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SECTION 4

Sensory integration/ learning disabilities

MOYA KINNEALEY and LUCY J. MILLER

KEY TERMS

A. Jean Ayres
Gravitational Insecurity
Praxis
"Research-Then-Theory"
"Theory-Then-Research"
Sensory Defensiveness
Sensory Integration and Praxis Tests
Sensory Integration Treatment
Sensory Integrative Equipment
Southern California Sensory Integration Test

LEARNING OBJECTIVES

Upon completion of this section the reader will be able to:

1. *Define sensory integration.*
2. *Summarize the theory of sensory integration.*
3. *Describe the development of sensory integration theory by A. J. Ayres.*
4. *Identify instruments that evaluate sensory integration dysfunction: The Southern California Test of Sensory Integration, the Sensory Integration and Praxis Tests, and other tests that permit observation and analysis of sensory integration.*
5. *Describe occupational therapy treatment using sensory integrative procedures including the conceptual model and the components of treatment.*
6. *Describe the clinical postulates underpinning the sensory integration approach.*

7. ***Describe treatment strategies including writing goals and objectives, activity planning, and use of equipment.***
8. ***Describe research of the effectiveness of sensory integration treatment including methods of studying sensory integration procedures.***
9. ***Describe the importance of building an empirical consensus based on collective research.***
10. ***Summarize the effectiveness of sensory integration intervention.***

Sensory integration theory

The theory of sensory integration was the life work of ***Dr. A. Jean Ayres*** (1920 to 1988) and continues to evolve and be modified by researchers and clinicians worldwide. The theory describes the way in which the brain works as a whole with the objective of improving functional ability. The development of the theory was originally based on work with learning-disabled children.

Sensory integration is defined as:

> . . . the neurological process that organizes sensation from one's own body and from the environment and makes it possible to use the body effectively within the environment. The spatial and temporal aspects of inputs from different sensory modalities are interpreted, associated and unified. Sensory integration is information processing. (Ayres, 1989a, p. 11).

The theory is summarized by Ayres as:

> Sensations from the body, especially during purposeful activity provide the means by which a neuronal model or precept of the body is established. . . . An accurate body scheme is necessary for practic tasks, for a sense of directionality and for relating body to space. At the same time conceiving, planning, and executing adaptive action is a major means by which sensation is made meaningful and translated into a body precept. . . . Praxis is a uniquely human aptitude that underlies conceptualization, planning and execution of skilled adaptive interaction with the physical world . . . (and) is fundamental to purposeful activity. Praxis and perception are both end products of sensory integration. . . . Somatosensory, vestibular, and visual input to sensory integration and praxis are essential to organism environmental interactions. (Ayres 1989b, pp. 11–12)

The purpose of theory in science is to provide a typology, a logical explanation, prediction and potential for control, and a sense of understanding (Reynolds, 1971). The two basic ways of developing a scientific body of knowledge are the "research-then-theory" approach and the "theory-then-research" approach (Reynolds, 1971).

Both approaches are useful for different purposes. The former is useful in the beginning stages of theory development. The ***"research-then-theory"*** process includes identifying a phenomenon, measuring the characteristics, analyzing the data to determine patterns, and making statements describing the outcome that contribute to developing the theory.

The ***"theory-then-research"*** strategy occurs more frequently when a theory has been developed and statements of theoretical relationships are being tested. If the statement from the theory does not correspond to the research results, appropriate changes are made in the theory or in the research design. In this way development of the theory is continuous through the interaction with empirical research.

The theory of sensory integration using both of the aforementioned approaches was developed in a methodical manner by Ayres over three decades until her death in 1988, first through factor analytic studies and later through predictive studies. Based on 15 years of clinical work, influences from the perceptual motor work of Newall Kephart and Marianne Frostig, and extensive reading of the neuroscience literature, Ayres determined that many of the behavioral and learning problems manifested by her clients had a biologic basis. Her hypothesis was that through therapeutic input designed to modify the neurobiologic basis of behavior, functional improvement could result.

Because there were no tests to evaluate these neurobiologic underpinnings, Ayres began to develop a variety of tests to quantify the phenomenon of interest, beginning with space visualization. She concomitantly continued to analyze and describe clinical phenomena.

Much of Ayres' early work is compiled in *The development of sensory integrative theory and practice: A collection of works of A. Jean Ayres* (Henderson et al., 1974). Ayres' work provided a unique perspective and constitutes one of the major theoretical frameworks of occupational therapy. The theory reflects her background in the neurosciences, psychology, and occupational therapy. She related neuropsychological processes to functional ability and behavior and developed postulates about the relationship between sensory input and brain development with the goal of changing the child's neuromotor efficiency and capacity.

After the development of testing tools, that is, the ***Southern California Sensory Integration Tests*** (Ayres, 1972a), the research-then-theory strategy was used to further refine and clarify components of the theory of sensory integration. A series of factor-analytic studies, which explored the relationships among perceptual and performance areas, and clinical observations were completed. The resulting theory was named "sensory integration."

Five basic assumptions underlie both the theory and the use of sensory integration treatment techniques (Ayres, 1972b):

1. There is *plasticity* within the central nervous system; thus, intervention procedures based on sensory integration theory can effect changes in the brain.
2. The sensory integrative process occurs in a *developmental sequence.*
3. The brain functions as an integrated whole but is composed of systems that are *hierarchically organized.*
4. Evincing an *adaptive response* promotes sensory integration, and the ability to produce an adaptive response is based on sensory integration.
5. An *inner drive* exists to develop sensory integration, which is manifested through participation in sensorimotor activities

In 1972, Ayres published her first book, *Sensory Integration and Learning Disabilities*, introducing the principles of brain function on which sensory integration theory was formulated. Six areas of dysfunction, related to learning-disabled children, were introduced and referred to as "syndromes":

- Auditory language disorder
- Bilateral integration
- Developmental apraxia

- Form and space perception
- Tactile defensiveness
- Unilateral disregard/right cerebral hemisphere dysfunction

In this volume, the six syndromes were described as well as methods for remediation of underlying disorders. The application of a child-directed therapeutic approach (guided exploration) and sensory integrative equipment (hammocks, balls, ramps, scooterboards) were detailed. Until that time the use of these techniques was not common in the profession of occupational therapy. In 1972, Ayres published her first test battery, the Southern California Sensory Integration Tests (SCSIT).

Experimental and predictive studies were necessary to determine the effectiveness of the approach and to further modify the theory. In a study sponsored by the Valentine Kline Foundation (1976), Ayres accomplished three objectives:

1. Exploring the relationship of academic, intellectual, language and sensory integrative functions
2. Determining the distribution of different types of disorders and the significance of those disorders to academic learning
3. Exploring the efficacy of therapeutic procedures

This study used The Post-Rotary Nystagmus Test (Ayres, 1975). For the first time in occupational therapy, the role of the vestibular system in learning disabilities was researched.

Another conceptual expansion of the theory occurred in 1985 as Ayres addressed the multiple aspects of developmental dyspraxia, with an emphasis on differentiating childhood-onset from adult-onset apraxia. For heuristic reasons she proposed three practic (motor planning) processes: ideation or conceptualization; planning or choosing a strategy for action; and motor execution.

At that time it was still unknown whether developmental dyspraxia was a unitary function. However, different functional areas manifesting apraxia and principles for intervention based on neurophysiologic literature were delineated. The functional areas included postural dyspraxia, motor sequencing deficits, dyspraxia on verbal command, oral dyspraxia, and constructional dyspraxia. About the relationship between praxis and language Ayres (1985) stated:

> Praxis is to the physical world what speech is to the social world, both enable interactions and transactions. Both are uniquely human; both are learned . . . some aspects of speech and language comprehension may be closely related—even dependent upon—the development of praxis. Both praxis and language require cognitive functions of ideation and concept formation, both require integration of sensory input and both require planning that enables motor expression. (p. 1)

In 1986, Rush University in Chicago and Western Psychological Services, the publisher of Ayres' tests, commenced a refinement and national restandardization of the existing test battery (SCSIT), eliminating some tests and adding five new tests to evaluate dyspraxia. The ***Sensory Integration and Praxis Tests*** (SIPT; Ayres, 1989a) were standardized on 1997 children in the United States and Canada.

