Methodology for the Systematic Reviews of Occupational Therapy for Children and Adolescents With Difficulty Processing and Integrating Sensory Information

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Systematic reviews of literature relevant to children and adolescents with difficulty processing and integrating sensory information are important to the practice of occupational therapy in this area. This article explains the five questions that were developed and served as the focus for these reviews: neuronal plasticity, subtyping, sensory integration and non–sensory integration occupational therapy interventions, and occupational performance for this population. Presented are the background for the reviews; the process followed for each question, including search terms and search strategy; the databases searched; and the methods used to summarize and critically appraise the literature. The final number of articles included in each systematic review, a summary of the results of the review, the strengths and limitations of the review, and implications for practice, education, and research are described.


Evidence-based practice (EBP) has been one approach to effective health care delivery since the early 1990s. Spurred on by the demands of payers, regulators, and consumers, occupational therapists and occupational therapy assistants are eager to provide effective services that are client centered, supported by evidence, and delivered in an efficient and cost-effective manner.

At the same time, many occupational therapists and occupational therapy assistants are challenged to understand how to use the best available evidence to inform their practice. Many practitioners did not acquire critical appraisal skills while in school; others have acquired the skills but are still not confident in them. For members of both groups, taking steps to review practice-oriented literature on their own is a challenge. In addition, limited access to electronic databases and system-level constraints, such as lack of time and management support, further limit practitioners’ ability to search, retrieve, and appraise evidence from the published literature that could be useful to their practices.

Since 1998, the American Occupational Therapy Association (AOTA) has instituted a series of EBP projects to assist members in meeting the challenge of finding and reviewing the literature to identify evidence and in turn use the findings from the evidence to inform practice (Lieberman & Scheer, 2002). Following the evidence-based philosophy of Sackett, Rosenberg, Gray, Haynes, and Richardson (1996), AOTA’s projects are conducted on the basis of the principle that the EBP of occupational therapy relies on the integration of information from three sources: (1) clinical experience and reasoning,
(2) preferences of clients and their families, and (3) findings from the best available research.

A primary focus of AOTA’s EBP projects is an ongoing program of systematic review of multidisciplinary scientific literature using focused questions and standardized procedures to identify practice-relevant evidence and discuss its implications for practice. Systematic reviews of literature relevant to children and adolescents with difficulty processing and integrating sensory information strengthen our understanding of the foundations of this important area of practice.

Background
In May 2004, a motion was presented to the AOTA Representative Assembly (RA) to establish a task group for the purpose of developing a professionally published information packet to highlight the benefits of using a sensory integration (SI) approach for occupational therapy practitioners working in schools and other settings. This packet was to support the use of SI in practice and to provide support to occupational therapy practitioners and families of children with difficulty processing and integrating sensory information when faced with payment and reimbursement challenges. Subsequently, the motion was revised by the RA, calling for an evidence-based literature review of the efficacy of SI interventions. The RA passed the amended motion during its meeting at the May 2004 AOTA annual conference, and the review was integrated into AOTA’s Evidence-Based Literature Review Project.

In August 2004, Carolyn Baum, AOTA president, expanded the RA motion to include evidence related to the basic sciences (e.g., neuroscience), social sciences, occupational science, and studies of clinical effectiveness. The intent was to ensure that the review provided the breadth and depth needed to guide present and future occupational therapy practitioners, researchers, and educators working in their respective areas. The working title of the project became “AOTA Evidence-Based Literature Review of Occupational Therapy for Children and Adolescents With Sensory Processing Disorder/Sensory Integrative Dysfunction.” Six questions were developed for intervention, synthesis, and interpretation of the findings. The comments were compiled, and the rank order of the questions with respect to their importance to the profession. In addition, advisory group members were encouraged to solicit feedback from other content experts.

The comments were compiled, and the rank ordering was tabulated. As a result of the comments, the environment–context question was combined with the intervention question because the literature was believed to be overlapping and one question would be sufficient. A decision was also made to eliminate the assessment question and target the reviews on intervention, neuroscience, and performance. During and after this review process, content and research experts were contacted regarding their interest in participating in this project as review authors for an individual focused question. During discussions with the experts, it was recognized that two distinct questions might be appropriate to examine the effectiveness of occupational therapy interventions for children with difficulty processing and integrating sensory information. One question would examine interventions using an SI approach, and the second would examine non-SI interventions. This approach was taken not only to better manage what might have become a large volume of literature but also to ensure that all perspectives of the question were covered adequately and appropriately. As an outcome of discussions with the advisory group and experts in the field, the following questions resulted.

