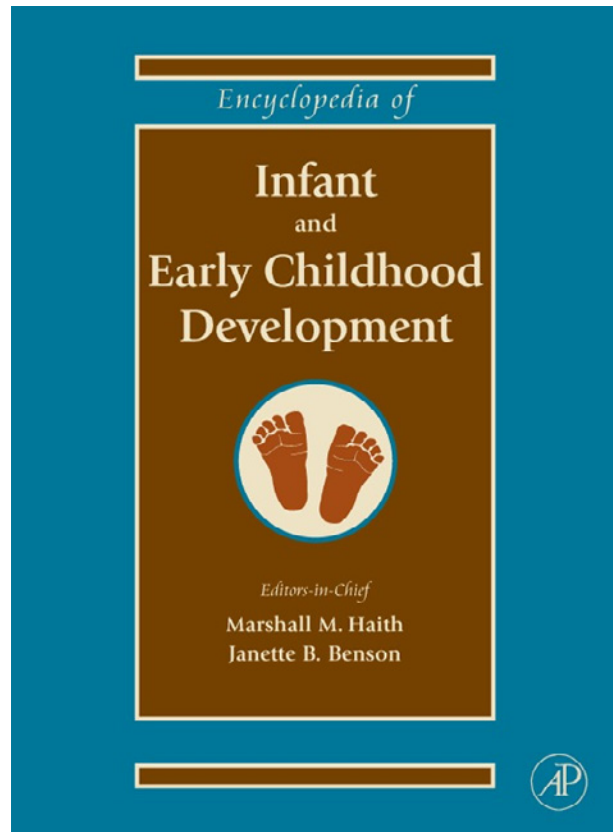


Provided for non-commercial research and educational use.
Not for reproduction, distribution or commercial use.

This article was originally published in the *Encyclopedia of Infant and Early Childhood Development*, published by Elsevier, and the attached copy is provided by Elsevier for the author's benefit and for the benefit of the author's institution, for non-commercial research and educational use including use in instruction at your institution, posting on a secure network (not accessible to the public) within your institution, and providing a copy to your institution's administrator.



All other uses, reproduction and distribution, including without limitation commercial reprints, selling or licensing copies or access, or posting on open internet sites are prohibited. For exceptions, permission may be sought for such use through Elsevier's permissions site at:

<http://www.elsevier.com/locate/permissionusematerial>

Miller L J and Schaaf R C, Sensory Processing Disorder. In: Encyclopedia of Infant and Early Childhood Development, ed. by Marshall M. Haith and Janette B. Benson. © 2008, Academic Press, San Diego

as structural characteristics of the language, cultural influences, maternal sensitivity, and responsivity to children's needs and abilities, and socioeconomic status of the family are found to have powerful impacts on children's semantic development. In addition, these factors too combine and complement each other to predict language outcomes in children.

See also: Attention; Bilingualism; Birth Order; Categorization Skills and Concepts; Grammar; Language Acquisition Theories; Language Development: Overview; Parenting Styles and their Effects; Pragmatic Development; Preverbal Development and Speech Perception; Social Interaction; Speech Perception.

Suggested Readings

- Bloom P (2000) *How Children Learn the Meanings of Words*. Cambridge, MA: MIT Press.
- Bowerman M and Levinson S (eds.) (2001) *Language Acquisition and Conceptual Development*. Cambridge, UK: Cambridge University Press.
- Hall DG and Waxman SR (eds.) (2004) *Weaving a Lexicon*. Cambridge, MA: MIT Press.
- Hirsh-Pasek K and Golinkoff RM (eds.) (2006) *Action Meets Word: How Children Learn Verbs*. Oxford: Oxford University Press.
- Hoff E (2006) How social contexts support and shape language development. *Developmental Review* 26: 55–88.
- Woodward AL and Markman EM (1998) Early word learning. In: Damon W, Kuhn D, and Siegler RS (eds.) *Handbook of Child Psychology: Vol. 2. Cognition, Perception and Language*, 5th edn., pp. 371–420. New York: Wiley.

