

OCCUPATIONAL THERAPY USING A SENSORY INTEGRATIVE APPROACH FOR CHILDREN WITH DEVELOPMENTAL DISABILITIES

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This article provides an introduction and overview of sensory integration theory as it is used in occupational therapy practice for children with developmental disabilities. This review of the theoretical tenets of the theory, its historical foundations, and early research provides the reader with a basis for exploring current uses and applications. The key principles of the sensory integrative approach, including concepts such as "the just right challenge" and "the adaptive response" as conceptualized by A. Jean Ayres, the theory's founder, are presented to familiarize the reader with the approach. The state of research in this area is presented, including studies underway to further delineate the subtypes of sensory integrative dysfunction, the neurobiological mechanisms of poor sensory processing, advances in theory development, and the development of a fidelity measure for use in intervention studies. Finally, this article reviews the current state of the evidence to support this approach and suggests that consensual knowledge and empirical research are needed to further elucidate the theory and its utility for a variety of children with developmental disabilities. This is especially critical given the public pressure by parents of children with autism and other developmental disabilities to obtain services and who have anecdotally noted the utility of sensory integration therapy for helping their children function more independently. Key limiting factors to research include lack of funding, paucity of doctorate trained clinicians and researchers in occupational therapy, and the inherent heterogeneity of the population of children affected by sensory integrative dysfunction. A call to action for occupational therapy researchers, funding agencies, and other professions is made to support ongoing efforts and to develop initiatives that will lead to better diagnoses and effective intervention for sensory integrative dysfunction, which will improve the lives of children and their families. © 2005 Wiley-Liss, Inc. MRDD Research Reviews 2005;11:143-148.

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Occupational therapy with a sensory integration approach (OT/SI) is designed to guide intervention for children who have significant difficulty processing sensory information, which restricts participation in daily life activities. The theory of sensory integration was developed by A. Jean Ayres [Ayres, 1972, 1979, 1989], an occupational therapist with postdoctoral training in educational psychology and neuroscience. Guided by her roots in the clinical field of occupational therapy (OT), Ayres developed the theory of sensory integration to explicate potential relationships between the neural processes of receiving, modulating, and integrating sensory input and the resulting output: adaptive behavior. The theory postulates that adequate processing and integration of sensory

information is an important substrate for adaptive behavior. Given its focus on adaptive behavior and functional skills, this approach is most frequently utilized by occupational therapists as part of a total program of occupational therapy. The goal of intervention is to improve the ability to process and integrate sensory information and to provide a basis for improved independence and participation in daily life activities, play, and school tasks.

HISTORICAL PERSPECTIVES AND NEUROBIOLOGICAL ROOTS

Ayres' work was prompted by her clinical observations of children with learning disabilities, many of whom she noted displayed perceptual, sensory, and motor difficulties. Hypothesizing that "learning is a function of the brain [and] learning disorders . . . reflect some deviation in neural functions [Ayres, 1972]," Ayres developed a theoretical model, the theory of Sensory Integration (SI). This theory, based on principles from neuroscience, biology, psychology, and education, hypothesizes that some children with learning disorders experience difficulty processing and integrating sensory information and that this, in turn, affects their behavior and learning. She theorized that the behavior and learning problems were, in part, due to faulty integration of sensory information and inability of higher centers to modulate and regulate lower brain sensory-motor centers [Ayres, 1972].

The theory is based on principles from neuroscience, developmental psychology, occupational therapy, and education: 1) sensorimotor development is an important substrate for learning; 2) the interaction of the individual with the environment shapes brain development; 3) the nervous system is capable of change (plasticity); and 4) meaningful sensory-motor activity

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is a powerful mediator of plasticity. Although new findings and knowledge demonstrate that the nervous system is even more complex and integrated than Ayres and others believed at the time, many of the principles that Ayres built the theory of sensory integration upon are still held in high regard. This knowledge has been strengthened by research demonstrating that structural, molecular, and cellular changes in neural functions are possible and that meaningful sensory motor activities can be mediators of plasticity [Merzenich et al., 1984; Greenough et al., 1987; Kandel and Jessell, 1995; Kempermann and Gage, 1999; McKenzie, et al., 2003].