The SIPT evaluates children ages 4 years, 0 months to 8 years, 11 months. The 17 subtests of the battery measure four domains of function: (1) form and space, (2) somatosensory and vestibular processing, (3) bilateral integration and sequencing, and (4) praxis.

With continued use of this relatively new test, the knowledge base in sensory integration will expand and the theory will grow and be modified in response to data accumulated from empirical research.

The fact that the theories and evaluative practices in sensory integration are evolving and changing is believed to be a strength by advanced clinicians (Clark, 1991), although the lack of stable "facts" may be frustrating to novice therapists. The changes are a result of new knowledge that impacts on theory and practice.

Change can be threatening but, as Ayres stated,

> Knowledge—especially theoretical knowledge—is tentative, and constantly changing. . . . Theory is not fact but an organization of ideas, hopefully supported by some facts, which guides one in solving problems. . . . Observing the manner in which a body of knowledge grows step by step, each step providing a foundation for more advanced thinking, is helpful in maintaining a perspective. . . . The amount of change in thinking from early papers to later papers [in sensory integration] reminds one that even greater change in thought will occur in the years to come. . . . (Ayres, 1974 p. xi)

Ayres encouraged others to have the "courage . . . to think independently, and along unorthodox lines" (Ayres, 1974, p. xi). Students of Ayres were taught to have a questioning attitude and to conduct research to explore the many questions existing in the theory and evaluation of sensory integration. "Although A. J. Ayres is no longer among us, the theories and work she dedicated her life to developing are alive and changing" (Clark, 1991 p. ix).

The work that Dr. A. Jean Ayres began has stimulated research in occupational therapy for several decades. Numerous occupational therapists in clinical and academic settings have implemented research studies, as discussed in the text that follows. In addition, in 1972 an organization was founded to support and facilitate research in sensory integration. Originally called the Center for the Study of Sensory Integration Dysfunction (CSSID), this organization published a quarterly newsletter, publications, and films, and provided an opportunity for therapists to be trained in the original test (SCSIT). About 50 occupational and physical therapists were trained to be "Faculty" to teach SCSIT certification workshops. These persons have continued to expand sensory integration theory through lectures, research, and clinical practice, and are now known as "Faculty Emeritus."

As worldwide interest in sensory integration grew, in 1984 the mission of CSSID was expanded and the name was changed to Sensory Integration International (SII). SII purchased the Ayres Clinic, thus the expansion into areas of treatment, clinical education, and research could be accomplished.

Sensory Integration International participated in the update and standardization process for the new test, SIPT, and developed a new certification process for SIPT administration and interpretation. Currently, in addition to continuing education opportunities offered nationwide, a graduate level course in sensory integration is offered at the Ayres Clinic.*

Introduction to sensory integration evaluation

> Tests yield numbers and numbers can do things that words or ideas cannot do. In occupational and physical therapy, measurement is central to differential diagnosis, gain or loss assessment, establish-

* For additional information on continuing education opportunities, contact Sensory Integration International, 1402 Cravens Ave., Torrance, CA 90501.

> ing client status, predicting response to therapy, building and testing theory, and conveying information across fields. It is difficult to accomplish any of these goals without some form of measurement. (Ayres, 1989b)

Evaluation in sensory integration is a combination of science and art. The therapist must use a variety of quantitative and qualitative procedures to arrive at a final conclusion, so that appropriate treatment recommendations can be derived. Generally, the evaluation procedure is complex and involves the synthesis of numerous behavioral observations as well as test scores.

A variety of standardized and criterion-referenced evaluation techniques can be analyzed within the sensory integrative frame of reference. Data from these scales provide information about levels of functioning in the central nervous system, the sensory modalities, postural responses, and related functional abilities.

Dr. A. Jean Ayres was a pioneer in sensory integration theory and evaluation, and based test item development on a *neurobiologic model*, as already discussed. Her tests were designed to assess abilities to detect position and movement in space (vestibular processing), ability to sense body position (proprioceptive processing), tactile perception, ***praxis*** (motor planning skills), visual perception (eye–hand coordination and visual discrimination), and other abilities.

Because sensory integration evaluation and theory are relatively new, theory, evaluation, and treatment practices are still evolving, based on new research and clinical findings. Thus, the evaluation process in sensory integration has evolved, and the domains originally evaluated have been modified.

The evaluation emphasis has evolved as new knowledge has been gained. In the 1960s, Ayres' work focused on visual perception. In the 1970s, the SCSIT were published, and the interpretation of dysfunctional performance was grouped into the six syndromes just discussed (Ayres, 1972a; 1980). In the 1990s, the SIPT were published with an emphasis on praxis (motor planning) abilities and sensory processing (Ayres, 1989b).

Specific sensory integration evaluations

Sensory integration and praxis tests

The primary instrument for identification of sensory integration dysfunction is the SIPT (Ayres, 1989a). The SIPT is a battery of 17 subtests that provides detailed information on the sensory integrative status of children ages 4 years, 0 months thorough 8 years, 11 months of age.

The SIPT can be administered in 90 to 120 minutes, depending on the age and ability of the child and the experience of the examiner. The SIPT is individually administered and computer-scored by the publisher, Western Psychological Services. This scoring system was chosen because it allows for "complex statistical comparisons between the tested child's pattern of SIPT scores and the typical score patterns observed in six different cluster groups" (Ayres & Marr, 1991).

Examiners who administer the SIPT must be carefully trained and must have extensive experience in pediatrics and at least one course in statistics and measurement. Examiners are required to complete three courses covering the theory, administration, and interpretation of the SIPT, and have successfully completed an observation session with a qualified observer before being eligible to take the SIPT Competency Examination. These courses are offered by Sensory Integration International.

All 17 subtests require performance by the child; none is based on verbal responses, although one (Oral Praxis) is dependent on auditory processing and language comprehension. Although several of the subtests measure performance in more than one area, Ayres categorized the subtests into four groups (in following text).

Measures of tactile and vestibular–proprioceptive processing†

- Kinesthesia (Kin)*
- Finger identification (FI)
- Graphesthesia (Gra)*
- Localization of tactile stimuli (LTS)*
- Postrotary nystagmus (PRN)
- Standing and walking balance (SWB)

The somatosensory tests are Kin, FI, Gra, and LTS, and are administered with vision occluded. Aspects of vestibular–proprioceptive functioning are evaluated by PRN, SWB, and Kin.

Measures of form and space perception and visual–motor coordination

- Space visualization (SV)
- Figure–ground perception (FG)*
- Manual form perception (MFP)*
- Motor accuracy (MA)*
- Design copying (DC)*
- Constructional praxis (CPR)

Nonmotor visual perceptual abilities are measured by SV and FG, which can be compared with visual–motor coordination on MA and DC. The haptic (tactile) component of form and space is measured in MFP. Visual construction abilities, including elements of form and space perception, are measured by DC and CP.

Measures of praxis

- Design copying (DC)*
- Constructional praxis (CPR)
- Postural praxis (PPR)
- Praxis on verbal command (PVC)
- Sequencing praxis (SPR)
- Oral praxis (OPR)

Visual praxis abilities are evaluated through DC and CPR. Motor planning related to aptitude in assuming unusual body positions is evaluated with PPR. Motor planning based only on comprehension of verbalized directions is measured by PVC. Abilities to process and remember a specific order of positions following demonstration is measured in SPR. Ability to plan and execute oral motor movement patterns is measured in OPR.

Measures of bilateral integration and sequencing

- Oral praxis (OPR)
- Sequencing praxis (SPR)
- Graphesthesia (Gra)*
- Standing and walking balance (SWB)

† The subtests marked with an asterisk (*), were originally included in the SCSIT, although many of these include modified and improved versions of items in the SCSIT.