Sensory Processing Disorder

L J Miller, Sensory Processing Disorder Foundation, Greenwood Village, CO, USA

R C Schaaf, Thomas Jefferson University, Philadelphia, PA, USA

© 2008 Elsevier Inc. All rights reserved.

Glossary

Adaptive response – An appropriate action in which the individual responds successfully to a challenging demand.

Occupational therapy using a sensory integrative approach – The use of sensory-rich activities, tailored to individual needs, that are playful yet organizing, and elicit adaptive responses. Usually involves total body movements that are rich in vestibular, proprioceptive, and tactile input. The goal of therapy is to improve the way the brain processes and organizes sensations. Intervention is based on sensory integrative principles that guide the therapist's clinical reasoning skills. The intervention addresses the underlying substrates of dysfunction (e.g., neurological immaturity) rather than difficulties with specific skills. This intervention approach is most commonly utilized by occupational therapists.

Proprioceptive system – The sensory system that detects information from the muscles and joints and perceives sensation about the position or velocity of movement of body parts including force, tension and position. Proprioceptive input tells the brain which muscles are contracting or stretching, when they are doing so, and the amount of resistance on the muscles and joints. The receptors for the proprioceptive system include the muscle spindle, the golgi tendon organ, and the joint receptors.

Sensory modulation disorder (SMD) – This condition is the inability to automatically regulate incoming sensory information resulting in sensory over-responsivity, sensory under-responsivity, and/or sensory seeking/craving.

Sensory processing – The ability to detect information through the senses, organize that information, and interpret the information making a meaningful and appropriate adaptive response. For most people the process of sensory processing is automatic and unconscious.

Sensory processing disorder (SPD) – This complex disorder is a neurological condition that affects children and adults. People with SPD misinterpret everyday sensory information, such as touch, sound, and movement. They may feel bombarded by information, crave intense sensory experiences, be unable to discriminate the fine qualities of sensation, or have awkward responses to sensory input. To be classified as a disorder, the symptoms of SPD must be severe enough that participation in daily life activities is restricted.

Tactile system – Receptors for the tactile system are located in the skin and are responsible for the sense of touch.

Theory of sensory integration – This theory explains the relation between deficits in interpreting sensory input and learning, behavior, or motor

difficulties. The theory recognizes brain–behavior interactions and focuses on the role of the senses in creating a foundation for higher level cognitive, emotional, and motor activities. The theory postulates that adequate detection, modulation, discrimination, and responses to sensory information are needed for normal adaptive behavior to occur.

Vestibular system – This sensory system responds to the position of the head in relation to gravity and to the acceleration or deceleration of movement. The receptors for the vestibular system are the semicircular canals and the utricle and saccule that are located in the labyrinth of the inner ear. These receptors detect the pull of gravity and movement of the head.

Introduction

What is sensory processing disorder? Sensory processing is our ability to take in information through our senses (touch, movement, smell, taste, vision, and hearing), interpret that information, and organize a meaningful response. For most children this process is automatic. When we hear someone talking to us or a bird chirping (auditory stimuli), our brain interprets this information as speech or an animal sound, and we respond to the information appropriately (e.g., turning our head to listen). When someone taps us on the shoulder (tactile stimulus) we turn our attention to that individual. When we are standing in a bus or train and it starts to move (vestibular stimulus), we automatically shift our weight so we do not fall. Individuals (both children and adults) who have sensory processing disorder (SPD) do not detect, regulate, interpret, and/or respond to sensory information accurately. SPD symptoms occur along a wide continuum from mild to severe and manifest in a variety of behavioral, motor, and social symptoms.

Seven sensory systems exist and SPD can occur in one or a combination of systems. The five well-known sensory systems are: visual, auditory, olfactory (smell), gustatory (taste), and tactile (touch). Two ‘hidden senses’ also exist, the vestibular and proprioceptive systems. The vestibular system detects information about the movement of the head in relation to the Earth’s gravity through receptors in the vestibules (hence the term vestibular) located in the inner ear. The proprioceptive system detects information in the muscles and joints and provides information about the location and movement of the parts of the body (i.e., you can feel where your little toe is located without looking at it).