To examine and field test her theory of SI, Ayres created a battery of tests, the Southern California Sensory Integration tests, which evaluated sensory processing, sensory motor, and perceptual motor skills. Using these tests, she conducted a number of cluster and factor analytic studies to further define the theory. She found clusters of symptoms that fell into meaningful patterns that described clinical samples of the children, which served to guide intervention strategies [Ayres, 1979, 1989]. For example, a factor termed "developmental dyspraxia" was consistently identified in children who seemed to have difficulty creating ideas for, planning, and carrying out new motor activities and processing tactile and other somatosensory information.

THE SENSORY INTEGRATIVE APPROACH

Professionals who use the sensory integrative approach follow a set of principles, based on sensory integration theory, that guide the therapists' clinical reasoning skills. These principles are operationalized in therapy to include concepts such as "Active Sensory-Motor Experiences," "the Just Right Challenge," "the Adaptive Response," "Active Participation," and "Child-Direction." These principles are further defined and delineated in Table 1. The intervention is unique in that it addresses the underlying substrates of dysfunction rather than just the functional difficulties itself. Ayres [1972] states:

A sensory integrative approach to treating learning disorders differs from many other approaches in that it does not teach specific skills. . . . Rather, the objective is to enhance the brain's . . . capacity to perceive, remember, and motor plan [as a basis for learning]. . . . Therapy is considered a supplement, not a substitute to formal classroom instruction. . .

Therapy provides opportunities for engagement in sensory motor activities rich in tactile, vestibular, and propriocep-

Table 1. Key Principles of the Sensory Integrative Approach

| Principle | Description |
|-----------------------|--|
| Just Right Challenge | The therapist creates playful activities with achievable challenges; the activities incorporate a challenge but the child is always successful. |
| The Adaptive Response | In response to the Just Right Challenge, the child adapts their behavior with new and useful strategies, thus furthering development |
| Active Engagement | The therapist's artful creation of challenging, yet playful, sensory-rich environments entice the child to participate actively in play; the methods of play incorporate new and advanced abilities that increase the child's repertoire of skills and processing. |
| Child Directed | The therapist constantly observes the child's behavior and reads their behavioral cues, thus following the child's lead or suggestions. The therapist uses the child's cues to create enticing, sensory-rich activities. |

tive sensations. The therapeutic environment is designed to tap into the child's inner drive to play. The therapist uses keen observation skills to observe and interpret the child's behaviors and interests and then creates a playful environment in which the child actively pursues achievable challenges [Bundy et al., 2002; Kimball, 1993; Smith-Roley and Spitzer, 2001; Schaaf and Smith-Roley, in press]. For example, occupational therapy using a sensory integrative approach for a child with developmental dyspraxia and poor body awareness might include facilitating the child climbing across a low platform to access a large area filled with colorful balls (ball pit), then completing an unfamiliar obstacle course that consists of climbing up a rope ladder attached to the wall, jumping into large pillows that have a variety of textures, and then pulling him/herself out of the pillows using a rope attached to the opposite wall. Thus, the child is guided through challenging and fun activities designed to stimulate and integrate sensory systems, challenge their motor systems, and facilitate integration of sensory, motor, cognitive, and perceptual skills.

Astute observation of the child's ability to process and utilize sensory information during these playful activities is a key skill of therapists trained in the sensory integrative approach and a feature that distinguishes this approach from others. The therapist observes the child's responses during the activity and increases or decreases the sensory and motor demands to create a challenging and therapeutic environment. In keeping with the theory, goals and progress are recorded in the observable changes in the child's ability to participate in sensory-based activities, regulate arousal level, improvement in sensory motor skills, and

improvement in ability to participate independently in daily life activities. In addition to direct intervention with the child, the therapist interacts and collaborates with parents, teachers, and others who are involved with the child to 1) help them understand the child's behavior from a sensory perspective, 2) adapt the environment to the needs of the child, 3) create needed sensory and motor experiences throughout their day in their natural environments, and 4) assure that therapy is helping the child become more functional in their daily life activities.