- Bilateral motor coordination (BMC)*
- Space visualization contralateral use (SVCU)
- Space visualization preferred hand use (PHU)

All these subtests assess the ability to integrate functioning on two sides of the body either in gross motor movements (SWB; BMC), fine motor movements (SPR; BMC), oral motor movements (OPR), and tactile perception (Gra). Two scores are derived from administration of SV; they measure ability of the child to cross the midline of the body (SVCU) and demonstration of preferred or dominant hand for writing (PHU).

The process of test development and national standardization has been well documented (Ayres & Marr, 1991; Ayres, 1989a). In addition, extensive reliability and validity information are reported in the literature and will continue to accumulate in future years (Ayres, 1989a; Ayres & Marr, 1991)

Southern California sensory integration test battery

The SCSIT was the precursor of the SIPT (Ayres 1972a; 1980). It included 17 subtests and was usually administered conjointly with the Southern California Postrotary Nystagmus Test (Ayres, 1975). The subtests above marked with an asterisk (*) originated with the SCSIT, although the SIPT includes modifications and improvements of some test items. In addition, the SCSIT also included the following subtests, which are not included in the SIPT because levels of reliability or validity were not acceptable: Crossing the Midline, Position in Space, Right Left Discrimination, and Double Tactile Stimuli Perception.

After the development and standardization of the SIPT, the publisher has ceased selling the SCSIT. Although normative information for the SCSIT is limited, some therapists originally certified in administration of the SCSIT use the subtests to supplement clinical observations of children's sensory integrative status.

Other tests that permit observation and analysis of sensory integration in children

Sensory integration, as defined in the preceding text, is a complex neurobiologic theory. It addresses the relationship among the sensory systems and between sensory processing and motor planning abilities. These sensory and motor processing abilities are considered essential to competent organization and appropriate functioning by the person within his or her environment. Thus, it can be seen that the evaluation of sensory integration is much broader than just the SIPT or SCSIT tests. Although these tests were milestone contributions to understanding sensory integration functioning in children ages 4 to 8 years, a variety of other measures exist that also provide insight into the sensory integrative status of people.

Sensory integration is a frame of reference. Sensory integration evaluation is not limited strictly to the subtests developed by Ayres. Thus, many assessments can be interpreted from a sensory integration frame of reference, although they were not initially intended as a specific measure of sensory integration status, as were the SIPT and the SCSIT.

For example, the Miller Assessment for Preschoolers (MAP; Miller, 1988a, 1982) was developed by an occupational therapist and describes in the theoretical chapter the underlying theoretical basis of that test as in part based on sensory integration theory. Although the MAP was originally intended as a screening test to provide information on preschool-aged children (2 years, 9 months to 5 years, 8 months) to assist in predicting children at risk for later developmental delays and learning difficulties, Miller (1988b) discusses the use of the scale to *assess* rather than *screen* sensory integrative aspects of functioning when the test is administered by a qualified therapist.

In particular on the MAP, items that measure what Ayres refers to as vestibular–proprioceptive sensory processing assess what Miller refers to as position and movement abilities. These items are Finger-Nose, Romberg, Stepping, and Vertical Writing. Two items specifically measure tactile abilities in preschoolers: Finger Localization and Stereognosis. A variety of items encompass the evaluation of motor planning skills, although Miller has labeled them "complex tasks": Draw-A-Person, Imitation of Postures, Block Designs, and Mazes.

Other tests that include items from which an understanding of the sensory integration abilities of children age 3 years through adulthood can be derived are the McCarron Assessment of Neuromuscular Development (MAND; McCarron, 1982) and the Haptic Visual Discrimination Test (HPVT; McCarron & Dial, 1979). McCarron is a neuropsychologist with a strong interest in psychoeducational testing and neurologic functioning.

Items on the MAND that provide information about sensory integrative functioning are Heel-Toe Walk and Stand One Foot in the Kinesthetic Integration subdomain, Beads on Rod and Nut and Bolt in the Bimanual Dexterity subdomain, Rod Slide and Finger-Nose in the Persistent Control subdomain, and Hand Strength and Jumping in the Muscle Power subdomain. Beads on Rod also provides interesting sensory integration information because vision is occluded during part of this item.

A frequently administered test, which is designed to measure gross and fine motor functioning in children ages 4 years, 6 months to 14 years, 6 months is the Bruininks-Oseretsky Test of Motor Proficiency (Bruininks, 1978). This assessment is designed to measure gross and fine motor proficiency of children. Although the author has a strong psychoeducational background, he does not come from a sensory integrative frame of reference. Thus, the descriptions in the test manual are from a physical education and motor learning point of view.

Nevertheless, many of the items administered can be interpreted from a sensory integrative frame of reference. For example, vestibular–proprioceptive processing can be inferred from performance in the Balance subtest and in Touching Nose with Index Fingers and Touching Thumb to Fingertips, eyes closed in the Upper-Limb Coordination subtest. Praxis can be observed throughout the assessment, but particularly in Bilateral Coordination, Upper-Limb Coordination, Visual-Motor Control, and Upper-Limb Speed and Dexterity subtests. Form and space perception and visual–motor coordination can be determined from results of the Visual-Motor Control, and the Upper-Limb Speed and Dexterity subtests. Bilateral Integration and Sequencing abilities can be detected through analysis of Bilateral Coordination, and Placing Pennies in Two Boxes with Both Hands, in Upper Limb Speed and Dexterity subtests.

Of primary importance in sensory integrative evaluations is differential diagnosis of motor-free visual perceptual dysfunction versus visual–motor integration disorders. Useful in this regard (supplementing or in place of the form and space perception subtests on the SIPT) is comparison of performance on a motor-free visual perception test such as the Test of Visual-Perceptual Skills, (Gardner, 1982) and the Motor-Free Test of Visual Perception (Colarusso, 1972) with performance on a test that requires the integration of visual and motor skills such as the Developmental Test of Visual-Motor Integration (Beery & Buktenica 1967), or the Test of Visual-Motor Skills (Gardner, 1986). A careful examination of the scores of items on these scales will show that some children have high scores on motor-free visual perceptual tasks and low scores on visual–motor coordination items, thus indicating that visual perceptual skills are intact, but either the motor component or the integration of motor and visual perceptual is causing the problem. In contrast, other children demonstrate low scores on both types of items, indicating a combination of both visual perceptual and motor problems.

A test useful in clinical interpretations of sensory integrative functioning is the DeGangi-Berk Test of Sensory Integration (TSI) (Berk & DeGangi, 1983). The TSI is a criterion-referenced test that hypothesizes three vestibular-based functions: postural control, bilateral motor integration, and reflex integration. The authors discuss that when used in the diagnosis of sensory motor dysfunction, the results should be incorporated with other relevant test results to reliably determine problem areas. Although the scoring system is subjective (particularly in the reflex integration subtest) and the test is not norm-referenced, the items are helpful in the clinical assessment of sensory integration functioning in this age group (3 to 5 years old). In particular, two areas can be supplemented by information from items in this scale: vestibular processing (by observation of the antigravity position items) and bilateral integration (by items such as Rolling Pin Activity, Jump and Turn, and Drumming).

A variety of other clinical assessments include items that tap into sensory integrative functioning. An inclusive review of all items from all assessments that measure sensory integration is beyond the purview of the material in this section. However, the concept has been presented that the domains of development identified by Ayres in over 30 years as an occupational therapist and scientist are measured by many items that are not necessarily labeled "sensory integration" by the test author. Thus, it becomes the responsibility of each clinician administering an evaluation or battery of tests to interpret those applicable parts within the sensory integration frame of reference.

Related areas in a sensory integration evaluation

A sensory integration evaluation should never be completed in the absence of the collection of other important data. An excellent description of additional components of a sensory integration evaluation and a detailed case study are presented by Fisher & Bundy (1991).