History

Dr. A. Jean Ayres, an occupational therapist (OT) and neuroscientist, pioneered the theory of sensory integration,

expanded primarily in the field of OT. Sensory integration theory describes the underlying brain mechanisms hypothesized to cause SPD, defines a set of behavioral characteristics indicative of SPD, and also suggests intervention methods for remediating the disorder. Ayres called the disorder sensory integrative dysfunction and termed the intervention sensory integration treatment. Her theory discusses the relation among the neural processes of receiving, modulating, and integrating sensory input and the resulting output that Ayres called adaptive behavior. The theory postulates that adequate processing of sensory information is needed for normal adaptive behavior to occur.

Ayres developed two assessment batteries, the Southern California Sensory Integration Test in 1972 and the Sensory Integration and Praxis Test (SIPT) in 1989. The SIPT includes 17 subtests evaluating children ages 4 years 6 months to 8 year 11 months. It measures the ability to detect and interpret sensory information by responding to tactile, proprioceptive, vestibular, auditory, and visual stimuli. The results provide detailed information about underlying sensory factors that may affect a child’s learning and behavior.

Although Ayres originally outlined the central theoretical tenets of the theory in her book *Sensory Integration and Learning Disorders* in 1972, she recognized that the theory would evolve and change as new scientific findings informed the field. This evolution is exactly what has happened over the 35 years since the original book was published. For example, Ayres originally identified six subtypes of sensory integration dysfunction: postural and bilateral integration dysfunction, developmental apraxia, form and space perception, tactile defensiveness, unilateral disregard, and auditory-language disorders. She later revised her theory and, based on new data, renamed some of the subtypes. However, as she predicted, new research has emerged and her theory has evolved. Thus, an update to Ayres’ original taxonomy is presented.

Signs and Symptoms of Sensory Processing Disorder

The newest taxonomy encompasses and expands Ayres’ original ideas based on new research. Dr. Lucy Jane Miller and colleagues note that delineating specific subtypes is crucial so that homogenous groups can be identified for intervention and research purposes. They have proposed a set of classic patterns with subtypes based on physiological research and behavioral studies. The new taxonomy utilizes the term SPD to identify the condition and includes all the subtypes identified by Ayres. The Ayres’ classification scheme is reorganized into a new nosology that includes subtypes that were not labeled previously. The current diagnostic taxonomy is delineated in [Figure 1](#) Definitions and behaviors observed in each subtype follow.

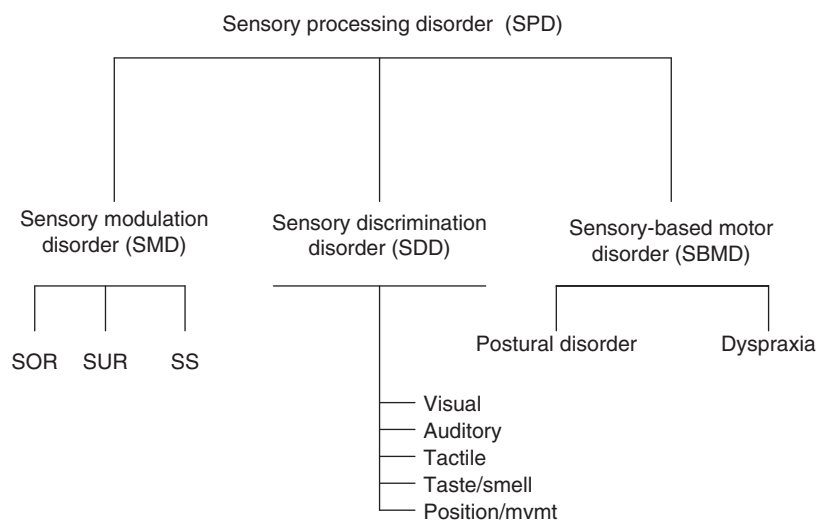


Figure 1 Current taxonomy of sensory processing disorder. SOR, sensory over-responsivity; SS, sensory seeking craving; SUR, sensory under-responsivity.