USEFUL POPULATIONS FOR THE SI APPROACH

Although the original theory was developed for children with learning disabilities, Ayres recognized the utility of the theory for other clinical populations. For example, Ayres and Tickle [1980] applied the theory to children with autism and noted that it helped decrease tactile and other sensitivities to stimuli that interfere with their ability to play, learn, and interact. Since that time, sensory integrative principles have also been applied to various populations, including infants born at risk and/or with regulatory disorders, children with autistic spectrum disorders, fragile X syndrome, attention deficit disorder (ADHD) [Ogibene, 2002], and children from environmentally deprived situations [Cermack, 2001].

A high frequency (80-90%) of sensory processing problems are reported in children with autism spectrum disorders [Ornitz; 1974; O'Neill and Jones, 1997; Kientz and Dunn, 1997; Huebner, 2001]. Poor sensory processing may contribute to the maladaptive behavioral profile of these children and impact on their ability to participate in social,

school, and home activities [Anzalone and Williamson, 2000; DeGangi, 2000; Schaaf et al., 2002]. Children with autism often demonstrate extreme aversion to or excessive seeking of sensory stimuli, avoidance of noisy situations, unusual preoccupation with smells or visual stimuli, or fearfulness of typical activities that involve touch, sounds, and movement [Kientz and Dunn, 1997; Huebner, 2001; Mailloux, 2001; Mailloux and Smith Roley, 2001]. Whether these aberrant behaviors arise as a mechanism to maintain arousal [Ayes, 1979; Ornitz, 1989], to limit distraction to other stimuli, or because the children are self-absorbed by sensation, the net effect is limitation of the child's ability to participate in school, home, and play activities with their family and peers. Self-reports from individuals on the autistic spectrum confirm these findings and are powerful in terms of describing the impact of sensory dysfunction on participation in daily life activities [Williams, 1992, 1994; Grandin, 1995; O'Neill and Jones, 1997]. These descriptions portray how over- or underresponsiveness to the typical sensations of daily life pervade behavior and limit the individual's ability to participate fully in society. For example, Grandin [1995], a high-functioning individual diagnosed with autism, articulates how her unusual processing of auditory, visual, and tactile information makes it difficult for her process more than one stimulus simultaneously, which impacts her ability to socially interact. As a result, she does not enjoy or participate in many typical activities with others.

UPDATES IN THEORY AND PRACTICE

Since its conception in the late 1960s, Ayres' original theoretical principles have been extended, updated, and advanced based on advancements in science and clinical practice. One recent development is the proposed grouping of SI into three classic patterns, each of which consist of several subtypes: Sensory Modulation Disorder, Sensory Discrimination Disorder, and Sensory-based Motor Disorders as demonstrated in Figure 1. The authors suggest that delineating these subtypes is crucial so that homogenous groups may be identified to guide intervention and research related to describing the phenotypes of sensory processing disorder and evaluating the effectiveness of intervention with this population.

The pattern of poor sensory modulation has been most frequently discussed in the literature. Defined as "a