In general, the following components must be included before the results of a sensory integration evaluation can be interpreted.

Complete referral information

The therapist should ascertain exact symptoms that make the child a candidate for a sensory integration evaluation. This includes detailing the presenting problems and identifying possible areas of sensory integrative deficits as well as functional problems that may be related to sensory integrative deficits. In particular, the therapist should carefully explore the aspects of the child's *quality of life* on which sensory integrative disorders may have an impact. These aspects may include psychosocial functioning, learning difficulties, communicative disorders, and problems with activities of daily living. The therapist can then tie the evaluation results back to the presenting problem, and thus make interpretation and remediation suggestions that will be meaningful to the referring source.

Detailed developmental history

It is essential to obtain a complete developmental history on the child. This should include the mother's pregnancy and birth history information; infant behavior and functioning; milestone attainment of performance areas including motor, communication, cognitive, and social–emotional abilities; academic performance/problems; and factors that describe the family functioning including both protective and risk factors. Often a variety of factors in the history will help to confirm or rule out various aspects of sensory integration dysfunction that may not be evaluated during the test session.

Classroom observation

Whenever possible, observations of the child in the context of the classroom or home environment should be made. This provides an opportunity to observe the child in a natural environment and to demonstrate differences between functioning in the test session (one-to-one situation) and functioning in a group. A classroom observation may illuminate school-related problems and provides an excellent opportunity to interview the child's teacher. In addition, it affords an opportunity for evaluation and remediation suggestions to be directed to one of the child's main occupations, school.

Related clinical observations

Much of the understanding of sensory integrative functioning is based on observing the child in a variety of situations. Numerous areas of sensory integrative functioning have no standardized assessment. For example, muscle tone, reflex integration, co-contraction skills, crossing the midline, tactile defensiveness, and antigravity reactions must all be clinically observed rather than specifically measured using a test "score." In addition, clinical observations conducted (preferably) over several sessions and in a variety of circumstances (such as on the playground, in the clinic, or within the home) frequently allow the therapist an opportunity to confirm suspected areas of strength and dysfunction that may be hypothesized based on the standardized evaluation.

Interpretation of sensory integration evaluations

Interpretation of a person's sensory integration status is a difficult and complex process. When the SIPT is administered, the process is facilitated in some ways because standardized scores

are derived in each of the component subdomains. However, good interpretation of the computerized SIPT results takes years of practice and necessitates completion of a professional training course.

The purpose of this section of Chapter 13 is to provide an overview of sensory integrative evaluation as a process, not detailed explanations of the interpretation of the SIPT (detailed descriptions available in Ayres, 1989a; Fisher et al., 1991); therefore, the following chart (Figure 13-32) has been compiled, which may apply to any evaluation that has sensory integration components. In using this chart the therapist should enter all information about the performance onto the chart, listing the child's strengths in the left column and limitations in the right column. An analysis of the chart will assist in an understanding of the child's sensory integrative status.

Occupational therapy using sensory integration procedures

Ayres developed a conceptual model of occupational therapy using sensory integration procedures, which is useful in identifying treatment priorities and planning treatment programs (Ayres, 1979) (Figure 13-33).

On the left side of this figure, the major sensory systems are depicted: auditory, vestibular, proprioceptive, tactile, and visual. Based on a person's development and experience, it is hypothesized that the input from these sensory systems is integrated and results in a variety of "end products," or adaptive functions.

Integrative tasks are demonstrated in a hypothesized hierarchy in levels 1, 2, and 3 in Figure 13-33 and include (for example):

Posture and balance abilities (level 1)
Efficient motor planning and coordination of two sides of the body (level 2)
Eye–hand coordination (level 3)

The end products (depicted on the right of Figure 13-33) include a variety of functional and adaptive abilities, such as self-esteem, self-control, and self-confidence. The capacity to demonstrate integrated and adaptive end products is based on efficient neurologic organization that includes competence in accurately perceiving sensory input, ability to process and integrate perceptions, and adaptive performance of the important occupations of life (such as learning, interacting, playing).

It is essential that occupational therapists focus on the end products when they use sensory integration techniques. Long-term objectives of treatment *must* reflect functional goals. The impact of using these techniques on the child's quality of life must always be the underlying motivation for normalization of his or her sensory perception and motor performance. A chart summarizing observable behaviors that may indicate sensory processing difficulties is provided by Dunn (1991).

Using the model in Figure 13-33 as a conceptual guide, occupational therapy using sensory integration treatment techniques can be planned and implemented after either a standardized or nonstandardized evaluation has been completed. The model provides an effective framework for assessing the full spectrum of ages from neonates to adults. In addition, it encompasses a variety of diagnostic categories including emotional disturbance, mental retardation, and physical handicaps.

It has been found that persons with a variety of diagnoses have sensory integrative deficits that impact negatively on treatment progress unless specifically addressed. This includes those with fragile X, substance-exposed or substance-affected children.

Subdomain of Development Assessed	Items Indicating Strengths in Subdomain Functioning	Items Indicating Limitations in Subdomain Functioning
Movement Perception		
Position In Space Perception		
Tactile Perception		
Visual Perception		
Visual–Motor Integration Abilities		
Fine Motor Abilities		
Gross Motor Abilities		
Postural Abilities		
Ocular Abilities		
Praxis Abilities		
Bilateral Integration Abilities		
Cognitive Abilities		
Auditory/Language Abilities		
Social/Emotional Abilities		

FIGURE 13-32. *Analysis of sensory and motor performance.*

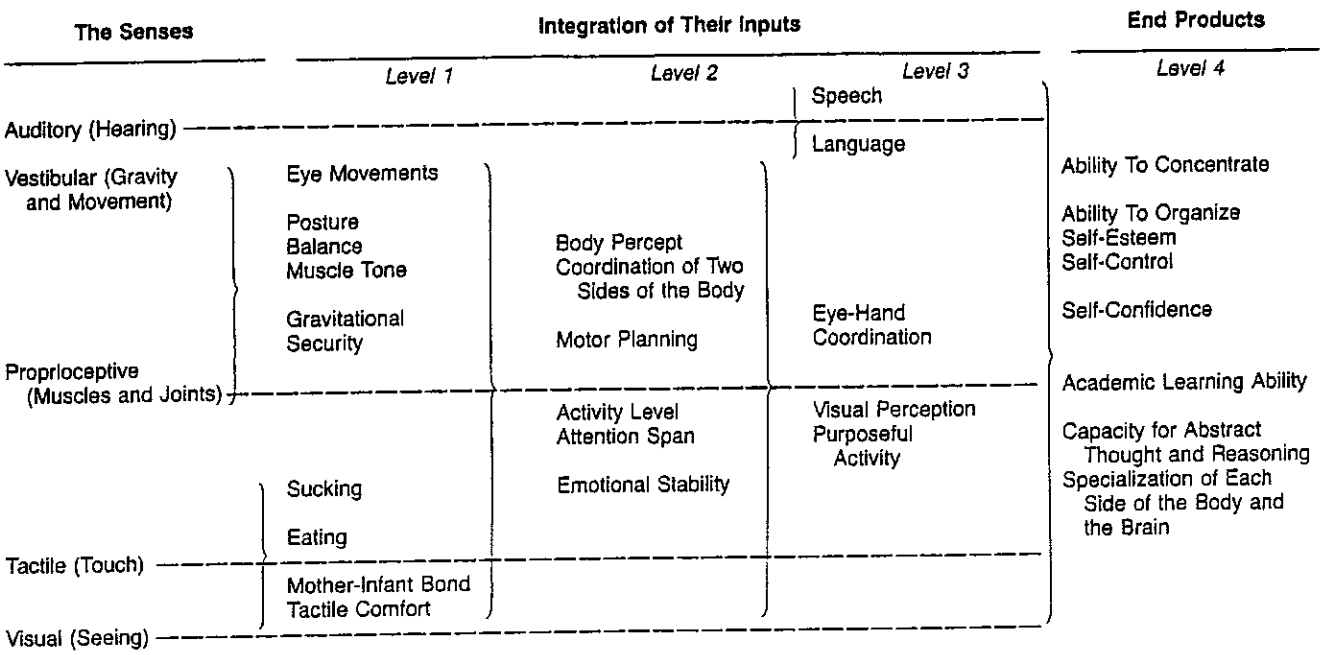

FIGURE 13-33. *The senses, integration of their inputs, and their end products. (From Western Psychological Services, 12031 Wilshire Blvd., Los Angles, CA 90025.)*

abused children, and children with cerebral palsy, mental retardation, and autism. In these populations, although sensory integration or any therapy does not purport to change a child's medical condition, it can improve functional independence, motivation, self-esteem, and overall competence in performing the usual occupations of life.