Sensory Modulation Disorder

The first classic pattern is sensory modulation disorder (SMD), defined as difficulty regulating and responding to sensory input in a graded manner. Almost all people experience SMD to some degree, at some point in their life. For example, when you get home after a long tiring day, any sensation can be 'too much' such as a loud radio or someone touching you. Because your stress level is high and your usual methods of coping with stimuli is poor, you experience normal levels of sensation as uncomfortable. However, poor modulation of sensation is a disorder only when it disrupts a person's ability to take part in daily life routines and self-care activities on a routine basis. Children and adults with the disorder demonstrate severe and frequent over or under-responsivity and/or sensory-seeking behaviors in response to levels of sensory stimuli in their environment that most of us would automatically process without effort.

Screening for SMD can be completed using parent, teacher, and self-report scales such as the 'sensory profile', the 'infant toddler sensory profile', and the 'adult sensory profile' developed by Dr. Winifred Dunn and colleagues, by the 'sensory processing measure' by Dr. Diane Parham and colleagues or by other similar report measures. Diagnosis of SPD also involves testing and observations by well-trained clinicians, usually OTs or other professionals with advanced training in sensory processing. In Miller's taxonomy, three types of SMD are proposed: sensory over-responsivity, sensory under-responsivity, and sensory-seeking.

Sensory over-responsivity

Children with sensory over-responsivity respond to sensation more quickly and intensely than most people. Their

responses appear to be fight or flight reactions and are sometimes labeled sensory defensiveness. They often try to avoid or minimize sensations by withdrawing from the situation (e.g., covering their ears, pushing a person who touches them away, or closing their eyes) or they respond with aggressive behavior. For example, a child touched unexpectedly may punch the person who touched him. Many of the common sensory symptoms and the behaviors that accompany sensory over-responsivity are described by Miller. A few examples of the sensory symptoms and accompanying behaviors are shown in [Table 1](#).

Sensory under-responsivity

Children with sensory under-responsivity do not respond to typical levels of sensation and, as a result, are lethargic and unaware of stimulation. They may seem oblivious to their environment and often do not respond to typical stimuli such as hearing their name called. Common behaviors associated with sensory under-responsivity are noted in [Table 1](#).

Sensory seeking craving

A third type of SMD is sensory seeking craving. Children with sensory seeking/craving are hypothesized to have a high threshold to sensory stimuli, and compensate by constantly seeking stimulation that is more intense or prolonged than most children prefer. Children who seek sensation often take part in extreme activities or move constantly to provide the sensory input their brains seem to crave to feel normal. They may make unsafe choices in play such as jumping from the top of a slide, play music or talk very loudly, and/or constantly intrude upon other people's space, touching people, and handling their objects. Other behaviors associated with sensory seeking are noted in [Table 1](#).

Many children have more than one type of sensory modulation problem and their symptoms include behaviors from several subtypes. To be diagnosed with SMD the child's responses to sensation must be extreme, well outside of the range typical responsiveness. The responses must be seen in a variety of settings such as school, day-care, home, and in the community. The child must exhibit these behaviors in 'ordinary' daily situations to receive a diagnosis of SMD (e.g., not just at the end of a tiring day or a long trip).

Table 1 Characteristics of sensory over-responsivity, sensory under-responsivity, and sensory seeking

Sensory over-responsivity

Sensory symptoms – Frequently bothered by

- Having his hair, fingernails, or toenails cut
- Food textures
- Noise in a restaurant, mall, or large gymnasium or loud, unexpected sounds
- Being upside-down, as when turning a somersault

Behaviors include being

- Aggressive or impulsive when overwhelmed by sensory stimulation
- Irritable, fussy, moody
- Unsociable; avoids group activities and has trouble forming relationships
- Upset by transitions and unexpected changes