These questions guided the selection of research studies for the review, synthesis, and interpretation of the findings:

1. **Neuroscience**: What is the neurophysiologic evidence that using a sensory-based approach in occupational therapy with children and adolescents will be effective?

2. **Neuroscience–subtyping**: What is the evidence for the existence of different types of SI and sensory processing problems in children and adolescents?

3. **Occupational therapy SI intervention**: What is the effectiveness of SI interventions (including the effect of context) to create, promote, establish, restore, maintain, modify, and prevent future limitations in activities of daily living (ADLs), instrumental activities of daily living (IADLs), education and transition, play and leisure, and social participation in children and adolescents whose sensory processing patterns are interfering with everyday life participation?

4. **Occupational therapy non-SI intervention**: What occupational therapy interventions (including the effect of context) are effective to create, promote, establish, restore, maintain, modify, and prevent future limitations
in ADLs, IADLs, education and transition, play and leisure, and social participation in children and adolescents whose sensory processing patterns are interfering with everyday life participation?

5. Occupational performance: What kinds of difficulties do children and adolescents with problems in SI and sensory processing demonstrate in ADLs, IADLs, education, work and transition, play and leisure, and social participation?

Method

Databases and sites searched included Medline, PsycInfo, CINAHL, ERIC, BIOSIS Previews, Science Citation Index, Social Science Citation Index, RehabData, and OTSeeker. In addition, consolidated information sources, such as the Cochrane Database of Systematic Reviews and the Campbell Collaboration, were included in the search. These databases are peer-reviewed summaries of journal articles and provide a system for clinicians and scientists to conduct evidence-based reviews of selected clinical questions and topics. Moreover, reference lists from articles included in the systematic reviews were examined for potential articles, and selected journals were hand searched to ensure that all appropriate articles could be included.

Search terms for the review were developed by the consultant to the AOTA Evidence-Based Literature Review Project and AOTA staff in consultation with the authors of each question and reviewed by the advisory group. The search terms were developed not only to capture pertinent articles but also to make sure that the terms relevant to the specific thesaurus were included. A medical research librarian with experience in completing systematic review searches conducted all searches and confirmed and improved the search strategies. In addition, a filter based on one developed by McMaster University (see www.urmc.rochester.edu/hsl/miner/digital_library/evidence_based_resources.cfm) was used to narrow the search to research studies. In addition to these general steps, procedures specific to each question are described in the following paragraphs.

Inclusion and exclusion criteria are critical to the systematic review process because they provide the structure for the quality, type, and years of publication of the literature incorporated into a review. The review of all five questions was limited to the peer-reviewed scientific literature published in English. The review also included consolidated information sources such as the Cochrane Database of Systematic Reviews, Except as described here, the literature included in the review was published between 1986 and 2006. The review excluded data from presentations, conference proceedings, non–peer-reviewed research literature, research reports, dissertations, and theses.

The search terms for Question 1 (neuroscience) included neuronal plasticity or neuroplasticity or neural plasticity (limited to humans) PLUS sensory systems (vision, tactile, auditory, olfactory, gustatory, proprioception, vestibular, temperature) PLUS diagnoses (attention deficit hyperactivity disorder OR ADHD, autism, brain injury, stroke, learning disabilities, nonverbal learning disabilities, developmental coordination disorder). Studies were limited to those that included the following measures: fMRI, MRI, EDR, EDA, skin conductance, and EEG. In addition, the publication lists of authors of classic animal studies were also reviewed. Animal studies of these authors were included if the study focused on neuroplasticity, and the article was included in the review regardless of publication date. Authors included in the review were P. Bach-y-Rita, E. L. Bennett, C. Corman, M. C. Diamond, D. E. Feldman, T. Field, W. E. Fordyce, F. Gage, W. T. Greenough, T. K. Hensch, D. H. Hubel, G. Kemperman, B. Kolb, N. J. Lenn, M. M. Merzenich, T. L. Petit, M. R. Rosenzweig, L. Rosselli-Austin, J. L. Rubenstein, M. P. Stryker, H. M. van Praag, R. N. Walsh, and T. N. Wiesel. The citations of 2,499 human studies and 1,658 animal studies were reviewed, for a total of 4,157 citations. Sixty-six articles were initially reviewed, and 50 were incorporated into the systematic review presented in this issue.