Effective treatment planning is based on information gathered from standardized testing, clinical evaluations, and developmental and family history (as described in the preceding text), and can be effectively organized utilizing the framework presented by the model in Figure 13-33.

Sensory integration treatment is a complex treatment modality. Its complexity is due to the numerous variations all included under the title, "Sensory Integration Treatment." A good summary of characteristics of sensory integration treatment is provided by Kimball (1988). Included in her description are the following components:

Active participation by the person being treated
Client-directed activity
Individualized treatment based on the age, disorder, developmental status, and response of the client
Purposeful activities requiring an *adaptive response*
Sensory stimulation as a part of the activities
Improving underlying neurologic processing and organization rather than focusing on the development of splinter skills
Treatment by a therapist with advanced training in specific sensory integration treatment techniques

> Sensory integration treatment is neither predetermined nor fixed, but rather varies from one individual to the next, and changes in response to the individuals' response to therapy . . . [make] a concise description of the treatment difficult. (Kimball, 1988, p. 423)

Three clinical postulates form the foundation for the sensory integration approach to assessment and treatment planning:

1. A continuum exists between hyporesponsiveness and hyperresponsiveness in each sensory system, which affects the ability of the person to interact effectively and efficiently with the environment.
2. The symmetry (or asymmetry) of function between the two sides of the body and the two hemispheres affects efficiency of function.
3. The brain functions as a whole; however, a hierarchy within the central nervous system affects neurologic functioning, and thus affects behavioral manifestations of nervous system integrity.

Continuum of hyper- to hyporesponsivness

Over- and underresponsiveness to sensory stimuli including tactile, vestibular, auditory, gustatory and visual systems can affect the child's behavior and functioning. One of Ayres' earliest clinical observations was a cluster of behaviors that she studied extensively (Ayres, 196+) and labeled "tactile defensiveness." Tactually defensive behavior, or hyperresponsiveness of the tactile system, is characterized by an adversive (or defensive) reaction to nonnoxious, tactile stimuli. Behavioral manifestations include hyperactive and distractible behavior, withdrawn behavior, and aggressive responses to touch, sometimes called the "fight-or-flight reactions."

Techniques for normalizing overly sensitive tactile systems, called tactile defensiveness, have been developed by Ayres (1972b) and Wilbarger and Wilbarger (1991). Exploration of the neurologic mechanisms believed to be involved in remediation have been described by Fisher and Dunn (1983).

At the other end of the hypo- to-hyperreactive continuum in the tactile domain are children who have unusually high thresholds of sensory perception and registration. In these children, concomitant problems are often observed in tactile discrimina-

tion and haptic abilities. In addition, poor tactile discrimination (hyporeactivity) may be related to poor execution of motor skills that require a high degree of skill and planning.

Hypo- or hyperresponsiveness to vestibular stimulation may also be observed clinically. According to sensory integration theory, an underresponsive vestibular system may result in vestibular bilateral disorders or vestibular language disorders (Ayres, 1976, pp. 82–83). Evidence of an overreactive vestibular system may be demonstrated by either gravitational insecurity or intolerance to movement, depending on which part of the vestibular system is affected (Ayres, 1976).

Gravitational insecurity is manifested by fear, anxiety, and distress when the person assumes positions to which he or she is unaccustomed, particularly when moved by another person. A child with this condition feels safest with both feet on the floor, is cautious and fearful of falling, and avoids activities involving movement such as jumping, somersaulting, and the like. *Intolerance to movement*, in contrast, is manifested through a variety of autonomic reactions such as severe discomfort, nausea, and headache with rapid movement (Ayres, 1979).

Hyper- and hyporesponsiveness can also be observed in the other sensory systems but the reactions are less well documented in occupational therapy literature.

The concept of ***sensory defensiveness*** has been described by Wilbarger and Wilbarger (1991):

> Sensory defensiveness is a tendency to react negatively or with alarm to sensory input that is generally considered harmless or non-irritating . . . common symptoms may include oversensitivity to light or unexpected touch, sudden movement or over reaction to unstable surfaces, high frequency noises, excesses of noise or visual stimulation and certain smells. . . . Sensory defensiveness results in varying degrees of stress and anxiety although symptoms vary with each individual. (Wilbarger & Wilbarger, 1991, p. 3)

Abnormal reactions to sensory input may potentially have negative effects on every aspect of a person's life and may result in social and emotional problems.

The reactivity model demonstrated in Figure 13-34 formulated by Lorna Jean King is useful in understanding the behavioral parameters of hyper- and hyporeactivity. The relationship between the model presented by King in Figure 13-34 and the model presented by Ayres in Figure 13-33 is interesting. Both models relate the senses (including reactivity to sensation) to "end products" or quality of life. These theorists were interested in the effect of deficits in the perception and processing of sensory information on functional abilities, or the occupations of children's lives. As the neurophysiologic theories relating to sensory integration have become more advanced based on new knowledge, there is a tendency to forget the less technically sophisticated and more meaningful aspects of sensory integration treatment depicted in Figure 13-33 as "End Products," and in Figure 13-34 as "Defective Behaviors, and Impaired Learning."

Symmetry and asymmetry of function

There are some conditions in functioning in which symmetric abilities indicate strengths in abilities and other conditions in which more advanced performance on one side of the body indicates more mature responses. For example, in a normal person both sides of the body are expected to show similar balance reactions, similar reflex integration, and similar development of muscle tone. The presence of definite asymmetries in any of these areas (such as those seen in hemiplegia) would be evidence of dysfunction.

Although dysfunction due to hemiplegia is clinically obvious, subtle asymmetries in the perception of sensory information may also cause dysfunctional performance. For example, there is some evidence that vestibular-based asymmetry in muscle tone and balance responses may be associated with persistent inner ear infections (Denning & Mayberry, 1987; Schaaf, 1985). There is also evidence that children who demonstrate significantly different abilities to perceive tactile stimulation on the right and left sides of their bodies are more likely to demonstrate motor planning deficits and other functional problems associated with tasks of daily living (Ayres, 1972b).