Sensory under-responsivity

Sensory symptoms

- Does not cry when seriously hurt and is not bothered by minor injuries
- Nearly always prefers sedentary activities like computer time to active physical games
- Often seems unaware of what's going on around him (e.g., does not hear his name being called)
- Often seems unaware of body sensations such as hunger, hot or cold or need to use the

Behaviors include being

- Passive, quiet, withdrawn
- Hard to engage in conversation or other social interaction
- Apathetic and easily exhausted
- Exhibits no inner drive to get involved in the world around himself (e.g., uninterested in exploring games or objects)

Sensory seeking/craving

Sensory symptoms

- Is on the move constantly, crashing, bashing, bumping, jumping and rough-housing
- Constantly touches objects and/or intrudes on people
- Seems unable to stop talking and has trouble taking his turn in conversations
- Frequently fixates visually on objects such as reflections of the sun in the side-view mirrors of the car

Behaviors include being

- Described by others as hyperactive
- Angry or explosive when he is required to sit still or stop what he's doing
- Intense, demanding, hard to calm, excessively affectionate
- Prone to create situations others perceive as 'bad' or 'dangerous'

From Miller LJ (2006) *Sensational Kids: Help and Hope for Children with Sensory Processing Disorder*. New York: Putnam.

Sensory Discrimination Disorder

The second classic pattern is sensory discrimination disorder (SDD), difficulty interpreting sensory input. When a child has this problem, he or she can detect the stimuli but does not recognize the precise details of sensation, including the quantity, location, duration, size, and/or shape of stimuli. This interpretation of sensory qualities is needed to execute fine and gross motor skills. SDD can occur in visual, auditory, tactile, olfactory, gustatory, proprioceptive, and/or vestibular systems. Some children with SPD can respond adequately when only one sensory modality is presented; however, when two or more stimuli are present (as is the case in many typical daily activities), they are unable to organize appropriate responses. As a result, they have difficulty successfully participating in learning, play, and social activities. Tactile, vestibular, proprioceptive, and visual discrimination can be assessed using the 'sensory integration and praxis test' battery. Common sensory symptoms and behaviors associated with SDD are noted in [Table 2](#).

Sensory-Based Motor Disorder

The final classic pattern type of SPD is sensory-based motor disorder. There are two types: postural disorder and sensory-based dyspraxia. Each is described below.

Postural disorder

Postural disorder includes problems with core body positions, for example, stability and mobility. Whenever the child is required to move against gravity (such as when lying on stomach and extending arms and legs into an airplane position, or lying on back and curling up into a ball or doing a sit up), the child with postural disorder has difficulty contracting muscles and using core stability.

Table 2 Characteristics of sensory discrimination disorder

Difficulties with these sensory tasks

- Distinguishing exactly what is touching him and/or where on his body
- Judging how much force is required for a task (e.g., how firmly to hold onto a pencil)
- Detecting whether he is in motion or not
- Identifying and distinguishing between different sounds
- Difficulty differentiating textures of food and smells

Behaviors include

- Difficulty following directions; gets lost easily
- Aversion to playing with puzzles or other visual games
- Frustration when unable to differentiate visual or auditory signals
- A need for directions repeated
- A need for more time than other children to perform assigned tasks

From Miller LJ (2006) *Sensational Kids: Help and Hope for Children with Sensory Processing Disorder*. New York: Putnam.

As a result the child may be slow to sit, crawl, walk, and run. This child frequently has difficulty using the two sides of the body in a coordinated manner, called poor bilateral integration. In addition, because they cannot contract the muscles needed for stability, they may exhibit poor balance. It is hypothesized that difficulty with these postural issues is related to poor detection of vestibular and proprioceptive stimuli resulting in poor muscle tone. Postural disorder is most frequently assessed using the 'clinical observations of sensory integration' by Dr. Erna Blanche, or by using a standardized motor development assessment that allows for observation of posture and balance. For example, the Miller assessment for preschoolers, The Miller function and participation scale, and the DeGangi-Berk test of sensory integration contain structured observations that are useful in the evaluation of postural disorder. The primary features of postural disorder are provided in [Table 3](#).

