Outcome Measures</i> • Sensory Over-responsivity Inventory • Parent Interview Two assessments were used to rule out the presence of additional diagnoses typically associated with sensory processing disorders: 1. Childhood Autism Rating Scale 2. Child Symptom Inventory-4.	3 case studies provided preliminary support for the existence of sensory overresponsiveness in the absence of other diagnostic classifications. Overresponsivity to tactile stimulation was a consistent area of deficit that affected family routines and ADLs.	Case reports make it difficult to generalize to other populations.

<p>Roger et al. (2003)</p>	<p>The objective was to examine the motor and functional skills of children with DCD.</p>	<p>Level III <i>Design</i> Nonrandomized, cross-sectional 20 children with DCD (8 boys, 12 girls, ages 4–8)</p>	<p>Nonintervention; observational study <i>Outcome Measures</i></p> <ul style="list-style-type: none"> • Neurodevelopmental Physiotherapy Assessment • PEDI • PDMS (fine motor portion) • VMI • Test of Legible Handwriting • Handwriting Speed Test • Videotaped sample of cutting using scissors • Pictorial Scale of Perceived Competence and Social Acceptance 	<p>The children with DCD performed at the lower end of the normal range on the PDMS. VMI performance was within the average range. Videotaped observations of the children's handwriting and cutting indicated that 29% were left handed and that a large proportion of all children used unusual pencil grasp patterns and immature prehension of scissors. The PEDI revealed generally average performance on social and mobility function; however, self-care function was below the average range for their age.</p>	<p>Pilot investigation, which by nature has a small sample size and limited generalizability to other populations</p>
<p>White, Mulligan, Merrill, & Wright (2007)</p>	<p>The objective was to determine whether children with possible sensory processing deficits, as measured by the Sensory Profile, performed less well on an occupational performance measure compared with children with typical Sensory Profile scores.</p>	<p>Level III <i>Design</i> Nonrandomized cross-sectional 68 children divided into 2 groups on the basis of their scores on the Sensory Profile</p>	<p>Nonintervention; observational study <i>Outcome Measures</i></p> <ul style="list-style-type: none"> • AMPS • Sensory Profile 	<p>Significant differences between groups were found on the AMPS ADLs Motor and ADLs Process measures; the children with atypical Sensory Profile scores showed more functional difficulties. Correlations revealed significant relationships among the measures.</p>	<p>Small, convenient sample of primarily White children was used; the sample may not adequately represent the population of children with and without sensory processing dysfunction. Because there is no definitive diagnostic cutoff on the Sensory Profile that determines whether a child has sensory processing deficits, the categorization of the children as typical or atypical sensory processors was made on the basis of clinical judgment of the child's Sensory Profile scores.</p>

Note. ADLs = activities of daily living; AMPS = Assessment of Motor and Process Skills; DCD = developmental coordination disorder; PDMS = Peabody Developmental Motor Scale; PEDI = Pediatric Evaluation of Disabilities Inventory; SRS = Social Responsiveness Scale; VMI = Developmental Test of Visual-Motor Integration.

ADLs and IADLs

Table 2 presents sample articles from the studies related to the theme of ADLs and IADLs. Two Level II studies, four Level III studies, two Level IV studies, and one qualitative study addressed ADLs and IADLs related to performance areas such as eating and self-care as well as overall functional behaviors and participation. Evidence was found to suggest that children with difficulty processing and integrating sensory information demonstrate more difficulty with functional performance, particularly the motor aspects of the functional tasks. Functional performance is defined as demonstrated performance in the areas of ADLs including but not limited to eating, dressing, grooming, and hygiene.