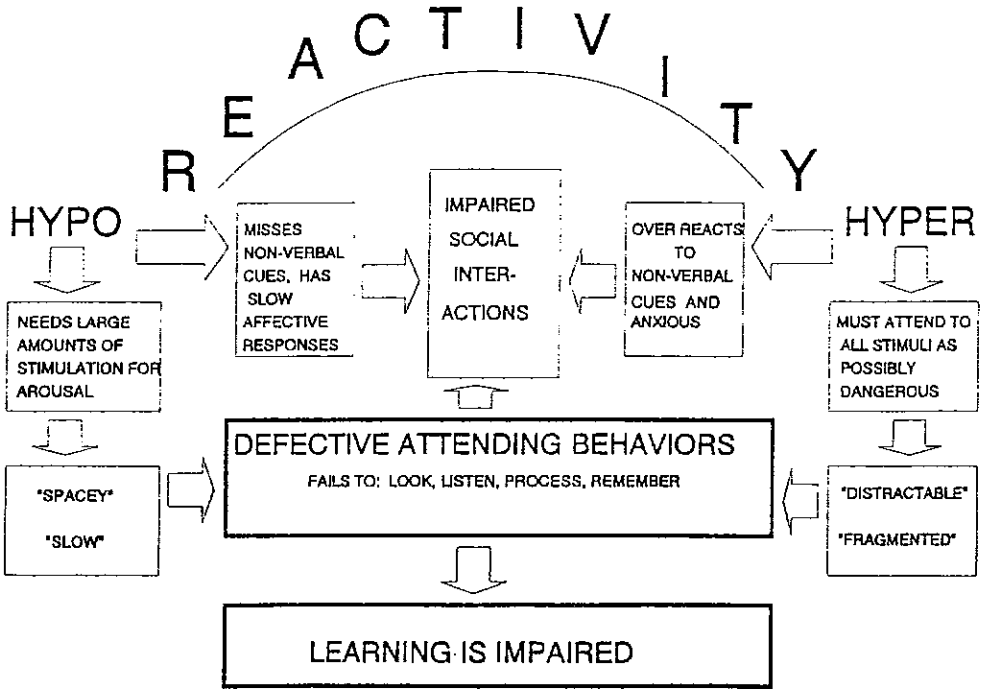

FIGURE 13-34. Schematic of hypo- and hyperactivity and their impact on attending and learning. (*From King, L. J. [1988]. Interpretation of social-emotional domain. In Miller assessment for preschoolers:* Seminar administration and interpretation manual. *San Antonio: The Psychological Corporation.*)

In other developmental tasks, however, it is appropriate to observe asymmetric functioning, that is, when one side of the body has developed particular skill in performance. One obvious example of this is in the establishment of hand dominance. It is anticipated that by a certain age children show particular skill and dexterity in performance of activities such as writing, eating, and other fine motor tasks. The lack of specialization (equal or symmetric performance by both hands) may be an indication of dysfunction if neither hand has established the skill needed to perform the activities expected at his or her age.

Clinical assessment of sensory and motor performance with particular emphasis on the presence of atypical asymmetry or on symmetric functioning when mature performance is based on one side demonstrating more advanced ability can be useful in indicating avenues of remediation.

Clinical testing of two sides of the body in the following areas can be useful in observing asymmetries:

- Muscle tone and strength
- Co-contraction
- Bilateral, smooth coordinated movements
- Diadochokinesis (rapid alternating movement patterns)
- Sequential fingertip opposition
- Tactile discrimination
- Crossing the midline of the body
- Tonic neck reflexes
- Fine motor skill and dexterity tasks

Levels of function

The central nervous system manifests a hierarchy anatomically and functionally. However, the brain functions as a whole and integration of the brain mechanisms including sensation occurs at many levels of the brain.

Occupational therapy using sensory integrative treatment techniques is founded on the belief that tactile, vestibular, and proprioceptive sensations that generate *purposeful movement and activity* provide a foundation for visual and auditory functions. A further postulate holds that efficient brainstem functions provide a foundation for higher level cortical functions (Seig, 1988).

Thus, the clinical symptoms for which a child may be referred to occupational therapy—poor handwriting and difficulties in motor performance—are often due to inefficient functioning at lower levels of the central nervous system. Thus, input directed at abilities mediated by lower central nervous system structures (such as reflex integration activities, tactile discrimination tasks, or activities which improve sense of position and movement) may affect other abilities mediated by higher central nervous system structures (such as cognitive, language, and integrative abilities). It is hypothesized that remediation focused on deficits in the lower levels of the central nervous system affect not only higher level central nervous system abilities, but also end products such as self-confidence, self-esteem, and academic performance.

CASE STUDY

José is referred for an occupational therapy evaluation by his teacher, who feels that he is demonstrating poor handwriting and immature motor abilities that are interfering with his schoolwork. After interviewing the teacher, the therapist finds out that José is extremely distractible, frequently fights in school, tends to play only with children younger than himself, and often displays "tantrums," particularly during self-care activities such as dressing, eating, and washing.

The therapist determines through observation, clinical assessment, and developmental history that the child is overreactive to sensory stimulation, particularly tactile. She concludes that the lowered threshold to sensory input (sensory defensiveness) is contributing significantly to José's distractibility in the classroom, and his difficulties completing self-care tasks.

On clinical assessment, José is found to have low muscle tone, which contributes to his difficulty sitting upright in a chair for an extended time without "wiggling." In addition, during writing and reading activities, José props his head on his hand (which, as the therapist observes, helps him to maintain an upright position and visually focus on the task in front of him).

Because José must use the nonpreferred hand to help him maintain balance, his alternate hand is not free to hold his paper when he is writing. In addition, his pencil grip is weak. Therefore, José demonstrates poor pencil control and illegible letter formation.

The therapist also clinically examines a variety of reactions and responses known to be related to efficient functioning of the vestibular system. José demonstrates low muscle tone, inability to hold the prone extension posture, inefficient balance responses, and difficulty with bilateral coordination. This set of observations suggests that his vestibular system may not be working efficiently and verifies the need for further standardized assessment.

Completed standardized testing confirms the presence of hyperresponsiveness in the tactile system, vestibular processing inefficiency, and bilateral integration difficulties.

Occupational therapy treatment is recommended to maximize José's potential in school. It is believed that by decreasing José's sensitivity to tactile stimulation, increasing his ability to efficiently process vestibular input, and normalizing his abilities to perform tasks requiring smooth integrated use of the two sides of the body, José will experience increased satisfaction at school in academic areas and in interpersonal relationships.

Long-term goals

I. Academic and classroom performance
   A. Improve handwriting
   B. Decrease distractibility
II. Social–emotional abilities at school
   A. Decrease aggressive behavior
   B. Increase interactions with children in his age group
III. Self-care skills
   A. Improve abilities to dress independently
   B. Improve ability to take care of usual grooming skills for his age

Related therapeutic methods and modalities

For each of the above long-term goals, numerous therapeutic methods and modalities would be beneficial to use in a treatment plan. The development of a comprehensive treatment plan is an

important and challenging part of the therapeutic process. Each child must have a comprehensive written treatment plan prior to initiating treatment.

Due to the complexity of developing treatment plans based on each child's diagnosis, strengths, and needs, it is difficult to synthesize the process in an introductory text as provided here. For each of the long-term goals, a variety of short-term goals and sensory and motor strategies (activities) can be used to achieve the goal. Examples of short-term goals are noted in the following text.

I. Improve handwriting‡
   A. Increase ability to copy shapes and forms
   B. Increase speed and dexterity of fine motor abilities
   C. Improve ability to organize writing on a page
   D. Improve pencil grasp
   E. Improve postural stability so that fine motor activities can be accomplished more easily

II. Decrease distractibility§
   A. Decrease hyperresponsiveness in the sensory systems, particularly reduce tactile defensiveness
   B. Raise threshold to distraction from outside, unrelated stimuli.
   C. Ensure that José's placement in the classroom is in the least distracting place in terms of outside environmental stimulation, peer distractions, and the like.

Goals and objectives of treatment

Goals of treatment and measurable objectives are required by school systems, hospitals, insurance companies, and others. However, the therapist must realize that the nature and wording of these objectives must be consistent with the intent of the organization through which the therapy is provided; the therapist also should take into account the purpose for which the goals and objectives are being written. For example, goals and objectives written for the family to take home and implement may well be different from those written for a referring physician.

Activity planning

Activities that address the short-term goals can be diverse. Many activities can be applicable to each goal. For example, above short-term goal A, "Increase ability to copy shapes and forms," the activities might include blackboard activities, tracing shapes in the sand, making finger-paintings with pudding, and so on. It is critical that the activities are specifically tied to the short-term and long-term goals for the child.

It must be realized that in occupational therapy using sensory integrative techniques, each goal and activity is designed based on an understanding of the neurobehavioral basis of the academic, social, or functional problem. Improvement in problems such as handwriting and distractibility is likely to result not only in improved handwriting, but in improved quality of life in terms of behavior, family relationships, peer interactions, and functional abilities. As a result, the end products (self-esteem, self-confidence, ability to organize, and so on) described in Figure 13-33 will improve. After abilities such as focusing on tasks or maintaining an upright seated posture become automatic (instead of requiring cognitive effort), a child is much more able to put energy into other important activities such as cognitive skills (listening to the teacher, improvement in reading), social–emotional skills (relating to peers, following directions), and the like.