Dyspraxia

The second type of sensory-based motor disorder is dyspraxia, also called motor planning problems. Children with this problem have difficulty utilizing tactile and proprioceptive information to plan and carry out motor

Table 3 Characteristics of postural disorder and dyspraxia (motor planning difficulties)

Postural disorder

Sensory symptoms

- Has poor muscle tone and/or seems weak compared to other children
- Often slumps over at a desk when writing
- Has difficulty crossing the middle of his body to complete a task (e.g., uses his left hand to write on left side of a piece of paper and his right hand for the right side of paper)
- Has poor endurance and gets tired easily

Behaviors include

- Appearing lazy, unmotivated, or indifferent
- Appearing weak and limp, tires easily
- Difficulty holding his own in competitive games like tug of war

Dyspraxia

Sensory symptoms

- Has difficulty with motor activities that require more than one step (e.g., opening a carton and then pouring a glass of milk)
- Has difficulty learning new motor skills, for example riding a bicycle, tricycle, big wheels
- Is clumsy, awkward, and/or accident-prone, tripping or bumping into other people or things
- Has difficulty keeping personal spaces such as a school desk or bedroom organized

Behaviors include

- Preference for fantasy games, talking or sedentary games rather than 'doing' things
- Messy or sloppy eating
- A disheveled appearance
- Frustration when unable to complete tasks due to poor motor skills

From Miller LJ (2006) *Sensational Kids Help and Hope for Children with Sensory Processing Disorder*. New York: Putnam.

activities. Dyspraxia is different from developmental coordination disorder, a diagnosis included in the Diagnostic and Statistical Manual (DSM)-IV because the core problem is based upon deficits in sensory awareness and planning. In contrast, the core issue in developmental coordination disorder is poor motor execution. Children with sensory-based dyspraxia appear clumsy and awkward in movements and are delayed in acquiring complex motor skills such as riding a bike or tying shoes. They have problems in particular with new motor actions or activities that require a series of motor steps to perform. The 'sensory integration and praxis test' battery provides an extensive series of subtests evaluating dyspraxia. Common characteristics associated with sensory-based dyspraxia appear in [Table 3](#).

Diagnosis and Diagnostic Classification of Sensory Processing Disorder

There is controversy regarding whether SPD is a valid diagnosis because, in the past, it was not listed in diagnostic classification references such as the DSM. Recently, however, it was accepted into two diagnostic classification resources. Both focus on one classic pattern of SPD, SMD, sometimes referred to as SPDs of regulation. While the differences in terminology may be confusing, important is that, for the first time, disorders of sensory processing are now recognized across professional disciplines. As a result, children with these problems have more formal justification for receiving treatment.

Research and advocacy efforts are underway to have SPD recognized by the DSM and the International Classification of Diseases (ICD). Only when SPD is formally recognized by these standard diagnostic manuals will third party payers likely be willing to consider benefits for children with this disorder. Formal recognition will also aide in efforts to receive federal funding to research this disorder.

Prevalence of Sensory Processing Disorder

Although clinicians and educators have speculated that a large number of children are affected by poor sensory modulation, prevalence data have been nonexistent until recently. Miller and colleagues recently conducted a survey to estimate rates of SPD in incoming kindergartners from one suburban US public school district. A conservative estimate of prevalence was made, assuming that all nonrespondents failed to meet positive criteria for SMD. This cautious estimate suggested that approximately 5% of the kindergarten enrollment met screening criteria for SPD. These percentages are consistent with hypothesized estimates published in the literature.

Other Clinical Populations of Children with Sensory Processing Disorder

In addition to children with SPD and no other diagnosis, children with other clinical disorders also have characteristics of SPD. These children are described in *The Nature of Sensory Integration with Diverse Populations*, a book by Smith Roley, Blanche, and Schaaf, as well as in other publications. These populations include children from 'at risk' environments or with low birth weight, cerebral palsy, visual impairments, fragile X syndrome (FXS), or autism spectrum disorder (ASD). Given the multiple and often complex nature of the needs of this group of children, treatment of their SPD provides an excellent complement to their comprehensive program of therapeutic and educational services.