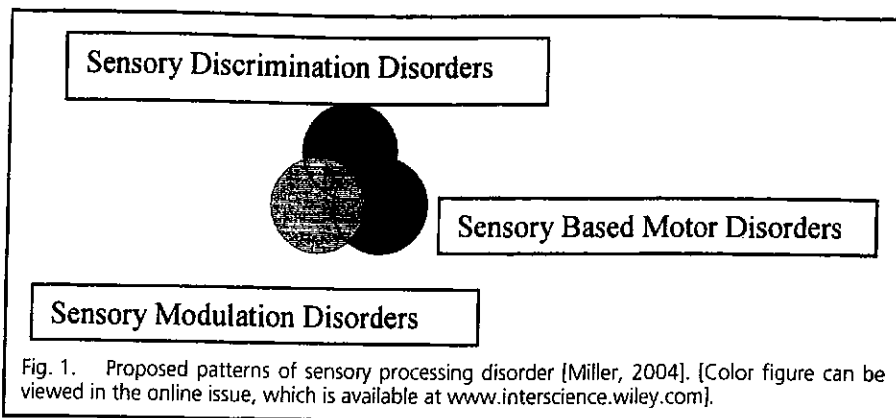


Fig. 1. Proposed patterns of sensory processing disorder [Miller, 2004]. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com].

problem in the capacity to regulate . . . response to sensory input in a graded . . . manner. . . [that] disrupts ability to achieve and maintain an optimal range of performance necessary to adapt to challenges in life" [Miller and Lane, 2000], children with poor sensory modulation are reported to over or underrespond to normal levels of stimuli in their environment. Efforts at screening for poor sensory modulation have been made easier by the Sensory Profile [Dunn, 1999a, 1999b], The Infant Toddler Sensory Profile [Dunn, 2002], and the Adult Sensory Profile [Brown and Dunn, 2002]. These tools are parent/self questionnaires that describe responses to sensation during daily life activities.

In an effort to identify the underlying mechanisms of poor sensory modulation, Miller, et al. [2005] completed a series of studies examining autonomic nervous system functioning in children with poor sensory modulation. They have shown that children with severe hyperresponsivity and Fragile X syndrome have markers of sympathetic dysfunction evidenced by electrodermal activity with significantly increased amplitudes, more frequent responses, and less habituation than matched controls [Miller et al., 1999]. They also studied children with poor sensory modulation and no other developmental diagnosis identified clinically. These children also showed significant markers of sympathetic dysfunction [McIntosh et al., 1999]. In addition to sympathetic markers of sensory dysfunction, parasympathetic markers have been evaluated [Schaaf et al., 2003], suggesting that the functioning of the sympathetic and parasympathetic systems should be considered together when trying to understand the contribution of the autonomic nervous system to poor sensory modulation. Studies of children diagnosed with attention deficit disorders showed a range of responses in regard to sensory processing

with about two-thirds of the sample showing symptoms of poor sensory processing [Mangeot et al., 2001]. Approximately 40% of the sample of children with poor sensory modulation also had symptoms of attentional deficits [Ahn et al., 2004]. This population had different sympathetic markers of sensory reactivity [Roley, et al., 2005] and decreased response inhibition in the presence of normal sensory habituation [Ognibene, 2002].

The most recent contribution to practice and to advance research is the efforts of the Sensory Processing Disorders Scientific Workgroup [SPD, 2004], a multidisciplinary group of established leaders in developmental psychobiology research. The group is studying diverse aspects of atypical sensory processing, including central metabolic differences using proton magnetic spectroscopy, physiological correlates of early perceptual processing, sensory gating evoked potential (P50) discrimination, and genetic factors that relate to the etiology, for example. Additional research questions posed by this workgroup relate to differences in dopamine D2 receptor binding availability, presynaptic dopamine synthesis, and serotonin receptor availability in SMD, and pharmacological agents for treatment of children with poor sensory processing.

PREVALENCE

Although clinicians and educators have speculated that the prevalence of children affected by poor sensory modulation is high, the true numbers have only recently been appreciated. Miller and colleagues conducted a survey to estimate rates of sensory processing disorders in incoming kindergartners from one suburban U.S. public school district [Ahn et al., 2004]. The Short Sensory Profile, a carefully researched version [McIntosh et al., 1999] of the Sensory Profile parent-report screening tool, was utilized. A conservative estimate of prevalence was

made, assuming that all nonrespondents failed to meet positive criteria for SMD. Approximately 5% of the kindergarten enrollment met screening criteria for sensory processing disorders.