Sensory integrative equipment

A variety of ***sensory integrative equipment*** is commercially available to implement treatment based on sensory integration principles. This equipment may be categorized into four groups:

1. *Tactile equipment,* consisting of textured mats, brushes, vibrators, pillows, and a variety of therapist-developed activities
2. *Nonsuspended moving equipment,* consisting of balls of all sizes, rolls, barrels, tiltboards, ramps, scooter boards, trampolines, jumping boards, and sit-n-spins (Figure 13-35)
3. *Hanging equipment,* consisting of hammocks, bolsters, platform swings, suspended ladders, bars, gliders, and inner tubes (Figures 13-36 to 13-38)
4. *Motor planning equipment,* consisting of a variety of obstacle courses, jungle gyms, and other creative and innovative pieces of equipment that facilitate unique previously unexecuted activities (Figure 13-39)

Sensory input can be divided into two categories for each sensory system: (1) facilitory input and (2) inhibitory input. Generally, input that is expected, rhythmic, sustained, or slow tends to be inhibitory. Input that is unexpected, arrhythmic, uneven, or rapid tends to be excitatory.

The therapist must carefully assess the goals of the treatment to ascertain which type of equipment is useful in maximizing efficient and optimal functioning for the child. Duration, intensity, frequency, and careful monitoring of the child's response to the stimulation are required.

Occupational therapy using sensory integration techniques is complex, multifaceted, and process-oriented. A major component of treatment depends on the child's motivation, choice of

FIGURE 13-35. *Balance and righting responses are challenged when sliding on a nonlevel surface in the saucer.*

‡ Many other examples of short-term goals related to improving handwriting could apply here.

§ Many other examples of short-term goals related to improving distractibility could apply here.

FIGURE 13-36. *Activities that require total body organization and movement help visual, spatial, and motor planning skills develop.*

FIGURE 13-38. *A therapist enables a child to challenge herself on the flying trapese.*

equipment, and the type and degree of guided sensory input the therapist provides.

A discussion of the use of each of the types of available equipment is beyond the scope of the material presented here. A particular piece of equipment may be used in a multitude of ways to provide the input appropriate to meet a child's needs. However, it was felt that by exploring the use of one common piece of equipment, for example, the large therapy ball, an understanding that pieces of equipment could be used for a variety of goals would be clear. Thus, the chart in Table 13-13 presents uses of the

FIGURE 13-37. *A therapist and child use linear movement to develop vestibular proprioceptive responses in the neck, arms, and back.*

FIGURE 13-39. *A child's ability to motor plan is developed through challenging sensory motor experiences.*

TABLE 13-13. *Use of Therapy Ball in Sensory Integration Treatment*

Treatment Needs Addressed	Goal	Position of Child	Type of Sensorimotor Input
Hyperreactive tactile system	Reduce hypersensitivity	Child on floor; child lying prone on ball	Press ball on child, ventral pressure, slow rhythmic rock, head in inverted position
Hyporeactive tactile system	Increase tactile awareness	Sitting or lying on ball	Heavy bounce, bare skin on towel on ball, brisk movement, brisk rubbing
Hyperreactive vestibular system	Reduce hyperreactivity	Sitting or in prone	Slow predictable rhythmic movement tolerance, heavy bounce tactile input simultaneously all pressure
Hyporeactive vestibular system	Increase reactivity	Any/many positions	Quick movements in any position or direction, movement requiring body adjustments including protective extension and righting reaction
High tone	Reduce tone	Prone arms extended	Slow rhythmic rocking, weight bearing, weight shifting
Low tone	Increase tone	Prone	Heavy movement front to back, bouncing, sustained weight shift
Motor planning	Improve basic pattern on which motor planning is based	Prone; supine, rotational movements	Work on total body patterns of flexion, extension, and trunk rotation, activities on small balls in which the body controls the movement of the ball

large therapy ball in addressing a variety of treatment needs for a child.

Many occupational and physical therapists have expanded the application of sensory integration theory and the use of sensory integration treatment techniques to a broader population base than the learning-disabled children for which it was initially intended. This includes autistic children and adults (King, 1987), severely retarded and schizophrenic adults (Mailloux, 1987), chronically mentally ill patients in an institutional psychiatric setting (King, 1974) and applications relevant to preacademic, academic, and classroom skills (Knickerbocker, 1980). Other therapists have used this theory base in the development of testing tools, as previously discussed in the evaluation section.

Research on effectiveness of sensory integration treatment

The issues in analyzing research in all fields of occupational therapy are complex. For a more complete description of issues related to research, see Chapter 12.

Interpreting the results of sensory integration studies

Two aspects of interpretation are critical to discuss: the limitations of available instruments in occupational therapy and the importance and variety of outcome measures that are used.

Instrumentation was discussed already briefly in regard to sample selection. However, the importance of understanding the psychometric properties and intended purpose of scales that are used in a study cannot be overemphasized. Before undertaking research and even prior to finalizing the research questions, it is useful to explore the options available to measure the constructs that are intended for study. Existing research is hampered by a serious lack in the profession of well-standardized, reliable, and valid measurement tools.

Cermak and Henderson (1989, 1990) documented the percentage of sensory integration efficacy studies that used each of the following outcome variables and found the following percentages:

Academic outcomes, 20%
Language outcomes, 45%
Motor outcomes, 45%
Postrotary nystagmus outcomes, 20%
Self-stimulation behaviors, 5%
Behavioral outcomes, 5%
Other outcomes, 10%¶

The choice of outcome measures is based on two factors: the research question and the validity of the measure. If the question relates to the effectiveness of sensory integration therapy in producing changes in school, academic measures might be of interest, for example. A review of the literature highlights the fact that in many instances the instrumentation is described, but the initial research hypothesis is not elaborated. It is not of particular interest, for example, whether children who receive sensory integrative treatment demonstrate changes in test scores unless documentation can be supplied that those test scores are indicative of changes in constructs that are under study.

Does a change in a test score on an intelligence scale mean that a child has become more intelligent? Probably not. Does the change mean that the child will be performing better in school? Not necessarily, although changes in the child that caused the child's test scores to improve may be related to changes that also affect school performance. Thus, it can be seen that researchers

¶ Some outcomes were used in more than one study; hence, the total is more than 100%.

need to clarify the choice of outcome measures and relate that choice back to the hypothesis of the study.

The psychometric properties and purpose of the outcome measures also need to be considered. Is a criterion-referenced scale appropriate for measuring change over time in a group of children? It may be valuable to provide descriptive documentation for a qualitative study, especially if the scores obtained represent small discriminating categories; however, if the purpose of the study is to document quantitative changes over time or compare the effectiveness of two treatment approaches, a scale with a reliable and valid final score must be used.

Unfortunately, few well-standardized scales in occupational therapy can be used for this purpose. Therefore, researchers are cautioned to modify the research question to those questions that can be answered using existing technologies and to use scales developed outside the profession, which are designed to measure related concepts. This does not mean that only standardized tests can be used in sensory integrative research, but that the choice of instrumentation in part determines the generalizability of results and the format of the research question. The obvious implications for the profession with regard to the importance of allocating resources to the development of standardized tests is emphasized once more by this discussion.

Cermak and Henderson (1989, 1990) include the following list of domains in which change in response to sensory integration therapy may be demonstrated: "organization, learning rate, attention, affect, exploratory behavior, biologic rhythm (sleep-wake cycle), sensory responsivity, play skills, self-esteem, peer interaction, and family adjustment" (p. 7). Although intriguing, these domains represent a challenge to the profession in terms of existing measurement technologies. With proper planning, implementation, and analysis, however, progress can be expected over the next decade in measuring these important aspects of the occupation of children.