Of particular note, children with ASD and FXS demonstrate a high incidence (80–90%) of SPD, contributing to their maladaptive behavioral profile and limiting their participation in daily life activities. They demonstrate significantly more sensory symptoms than typically developing children and children in other clinical groups. Their SPD leads to a restricted range of behaviors including self-stimulation, avoidance, or fearfulness. Children with autism often demonstrate stereotypic behaviors and repetitive behaviors that are sensory seeking in nature such as spinning, hand flapping, or tapping that limits their ability to participate in the activities with their family and peers. Recently, there has been a surge in research on SPD in ASD and FXS. Given the unique cluster of behaviors and their inherent heterogeneity of children with ASD and FXS, this research is challenging, yet it promises to provide useful data to improve behavior and learning in these children.

Children diagnosed with attention deficit disorders show a range of responses to sensory stimuli with about two-thirds of those studied demonstrating some symptomatology suggestive of poor sensory processing. SPD and attention deficit hyperactive disorder (ADHD) appear to be comorbid diagnosis in approximately 40% of children. Critics of the diagnosis of SPD comment that SPD is 'just another form of ADHD'. However, children with ADHD and SPD have been compared on physiological measures such as sensory habituation and response inhibition and found to differ significantly. Thus, evidence suggests that SPD and ADHD, while frequently co-occurring, are different conditions.

Proposed Mechanisms of Sensory Processing Disorder

Ayres' theory of sensory integration is based on principles from neuroscience, biology, psychology, and education. Noting that many children with learning disorders also

demonstrated difficulty with perceptual-motor and sensory processing skills, Ayres theorized that their behavior and learning problems were, in part, due to faulty processing of sensory information and an inability of higher brain centers to modulate the information for lower brain sensory centers. In contrast to other learning-based theories, Ayres' theory was based on the relations among the underlying mechanisms and inadequate learning, behavior, and motor function. Ayres proposed that the integration of vestibular, proprioceptive, and tactile inputs provides a foundation for learning and behavior.

Ayres proposed that dysfunction occurred primarily in the brainstem, viewed as the primary integrator and modulator of sensory information. Specifically, she focused on the vestibular system and the reticular formation, an area in the brainstem, as centers for regulating responsiveness, for example, alerting, arousing, or suppressing sensory input. She believed that the cerebellum and the thalamus played major roles in sensory processing, the cerebellum through the processing of proprioception and the integration of sensory and motor stimuli, and the thalamus through integration of sensory information. Finally, Ayres viewed the limbic system as an important system that contributed to the emotions associated with sensory dysfunction. As her theory evolved, Ayres later included a focus on the role of the cerebral cortex in processing and integrating sensory information, particularly for praxis (motor planning).

Ayres' theory included a set of postulates about nervous system functioning that guided her development of an intervention model. She proposed that the nervous system has an innate drive to seek out the input that it needs for organized interactions with the environment, and that stimuli from one sensory system has the capacity to affect every other system. In addition, she outlined several key principles:

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 is a powerful mediator of plasticity.

Since Ayres outlined her theory of sensory integration, several advances in science have shaped the further evolution of the theory. Much of the evolution has been in the domain of SMD where significant scientific advances have occurred since the mid-1990s. Miller and colleagues completed a series of studies examining autonomic nervous system functioning in children with poor sensory modulation. The evidence suggests that children with severe over-responsivity to sensory stimuli have sympathetic

dysfunction as evidenced by increased electrodermal activity compared to typically developing controls. Electrodermal activity is a psychophysiological measure that evaluates how much you respond to stimuli by measuring electrical changes in the skin. Your skin conducts more electricity because of eccrine sweat gland activity. Eccrine sweat glands are innervated by cholinergic fibers of the sympathetic nervous system. Thus, measuring electrodermal activity provides an index of sympathetic nervous system activity in the brain.