The neuroscience–subtyping (Question 2) and performance questions (Question 5) both used the same search terms to identify and capture applicable articles: discrimination (sensory, tactile, visual/spatial, proprioceptive and auditory), dyspraxia, emotional regulation, hypersensitivity, hypotonia, oversensitivity, oversensitivity, postural disorder, sensation seeking, sensorimotor or sensory motor, sensory based motor disorder, sensory defensiveness, and undersensitivity. The results for several of the search terms (discrimination, hypersensitivity, hypotonia, sensation seeking, sensorimotor, and sensory motor) were limited to those articles pertaining to diagnostic categories included in the intervention questions. A complete list of diagnostic categories and clinical conditions is included in Table 1. Five hundred forty citations were reviewed for subtyping (Question 2) and performance (Question 5). For subtyping (Question 2), 95 articles were retrieved, and 57 were included in the final selection and review process.

The occupational performance review (Question 5) was completed, in part, as an academic partnership between the review author and AOTA staff and consultant. The review author worked on the review with a group
of entry-level master’s students for a project to fulfill requirements for a capstone research course. Although the 540 citations cited previously provided the initial group of articles for the review, later searches through 2008 yielded additional citations. Other later modifications to the search strategy were the inclusion of articles specifically on developmental coordination disorder because it is frequently used as a synonym for dyspraxia, and the limitation of articles on performance issues in autism spectrum disorder to those studies incorporating a measure of sensory performance.

Selected articles met the following inclusion criteria:
- Participants demonstrated (through observation or assessment) limitation in occupational performance.
- A comparison group included participants with relevant diagnostic categories or a sensory processing deficit affecting performance.
- Descriptive articles included data on performance deficits in areas of occupation.

Studies were excluded that either lacked an occupational performance component or an assessment of occupational performance. Thirty-five articles were included in the systematic review on performance.

The search terms for Questions 3 and 4 for the systematic reviews of occupational therapy interventions using SI and non-SI approaches interventions are listed in Table 1. Studies of intervention effectiveness were included if the intervention described was within the domain of occupational therapy, although it did not have to be a common occupational therapy intervention or administered by an occupational therapist or occupational therapy assistant. The following inclusion criteria were specific to this review. Participants in the intervention study were 2 age 21. The search was limited to 1996–2006, but earlier systematic reviews and classic articles that may or may not have been incorporated into a systematic review were also included. In addition, selected articles published in 2007 were recommended by experts in the field and were included in the review. A total of 1,079 citations were reviewed. Twenty-seven articles were included in the systematic review of SI approaches, and 20 articles (reporting on 21 studies) were included in the review of non-SI intervention approaches.

The teams working on each focused question reviewed the articles according to their quality (scientific rigor and lack of bias) and levels of evidence. AOTA uses a grading system for levels of evidence based on standards from evidence-based medicine. This system standardizes and ranks the value of scientific evidence for biomedical practice using the grading criteria in Table 2. The highest levels of evidence are produced by studies that are systematic reviews of the literature, meta-analyses, and randomized controlled trials. Systematic reviews and meta-analyses are literature reviews that identify high-quality evidence.