Building an empirical consensus based on collective research

The concepts for bulding an empirical consensus are based on the thought-provoking and stimulating concluding chapter in the book by Fisher et al., *Sensory Integration: Theory and Practice*, to which all serious students of sensory integration are referred. In his chapter, Ottenbacher (1991) raises complex issues, including the importance of developing a consensual science that supports and documents the effective elements of sensory integration.

Because sensory integration is such a complex issue, Ottenbacher notes an "absence of a unifying research paradigm," and cautions that "research is only one component of science, and in fact, can produce little of lasting value unless it grows out of consensus supported by theory" (p. 398). Clark (1991) notes that Ayres in her more than 30-year career "discovered a new paradigm for explaining a variety of neurological disorders in children." Dr. Ayres was a proponent of change; it is a challenge for all students of sensory integration to follow her lead in asking questions and seeking answers. Our current challenge is to grow beyond the existing knowledge that she dedicated her life to developing and to continue to provide new knowledge that will help all potential clients to validate the new paradigm that Dr. Ayres constructed.

For a theory to become accepted as fact (or to represent a new paradigm), it must be carefully documented by a large body of well-implemented research. This research becomes meaningful only when discussed in terms of concepts that have pragmatic relevance to the field. Thus, the growth of theory is based on research, and the relevance of research is based on theory. Ottenbacher (1991) emphasizes the importance of a collective body of research in establishing empirical consensus that can be translated into professional agreement.

Cruickshank (1974) noted that Ayres

> ... has the unique role of not only having added much to the work of previous authors, but of having essentially turned a whole profession around. The writings of Jean Ayres, in large measure, have been instrumental in setting new directions for a total discipline, or at least have directed the profession of occupational therapy into areas that are historically and functionally different from that which characterized it prior to 1955. (p. viii)

Clark (1991) notes "how the work of scientists of lower standing is prone to resistance by scientists of higher standing" and cites as an example the criticism of von Nageli, who was in a position of authority over Mendel, who judged Mendel's groundbreaking work in genetics to be insignificant. This resistance may in part account for the slow acceptance of sensory integration into the main body of occupational therapy theory and practice.

Sensory integration therapy has been heavily criticized both from within occupational therapy and from the medical and educational professions. This may be partly due to the kind of resistance discussed by Clark (1991) and partly due to the lack of a well-researched or validated theory and research base (although despite methodologic problems, more research exists on sensory integration within the profession than on any other area of practice). Ottenbacher's statements regarding empirical consensus building in the context of collective research are critical for the profession of occupational therapy. Because not until professional agreement exists regarding the constructs of sensory integration based on empirical findings of research studies that are synthesized into a well-formulated theory base, will sensory integration make the transition from a set of ideas to a paradigm embraced by the profession.

Summary of the effectiveness of sensory integration therapy

A brief summary of the research that supports the efficacy of sensory integration procedures is provided by the American Occupational Therapy Association (Efficacy: Data brief, 1988). More detailed descriptions of studies are provided by Clark and Pierce (1988) and Cermak and Henderson (1989, 1990).

Cited in these reviews is the meta-analysis by Ottenbacher (1982), which examined 49 published research studies and included eight that met stringent criteria. Ottenbacher found that 78.8% of children who received sensory integration treatment demonstrated better performance than children who did not receive treatment. These advantages were found in motor performance, academic achievement, and language functioning.

The comprehensive review by Clark and Pierce (1988) provides the following conclusion: Positive treatment effects are documented in both single subject design studies (Madsen & Conte, 1980) and in group design studies (Ayres, 1972c), al-

though there is not a consistent result among all studies (Carte et al., 1984).

An example of an experimental group design with a rigorously controlled design is provided by several studies completed by Ayres (1972c, 1976). In the 1972 study, Ayres found that in both the generalized sensory integration group and the auditory language problem group, children who received sensory integration treatment made greater academic gains in reading than the children who did not receive sensory integrative treatment. In the 1976 study, it was demonstrated that sensory integrative treatment ameliorates dysfunction identified by hyporeactive nystagmus and promotes efficiency of academic learning (as measured by scores on the Wide Range Achievement Test: Reading and Spelling).

Numerous other studies have been conducted using comparisons of groups. In summary, Clark and Pierce (1988) state:

> Results of these studies suggest that sensory integrative procedures seem to produce language or language-related gains in both learning disabled and mentally retarded children . . . that they may promote eye-hand coordination, and that their effects on nystagmus duration are unclear. (p. 4)

The review of research using single subject design highlights the usefulness of that technique in understanding the role of individual variation in response to sensory integration therapy. Single subject design studies serve as a useful tool for generating hypotheses for study in larger experimental approaches. In general, the findings of the case studies were "generally consistent with the findings of the studies on the effectiveness of sensory integrative treatment that utilized group designs" (Clark & Pierce, 1988, p. 5). Three of the four studies reviewed found positive effects of therapy on outcome measures.

Strong evidence exists in the literature that sensory integration may be effective; however, research evidence is not conclusive. Due to a variety of methodologic problems, many of the studies are open to criticism. *The lack of conclusive scientific evidence does not mean that the construct of sensory integration lacks validity, however.* Ottenbacher (1988), in reviewing efficacy studies in sensory integration, concludes that although there are design flaws in existing studies, *most sensory integration efficacy studies reveal that sensory integration treatment is effective.* Thus, he concludes that "an aggressive empirical effort [should be instituted] to establish the credibility of these initial findings" (p. 426).

As noted by Cermak and Henderson (1989, 1990), occupational therapists and professionals in education, medicine, and psychology are faced with similar dilemmas. It is important to believe in the efficacy of the treatment that you are undertaking. It is essential to feel that there is merit in the clinical approach that defines your profession and thus to respond to demands for service made upon the profession. Nevertheless, each discipline has an ethical obligation to question the efficacy of its treatment approaches and must be diligent in researching effects of various treatments. As new research results are reported, the field must be open to changes. Improvements in treatment modalities are only possible given the acceptance of data-based results of efficacy studies.

It is possible that the paradigm of sensory integration, as it continues to grow and change and is actualized into the profession in the future, may bare only partial resemblance to that envisioned by its originator, Dr. A. Jean Ayres. These changes, if based on collective research in the profession, will be positive and will support the importance of a questioning attitude and continued growth and expansion of knowledge, as exemplified by Ayres' statement, "Truth, like infinity, is to be forever approached, but never reached" (Ayres, 1972b, p. 4).

Where do we go from here?

It is hoped that this review of the methodologic problems inherent in sensory integration efficacy research has not dissuaded the serious student from completing research in this field. Obviously, the need for efficacy research with the concomitant theoretical leaps that can be made from a synthesis of new knowledge is immense.

It is apparent that a single person or even a few people are unlikely to produce the body of research needed to prove (or disprove) the efficacy of this paradigm of treatment. However, through multisite studies and collaborative research of other types, new knowledge can be gained that will shed light on which aspects of sensory integration treatment are valid and which must be modified.

Each person is well cautioned to take to heart some of the suggestions made by occupational therapists referenced in this section. Overly ambitious projects that attempt to answer unrealistic research questions will probably provide information that is so diffuse that it will not add to the body of knowledge in the field. However, studies that have carefully thought-out research questions, clearly delineated hypotheses, and detailed quantitative or qualitative research methodologies are likely to provide information that will have relevance for many decades and ultimately benefit many children. The profession of occupational therapy is responsible for valuing and supporting research in the profession, both financially and in terms of human resources. Only by integrating research into our clinical practice, can the necessary knowledge result in changes in treatment practices be actualized.

The photographs in this section were taken by Shay McAtee.

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SECTION 5

Autism

LISA A. KURTZ

KEY TERMS

Behavior Modification or Operant Conditioning
Behavioral Deficits
Cognitive Deficits
Communication Deficits
Pervasive Developmental Disorders
Sensory Integration
Sensory Processing Disorders