EVIDENCE SUPPORTING THE THEORY, PRINCIPLES, AND PRACTICE OF SI

General knowledge and empirical research are needed to validate a new area of clinical investigation. To develop consensus, a state of "equipoise" (Kuhn Structure of Scientific Revolution) must be reached. Equipoise is a state of agreement within the community for whom the issue has meaning, such as families with children affected, researchers, clinicians, and scholars. To achieve this state, empirical research must be conducted and findings must be generalized to the people who are stakeholders. The researchers and stakeholders build a community based on a consensus of beliefs. An excellent method to generate confidence in a new methodology is by replication of treatment effects.

Currently, efforts to facilitate consensus regarding the merits of OT using a sensory integrative approach are underway. One reason for the lag in this area is that the science of OT is relatively new compared to fields such as psychology and medicine with longer traditions of research and trained scientists. OT is historically a field of service provision, so efforts have mainly focused on practice issues. Many case studies detailing the use and effectiveness of OT using a sensory integrative approach have been published in the peer-reviewed literature with examples of strategies that might have utility for clinicians and for generating hypotheses [Schaaf, et al., 1987; Case-Smith and Bryan, 1999; Linderman and Stewart, 1999; Baranek, 2002; Mulligan, 2003a, 2003b]. As the number of occupational therapists with doctoral level training increases, the availability of research scholars who can implement independent research grows, and the funding for this type of research is expanded, new research to facilitate consensus will expand.

The best route to establishing a consensus is convergence of results from multiple studies and replication [Ziman, 1968]. Public acceptance of the principles of SI also encourages empirical research. For OT/SI this has been supported by several factors. First, individuals affected by autism began to verbalize the impact of poor sensory processing on behavior and function [Grandin, 1986; Williams, 1992, 1994;

Grandin, 1995]. These verbal individuals provided new insight into how sensory over- or underresponsiveness limits their own ability to function effectively in their various roles and daily life activities. They report the importance of intervention strategies to address their own atypical sensory processing. Second, the popular best seller, *The Out of Sync Child* [Kranowitz, 1998], rekindled interest in OT using a sensory integration approach. Parents identified with the descriptions provided in the Kranowitz book and began to seek treatment approaches that addressed sensory issues. They began pushing from the consumer side for services based on a desire to help their child rather than waiting for analysis of scientific evidence.

Although public awareness and acceptance of OT using a sensory integrative approach increased, a tension between the push for services and empirical science supporting this approach remained. Until empirical consensus is reached about the effectiveness of this approach, the practice will not be widely accepted by the broader scientific community, and the consensus will be limited to the therapeutic community. Fortunately, the efforts described in this article are actively working to close the gap between practice and research.

It is interesting to note that, although controversy regarding the effectiveness of OT using a sensory integration approach exists, over 80 studies have been conducted that measure some aspect of the effectiveness of this approach for intervention. About half of the studies demonstrate some type of treatment effectiveness. Two metaanalyses [Ottenbacher, 1982; Vargas and Camilli, 1999] and four research reports [Polatajko, et al. 1992; Arendt et al., 1988; Hoehn and Baumeister, 1994] have been published summarizing these outcome studies. Some of the syntheses concluded that the approach is effective and other syntheses suggest the intervention was equally effective as other approaches.

At this point in time, interpretation of the findings of these 80 studies is difficult due to three methodological limitations. The first key challenge for OT researchers is defining the independent variable (the treatment) in a manner that is replicable. As this intervention approach is individualized (often compared to the way psychotherapy is individualized), standardization of treatment has been a challenge to outcome research. Recent progress to define the intervention has been made by a multisite research group funded by an NIH R21

planning grant. This group completed a thorough review of existing treatment resources and developed a treatment protocol and a "Fidelity to Treatment Measure" to evaluate whether the therapy that is administered is true to the principles established in the literature for the treatment. The Fidelity Scale evaluates constructs related to the intervention provided, details the training of the persons administering the intervention, and specifies the environment in which the treatment is conducted.