### Table 1. Search Terms for Occupational Therapy Sensory Integration (SI) and Non-SI Intervention Systematic Reviews

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<tr>
<th>Category</th>
<th>Search Terms</th>
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<tr>
<td>Diagnoses and clinical conditions included</td>
<td>Children with handwriting problems; clumsy child syndrome; developmental coordination disorder; disorder of attention, motor, and perception; developmental dyspraxia; fine motor deficits; gross motor deficits; learning disabilities; perceptual motor deficits; sensory integrative dysfunction; sensory modulation disorder; sensory modulation dysfunction; sensory motor deficit; sensory processing disorder</td>
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<tr>
<td>Diagnoses and clinical conditions (only if a sensory motor/perceptual–motor component is included in the study)</td>
<td>Attention deficit disorder, attention deficit hyperactivity disorder, autism spectrum disorder (including autism, Asperger syndrome, and pervasive developmental disorder), deprivation—sensory deprivation (excluding deafness and blindness), dyslexia, fragile X syndrome, fetal alcohol syndrome, learning disabilities, prematurity, specific language disorder</td>
</tr>
<tr>
<td>Diagnoses and clinical conditions excluded</td>
<td>Acquired brain injury, cerebral palsy, childhood stroke, deafness or blindness, mental retardation, regulatory disorder, seizure disorders, spina bifida, stroke, traumatic brain injury</td>
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<tr>
<td>Interventions</td>
<td>Activities of daily living (also self-care and instrumental activities of daily living), activity, activity groups, adaptive behavior, antisocial behavior, assistive technology, attention, augmentative communication, behavior modification, behavioral interventions (e.g., applied behavioral analysis—Lovaas, discrete trial training), comprehensive behavioral programs (e.g., Treatment and Education of Autistic and related Communication Handicapped Children, Learning Experiences—An Alternative Program for Preschoolers and Parents, consultation, cooperative behaviors, decision-making skills training, environmental modification, executive function, exercise, family coping and coping skills, floor time, friendship, functional approaches, handwriting, intervention, job training, massage, natural environment intervention, neurodevelopmental treatment, neuromotor occupational therapy, oral sensorimotor programs, parent and teacher mediated, perceptual motor learning, peer group, peer interaction, peer-mediated, play, prevocational, priming, problem-solving skills training, relationship-based intervention, routines-based interventions, sensory diet, SI, sensory integrative, social competence, social participation, social skills training, social stories, tactile stimulation, therapeutic listening and auditory integration training, time management, token economy, touch pressure, transitioning, vestibular stimulation, weighted vests and weighted materials, Wilbarger protocol, work</td>
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relevant to a given question and appraise and summarize that evidence. In randomized controlled trials, the outcomes of an intervention group are compared with the outcomes of a control group, and participation in either group is determined randomly. The systematic reviews included Level I studies, which are randomized controlled trials, meta-analyses, and systematic reviews; Level II studies, in which assignment to a treatment or a control group is not randomized (cohort studies); Level III studies, which use one-group pretest–posttest or before–after designs; Level IV studies, which use a single-case experimental design, sometimes reported over several participants; and Level V studies, which include case reports and expert opinion such as narrative literature reviews and consensus statements. In addition, two qualitative studies were included in the occupational performance review. Each article included in the review was then abstracted using an evidence table that provides a summary of the methods and findings of the article and an appraisal of the strengths and weaknesses of the study on the basis of design and methodology. Review authors also completed a Critically Appraised Topic (CAT), a summary and appraisal of the key findings, clinical bottom line, and implications for occupational therapy of the articles included in the review for each question. AOTA staff and EBP project consultants reviewed the evidence tables and CATs to ensure quality control. All review authors were either doctoral-level trained occupational therapists with expertise in the content area examined by the focused question or graduate students or master’s-level trained occupational therapists under the guidance and direction of the review author.

Summary of the Review and Implications for Practice, Research, and Education

The results of the group of systematic reviews published in this issue of AJOT provide important information for those working with children and adolescents with difficulty processing and integrating sensory information. By reviewing the scientific literature broadly and appraising and synthesizing specific studies, the authors have been able to provide up-to-date answers to critical questions that may have previously been answered only on the basis of clinical expertise. Results of the systematic review indicate, for example, that children and adolescents with difficulty processing and integrating sensory information have problems that limit their performance in occupations taking place in a variety of environments. Evidence for performance difficulties was found, for example, for social participation, IADLs, ADLs, and school function. Although occupational therapy practitioners with expertise in this area have long been aware of these challenges and the effect on their clients, having the evidence to inform and guide their practice is critical. Support from the scientific literature is valuable when communicating to family members and outside audiences, such as payers, teachers, physicians, and administrators. One may use this information when advocating for occupational therapy services to an outside payer or providing information and support to a parent expressing concern with a child’s participation in daily activities at home and at school.

Although some evidence supports the existence of subtypes of sensory integrative dysfunction/sensory processing disorder, evidence in the published literature is somewhat limited. The evidence is stronger, however, that there are differences in sensory processing and SI within diagnostic categories (e.g., ADHD, developmental coordination disorder). From a clinical perspective, this finding indicates that occupational therapists working with children and adolescents with difficulty processing and integrating sensory information not only must be familiar with global measures of sensory processing but also need to understand the specific sensory processing challenges for the diagnostic groups of children with whom they work. In turn, this familiarity will allow occupational therapists to provide a more comprehensive assessment of children and adolescents in their practice. Future research in this area would also benefit from this approach.