In a Level III study by White, Mulligan, Merrill, and Wright (2007), significant differences in Assessment of Motor and Process Skills (AMPS; Fisher, 2003) and ADL measures were found between typically developing children and children with atypical scores on the Sensory Profile. Children with low scores on the Sensory Profile demonstrated more difficulties than typically developing children, especially with the motor aspects of ADLs. In another Level III study, however, with children with difficulties processing and integrating sensory information, Case-Smith (1995) found few correlations between foundational components of fine motor skill and functional performance in self-care, mobility, and social function in the investigation of relationships of sensorimotor components and functional skills. The study did find significant correlations among sensorimotor components and discrete fine motor skills. Case-Smith's findings on the correlations between sensorimotor components and fine motor skills were supported in another Level III study of children with DCD by Rodger et al. (2003). The children with DCD were found to perform on the lower end of the normal range of the developmental fine and gross motor scales, with the children using unusual pencil grasp patterns and immature prehension of scissors, but they scored in the average range on tests of visual-motor integration. In addition, the children with DCD generally had performance in the average range in social and functional mobility function, but self-care function was below average for their age.

Two Level IV case study design articles by Linderman and Stewart (1999) and Reeves (1998) assessed functional behaviors in single-case participants who were referred for occupational therapy to address difficulties processing and integrating sensory information; participants displayed performance deficits in the areas of functional ADLs, poor feeding behaviors, and functional behaviors.

These were descriptive studies that then examined response to intervention. In both studies, only baseline assessments were used to view performance difficulties for the purpose of this review.

In a Level V case study description by Reynolds and Lane (2008), children with sensory overresponsive patterns, as measured by the Sensory Profile, demonstrated disruption of family routines and more difficulty with self-care performance. Tactile sensitivity was associated with performance deficits (refusal, avoidance) in dressing, and taste sensitivity was associated with restricted food preferences. These three children with sensory overresponsivity and no other diagnostic classification demonstrated performance difficulty primarily associated with self-care skills in the home. Specifically, parent descriptions included avoidance of tooth brushing, hair and face washing, and hair combing; restricted food preferences; and difficulty with dressing. In fact, parents reported that the "biggest sensory related challenges at home were due to tactile sensitivities, especially dressing" (p. 525). In children with sensory overresponsivity without any co-occurring diagnoses, similar restricted diets were seen in children with taste sensitivity (Reynolds & Lane, 2008). In this case report, overresponsivity to tactile stimulation was a consistent area of deficit that affected family routines and ADLs.

Rest and Sleep

Table 3 presents a Level III study that makes a direct link between sensory hypersensitivity and sleep disturbances: Shochat, Tzischinsky, and Engel-Yeger (2009) found significant relationships between sensory processing, sleep, and behavior in a sample ($n = 51$) of typically developing schoolchildren. Specifically, children who had tactile sensitivity had significantly higher disturbances in sleep behavior, and differences in tactile sensitivity accounted for 25% of the variance in sleep behaviors. Underresponsive/seeking sensation was a predictor of behavior as well, indicating links to arousal that may affect day and night sleep and behavior.

Education and Work

Table 4 includes sample articles related to education, transition, and work. Seven articles were reviewed within this topic, including five Level II studies, one Level III study, and one Level V study. Evidence from several studies found that children and adolescents with difficulties processing and integrating sensory information showed lower participation in school activities; children from diagnostic groups associated with difficulties processing and integrating sensory information demonstrated

decreased academic achievement and attention and were at a higher risk for learning difficulties. Specifically, this phenomenon is demonstrated in a Level III study by Baranek et al. (2002) in which the relationship between sensory processing and occupational performance was examined in children with fragile X syndrome. Several significant correlations were found that were independent of effects of age and IQ. Children who demonstrated aversive–avoidant sensory behaviors had lower scores in school function. The results were mixed in that children with greater internally controlled aversion (avoidance) had lower levels of participation in school activities, were less independent in self-care, and engaged for shorter play durations; however, children with high externally controlled aversion tended to be more independent in self-care performance. A Level II study by Parham (1998) also found that academic skills were affected by sensory integrative development. Sensory integrative factors, such as dyspraxia and motor coordination, were strongly related to arithmetic achievement for children at younger ages; this finding declined with age. The reverse was true of reading skills in which reading achievement was significantly related to sensory integrative factors at older ages. In addition, the relationship between praxis and academic achievement was found to be surprisingly strong.