A second key challenge to interpreting existing research that evaluates the effectiveness of OT using a sensory integrative approach is 1) dependent measures used in previous research were not related to the purpose of the intervention; 2) researchers did not utilize a theoretical base to explain the how the putative mechanisms of the treatment are measured by the specific outcomes utilized; and 3) multiple outcomes were utilized instead of specifically targeted outcomes to the surmised mechanisms of treatment.

In addition, research has been conducted on "sensory integration" as an isolated modality rather than embedding it in the context of a full OT program [Polatajko et al., 1992] as was originally intended. Ayres always used an occupational frame of reference in providing intervention [Ayres, 1972, 1979, 1989]. This means that the goals of therapy are always functional abilities and routines, include "occupations" of early childhood such as sleeping, eating, dressing, playing, interacting with others, learning, and so on, and embody key concepts such as active participation and the just right challenge. Thus, these studies, while interesting, are not informing the public about OT using a sensory integrative approach. Next, few studies establish a theoretical basis for their hypotheses, citing instead the question, "Does sensory integrative treatment work?," which is a simplistic and atheoretical question. Finally, in existing research many studies use multiple outcome measures with no good explanation of how the outcomes relate to the suspected effects of treatment and utilize [Densem et al., 1989] a "fishing expedition" approach hoping to find *something* that might be statistically significant. The statistical result of this type of study is that the strength of the treatment is likely to be reduced because there is no hypothesis about the relation between the treatment and outcomes. Researchers run the risk of nonsignificant and uninterpretable results [Ottenbacher,

1991], hence some of the findings of nonsignificance are difficult to interpret.

The multisite R21 research team working on the challenge of treatment replication is also working on a systematic way to apply goal attainment scaling (GAS) as a primary outcome measure for effectiveness studies. GAS provides a means to establish intervention goals that are specifically relevant to individuals and their families and that allow comparison of achievement across diverse desired functional outcomes. GAS in combination with physiological outcome measures will provide a method for measuring effectiveness that will increase the integrity, strength, and replicability of future effectiveness studies.

The third key challenge relates to the homogeneity of the samples studied. A limitation of previous studies was the difficulty in defining a homogenous group. The heterogeneity of samples in previous research increased within-group variability and reduced the probability of finding significant group differences. Now with the publication of the Sensory Profiles and the physiological paradigm, the Sensory Challenge Protocol [Miller et al., 1999], which suggests electrodermal activity criteria for inclusion in specific sensory processing subtypes, future studies can define their samples in a manner that allows replication across sites.

The limitations in previous studies result in the absence of consensus in the field regarding the effectiveness of SI interventions. The field is using lessons learned to improve future studies, moving the research forward. Careful examination of the approximately 80 previous studies reveals that important contributions to the study of sensory processing disorder have been made. Given the current level of research, diverse findings are not surprising. This inconsistency is predictable, given the variation in sample characteristics, intervention methods and duration, and outcomes measured. The knowledge base in this field is in its infancy and substantial work is needed before enough rigorous empirical data are available to proffer valid conclusions about the effectiveness of this intervention approach.

In conclusion, significant progress has been made in defining homogenous subgroups for analysis, in describing a replicable treatment, and in choosing valid outcome measures. However, gaps exist in knowledge related to sensory processing disorder and the effectiveness of occupational therapy in ameliorating this condition. Hence, in the field of occupational therapy, we have a clear and

exciting challenge to action. The field offers tremendous promise. Studies are underway to elucidate the underlying mechanisms of the impairment, to define the phenotypic characteristics of the disorder, to discriminate the disorder from other developmental disorders (e.g., ADHD and autism), and to evaluate the effectiveness of OT services in remediating the dysfunction. New research with stronger empirical standards is forthcoming. We are on the cusp of an explosion of knowledge in this area providing rigorous scientific data to move the field forward. Scientists and practitioners alike must promote research that leads to better diagnoses and effective interventions, improving the lives of children and their families. ■

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