The review of the animal and human literature reveals strong evidence of plasticity in the nervous system. There is also strong evidence that sensory input is a mediator for this

<table>
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<th>Levels of Evidence</th>
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<td>Level I</td>
<td>Systematic reviews, meta-analyses, randomized controlled trials</td>
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<tr>
<td>Level II</td>
<td>Two groups, nonrandomized studies (e.g., cohort, case–control)</td>
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<tr>
<td>Level III</td>
<td>One group, nonrandomized (e.g., before and after, pretest and posttest)</td>
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<tr>
<td>Level IV</td>
<td>Descriptive studies that include analysis of outcomes (e.g., single-subject design, case series)</td>
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<tr>
<td>Level V</td>
<td>Case reports and expert opinion that include narrative literature reviews and consensus statements</td>
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Note. From Sackett et al. (1996).
plasticity, and there is evidence that motor activity also contributes to plasticity. Although no evidence, however, supports that occupational therapy using an SI approach directly results in neuroplasticity in animals or humans, the scientific literature provides indirect support for neuroplasticity resulting from an SI approach that incorporates meaningful activity. The evidence indicates that this active engagement may be most effective when activities tap into more than one sensory processing system and when the interventions involve self-initiated adaptation to challenges as opposed to teaching a specific activity. It is imperative that all occupational therapy practitioners have a thorough understanding of the literature to provide appropriate interventions to their clients.

The systematic reviews of SI and non-SI interventions for children and adolescents with difficulty processing and integrating sensory information indicate that there is promise for both types of interventions. Although present the evidence for occupational therapy interventions other than SI is stronger, particularly for performance-oriented approaches based on contemporary motor learning theories, the diagnostic categories to which this intervention can be applied are somewhat limited. The heterogeneity to which SI interventions have been studied is both a strength and a limitation of the research. The review of this literature indicates that motor skill development is the outcome most consistently improved by SI intervention. Recent research efforts in SI interventions have attempted to resolve some of the problems of early studies in this area. The more recent work emphasizes fidelity to assessment and treatment and use of an occupation-based and client-centered approach. The implications of the results of these reviews for occupational therapy practice indicate that both SI and non-SI approaches are valuable for children and adolescents experiencing challenges in occupational performance that result from difficulties in processing and integrating sensory information.

**Strengths and Limitations of the Review**

A total of 198 articles were included in the review of the five focused questions. The review was broad, incorporating not only evidence regarding intervention effectiveness but also evidence on neuroscience, subtyping, and performance issues for children and adolescents with difficulty processing and integrating sensory information. Although the review included published literature from occupational therapy and related fields, all studies provided evidence within the scope of occupational therapy practice. One hundred forty-one (71%) of the articles were at Level I or Level II, indicating that the review incorporated evidence at the highest levels.

Although the limitations of each review are discussed in greater detail in the articles, several overarching limitations pertain to the reviews. Several of the studies in all five systematic reviews had small sample sizes, which reduced the power of the statistical analysis. In addition, there was a lack of blinding, and group (both intervention and control) characteristics were frequently not described in enough detail to allow for replication. In some studies, it was difficult to distinguish the intervention and control groups because of their similarity. Many studies included in the reviews did not control for medication use, and variations in medication use by participants may have affected the results. Outcomes were based on parent report in several studies, and the variety of outcome measures used in the studies may make it difficult to group the results of studies. Where heterogeneous populations have been noted, the authors indicated that the results must be interpreted with caution. In addition, studies that included a select or limited diagnosis could reduce the generalizability to other populations. Studies at lower levels of evidence lacked randomization and a control group, making it difficult to generalize results to other samples.

The systematic reviews presented in this issue provide summaries of the best scientific literature to answer the focused questions. Strategies for the future indicate that researchers should build on existing studies. Whether scientists are engaging in basic science or clinical research, they need to be familiar with the most recent work to incorporate it into future research plans. For example, the use of fMRI and other technologies have permitted researchers to use human participants to study neuroplasticity noninvasively, in ways that were not possible previously. It is clear that more work is needed to definitively answer the five questions included in this project. Although some future research can be conducted in isolation, research questions in this area are often complex and may be best answered through collaborative research with other disciplines, such as neuroscience, psychology, education, and neurology. In addition, researchers should collaborate with clinicians when planning and conducting well-controlled research projects. Future research also needs to place more emphasis on the adolescent population because this review included few studies examining this group.

The future of our profession is based on all occupational therapy practitioners’ developing a firm grasp of the best available evidence. This agenda is also clear for academic programs training the next generation of occupational therapy practitioners. Educators need to be
aware of the results of the systematic reviews and present this multifaceted information to students. Whether teaching neuroscience or pediatric assessment and intervention, one must incorporate all results into the curriculum rather than focus on a favored perspective. The findings discussed in this series of articles fit seamlessly within an occupation-based and client-centered approach.

Although the results of these systematic reviews have wide-ranging implications for occupational therapy, the ultimate target audiences are children with difficulty processing and integrating sensory information and their families who struggle with participation in everyday activities at school, at home, and in the community. ▲

References