In a similar Level II study, Rogers, Hepburn, and Wehner (2003) found that sensory reactivity had a significant relationship with the acquisition of adaptive behavior skills in children. Neither developmental level nor IQ was found to be related to abnormal sensory reactivity in children with autism or developmental disorders.

In two Level II studies related directly to academic skills, Dewey, Kaplan, Crawford, and Wilson (2002) compared 51 children with DCD to 78 children without motor coordination deficits. They found that children with DCD had significantly poorer performance on attention tasks and learning tasks such as spelling, reading, and writing than the comparison group. No studies were reviewed that specifically examined transition issues and how a sensory integrative/sensory processing disorder may affect transitioning from school to work settings.

Discussion and Implications for Practice

The results of the evidence-based literature review indicate that children and adolescents with difficulties processing and integrating sensory information do display performance deficits in areas of occupation such as social participation, play, IADLs, ADLs, and school function. A significant limitation in the interpretation of this work is that studies often do not have a specific measure of oc-

cupational performance or participation, thus making it challenging to link difficulties processing and integrating sensory information with performance difficulties, which affect participation. However, the results of this review may help occupational therapy practitioners in three ways: guiding assessment, guiding intervention, and improving research design.

Assessment

In children who are demonstrating difficulties processing and integrating sensory information as demonstrated by assessment of specific sensory functions, occupational therapists need to assess their ability to perform their everyday occupations using performance-based assessments at home and school. Evidence suggests that individual differences in occupational performance may be seen in children with difficulties processing and integrating sensory information that may be related to use of coping strategies during functional tasks (Baranek et al., 2002). For example, some children with sensory over-responsivity showed greater independence in self-care skills, which may be an effort to control incoming stimuli. In addition, for children with dyspraxia, DCD, or other sensory-based motor disorders, it is important that assessment of sensory functions as well as motor functions be assessed so that the relationship between these variables and participation measures can be elucidated.

Intervention

The results of this review suggest that occupational therapy practitioners who work with children and adolescents with difficulty processing and integrating sensory information should strengthen their role in programs that encourage social skills and community participation in natural settings. Difficulties with processing and integrating sensory information, including dyspraxia, have been shown in this review to be moderately related to social competence and socialization. In addition, motor coordination deficits or dyspraxia affect a child's actual and perceived level of participation. For children with deficits in motor planning and coordination, their participation in school and play activities is compromised, which has implications for social and emotional well-being. Occupational therapy practitioners should not only focus intervention on the motor planning issues but also explore how these affect social competence in community settings.

Research

Occupational therapy researchers need to perform more studies that directly examine and describe the relationships between sensory processing/sensory integration and

Table 3. Evidence for Functional Performance Difficulties in Children and Adolescents With Difficulty Processing and Integrating Sensory Information: Rest and Sleep (Sample Article)

Author/Year	Study Objectives	Level/Design/Participants	Intervention and Outcome Measures		Results	Study Limitations
			Intervention	Outcome Measures		
Shocat, Tzischinsky, & Engel-Yeger (2009)	The objective was to explore the relationship between sleep habits, behavior, and sensory processing.	Level III <i>Design</i> Nonrandomized, cross-sectional 51 typically developing schoolchildren (mean age = 8.6)	Nonintervention: observational study <i>Outcome Measures</i> • Children's Sleep Habit Questionnaire • Short Sensory Profile • Conners' Global Index from the Conners' Parent Rating Scale		Significant relationships between sensory processing, sleep, and behavior were found. The relationship between sleep and behavior was not as strong when sensory processing abilities were controlled, indicating that sensory processing may contribute more to sleep disturbances, especially in the areas of tactile sensitivity. Tactile sensitivity was also a predictor of behavior as measured by the Conners' Global Index. Underresponsive/seekers sensation was a predictor of behavior as well, indicating links to arousal that may affect day and night sleep and behavior.	The sample size was small and relied only on parent report of sensory processing, behavior, and sleep habits.

Table 4. Evidence for Functional Performance Difficulties in Children and Adolescents With Difficulty Processing and Integrating Sensory Information: Education and Work (Sample Articles)

Author/Year	Study Objectives	Level/Design/Participants	Intervention and Outcome Measures		Results	Study Limitations
			Intervention	Outcome Measures		
Baranek et al. (2002)	The objective was to examine sensory processing and its relationship to occupational performance in children with fragile X syndrome	Level III <i>Design</i> Nonrandomized, cross-sectional 1 group, 15 boys with full-mutation Fragile X syndrome, ages 53–123 mo	Nonintervention; observational study <i>Outcome Measures</i> • School Function Assessment • Vineland Adaptive Behavior Scales • Sensory Profile Caregiver Questionnaire • Tactile Defensiveness and Discrimination Test—Revised • Sensory Approach—Avoidance Rating		Several significant correlations were found, independent of effects of age and IQ. Avoidance of sensory experiences (internally controlled) was associated with lower levels of participation in school, self-care, and play. Aversion to touch from externally controlled sources was associated with a trend toward greater independence in self-care.	Replication studies with larger samples of children with fragile X syndrome, as well as children with other developmental disorders, are needed to determine the generalizability of these findings. Further research also needs to address the limitations inherent in some measures developed for this study.
Dewey, Kaplan, Crawford, & Wilson (2002)	This study investigated the problems of attention, learning, and psychosocial adjustment evidenced by children with DCD.	Level II <i>Design</i> Case-control 45 children identified with DCD, 51 children identified as being suspect for DCD, and	Nonintervention; observational study <i>Outcome Measures</i> • Attention Problems subscale of the Child Behavior Checklist • Hyperactivity Index from the Abbreviated Symptom Questionnaire		Results revealed that both children with DCD and children suspect for DCD obtained significantly poorer scores on measures of attention and learning (reading, writing, and spelling) than the comparison children. Children with DCD and those suspected to have DCD were also found to display a relatively high	The sample may be biased because a sample of children with DCD was ascertained from a large sample of children, which included typically developing children and children with attention and learning problems. No child was specifically referred because of motor skill difficulties.

<p>78 comparison children without motor problems on standardized tests of motor function participated in this study.</p>	<ul style="list-style-type: none"> • Parent form of the Child Behavior Checklist • Woodcock–Johnson Psychoeducational Battery–Revised 	<p>level of social problems and a relatively high level of somatic complaints, on the basis of parent report.</p>
<p>Parham (1998)</p> <p>The objective was to investigate the relationship of sensory integrative development to school achievement.</p>	<p>Level II</p> <p><i>Design</i></p> <p>Multivariate longitudinal case-control study</p> <p>2 groups: 32 randomly selected, school-identified, children with learning disabilities and 35 randomly selected children without learning disabilities (age 6–8)</p>	<p>Sensory integrative factors were strongly related to arithmetic achievement at younger ages, and the strength of this association declined with age. The reverse pattern was found for reading: Sensory integration was not significantly related to concurrent reading achievement at younger ages but was related to it at later ages. An unexpected finding was the strength of the relationship of the sensory integrative factors, particularly praxis, to arithmetic achievement.</p>
<p>Rogers, Hepburn, & Wehner (2003)</p> <p>The objective was to examine how early and how well sensory symptoms differentiate autism from other developmental disorders by using various tools to examine the relationship of sensory symptoms with intellectual ability, age, overall severity of autism, and severity of specific symptom clusters associated with autism, and how these sensory symptoms may contribute to the acquisition of adaptive behavior in young children.</p>	<p>Level II</p> <p><i>Design</i></p> <p>Case-control</p> <p>4 groups totaling 102 participants: 26 children with autism, 20 children with fragile X syndrome, 32 children with developmental disabilities of mixed etiology, and 24 typically developing children (21–50 mo)</p>	<p>Differences were detected between the groups for tactile sensitivity, taste–smell sensitivity, underactive–seeks stimulation, auditory filtering, and low energy–weak muscles.</p> <p>Children with fragile X syndrome and children with autism had significantly more sensory symptoms overall than the 2 comparison groups. Both groups were more impaired than the developmentally delayed and typically developing children in tactile sensitivity and auditory filtering. Children with autism were more abnormal in responses to taste and smell than all other groups. Children with fragile X syndrome were more impaired than all other groups in low energy–weak muscles.</p>
<p>A real understanding of sensory symptoms in autism and other disorders will require not only behavior observation and reports but also psychophysiological responses to sensory stimuli.</p>	<p>Nonintervention; observational study</p> <p><i>Outcome Measures</i></p> <ul style="list-style-type: none"> • Short Sensory Profile • Autism Diagnostic Interview–Revised • Autism Diagnostic Observation Schedule • Mullen Scales of Early Learning • Vineland Scales of Adaptive Behavior, Interview Edition 	<p>A significant correlation was found between parent report of sensory symptoms using the Short Sensory Profile and clinician observation of repetitive–restricted behavior symptoms on the Autism Diagnostic Observation Schedule for the group with autism. Finally, abnormal sensory reactivity had a significant relationship with overall adaptive behavior.</p>

Note. DCD = developmental coordination disorder.

everyday performance of areas of occupation. Examining actual demonstrated performance in areas of education, play, ADLs, and social participation and correlating that performance to specific problems in sensory integration and sensory processing will add to our understanding. This understanding will likely differ among clinical groups (e.g., autism vs. DCD); thus, it will be important to systematically conduct studies within and among various clinical groups. Moreover, researchers should more clearly elucidate the relationship between subtypes of sensory processing (hyporesponsive, hyperresponsive, sensory-based motor disorders) and the differential effect on occupational performance. For example, if research demonstrates that children with sensory overresponsive patterns and sensory-related motor disorders have more difficulty with social participation and ADL performance than children with underresponsive patterns, therapists can target these areas of occupation during assessment and intervention. With this information, occupational therapy practitioners could use the evidence to directly translate to practical application that discriminates which interventions work best for specific populations and what outcomes need to be targeted.

Limitations

Limitations of the studies incorporated into the review include lack of randomization, lack of control group, small sample sizes, use of parent-report measures, and minimal use of functional performance measures to examine differences between typically developing children and children with difficulties processing and integrating sensory information. In addition, for children with dyspraxia, DCD, or other sensory-based motor disorders, it was not possible to tease out the sensory and motor contributions to the participation difficulties found. Thus, the interpretations of this aspect of the literature may be limited.

Few articles examined demonstrated functional performance versus test scores as outcome measures. Researchers should conduct studies with children and adolescents who have difficulties processing and integrating sensory information to describe functional performance deficits on measures related to (1) actual demonstrated performance; (2) measures of participation in home, school, and community activities; and (3) assessments that have a functional component that directly applies to key areas of occupation, such as the School Function Assessment (Coster, Deeney, Haltiwanger, & Haley, 1998) or the AMPS. Inherent limitations of the Level IV and V studies include lack of any comparison group or participants who limit generalizability; use of subjective assessment measures that provide description but do not have good psycho-

metrics; and, similar to Level II and III articles, a lack of relating functional performance to sensory processing issues. As researchers more clearly differentiate sensory processing patterns, it will be imperative to include functional behavior and demonstrated performance measures to understand the effect of difficulty processing and integrating sensory information in the daily lives of these children and adolescents. This systematic review demonstrated the effects that difficulties processing and integrating sensory information have on all areas of occupation. By addressing problems in sensory integration and processing, occupational therapy practitioners can have a direct impact on children's or adolescents' ability to engage in play, school, and functional ADLs. ▲

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