The research showed that children with sensory over-sensitivity during functional activities in daily life also had significantly increased amplitudes, more frequent responses and less habituation of electrodermal responses compared to matched controls suggesting that SMD is associated with sympathetic overactivity. In addition, evaluation of parasympathetic markers suggests that children with SMD also have low parasympathetic activity.

Additional work on the mechanisms of SPD is being completed by two national workgroups: (1) the Sensory Processing Disorders Scientific Workgroup, a multidisciplinary group of established leaders in neuroscience and developmental psychobiology and (2) the Alpha research group, a national group of occupational therapy sensation processing researchers. Current research questions under study are noted in [Table 4](#). Future studies

will provide additional data about the mechanisms of SPD, the accurate identification of those with SPD and treatment of disorder.

Intervention for Individual's with SPD

The intervention for SPD is called occupational therapy with a sensory integrative approach. The goal of intervention is to improve the ability to process sensory information, providing a basis for improved independence and participation in daily life activities, play, and school tasks. The approach focuses on maximizing adaptive behavior and functional skills, and is most frequently utilized by OTs though some other professionals also have training in this intervention technique (e.g., physical therapists, speech/language therapists). Mastery of this intervention requires advanced clinical training that includes didactic coursework and mentoring as the trainee actively participates in supervised treatment.

Professionals who use the sensory integrative approach follow a set of principles, based on sensory integration theory, that guide their clinical reasoning skills. Clinical reasoning is a creative and flexible way of looking at a child's personal characteristics and context and then deciding what modifications will help the child function

Table 4 Research question and method

<i>Research question</i>	<i>Method</i>	<i>Primary researcher</i>
Do individuals with poor sensory modulation demonstrate metabolic differences compared to controls?	Proton magnetic spectroscopy study	Dr. Sinclair Smith Drexel and Temple Universities
Can physiologic correlates of early perceptual processing in individuals with poor sensory modulation determine subtypes of the disorder?	Auditory and somatosensory evoked potential study	Dr. Barbara Brett-Green University of CO Health Sciences Center
Does the sensory gating evoked potential (P50) discriminate children with over-responsivity from matched controls?	Auditory ERP study	Dr. Patricia Davies CO State University
Are there genetic factors that relate to the etiology of SPD?	A twin study	Dr. Hill Goldsmith University of Wisconsin at Madison
Is there a difference in dopamine D2 receptor binding availability, presynaptic dopamine synthesis and serotonin receptor availability in SPD?	A positron emission tomography (PET) study using a primate animal model	Dr. Mary Schneider University of Wisconsin at Madison
Are selective serotonin reuptake inhibitors and GABA agonists pharmacologic agents effective in affecting sensory gating?	Rat model	Dr. Edward Levin Duke University
Is low parasympathetic activity a marker of over-responsivity to sensation?	Vagal tone study	Dr. Roseann Schaaf Thomas Jefferson University
Do children with SPD show changes in cortisol levels during the Sensory Challenge Protocol?	Salivary cortisol study	Dr. Stacey Reynolds Virginia Commonwealth University
Can a reliable performance assessment be developed to characterize sensory over-responsivity?	Psychometric child and adult study	Dr. Lucy Miller and Dr. Sarah Schoen Sensory Processing Disorder Research Institute

GABA, gamma-aminobutyric acid; SPD, sensory processing disorder; ERP.

more successfully, in the moment. Rather than a rigid formula for what to do, clinical reasoning is an elastic way to think.

These principles are described in detail in several books that are designed to guide therapists through the clinical reasoning process using sensory integration theory. The primary principles of this intervention approach are described as follows: (1) the intervention is rich in sensory opportunities especially tactile, proprioceptive, and vestibular sensations; (2) activities are tailored to provide the 'just right challenge' for the child's developing skills; (3) intervention is 'child directed', for example, the therapist reads and follows the child's cues guiding him/her to seek the needed sensory activities; (4) intervention supports the child's arousal level, self regulation, and organization of behavior; and (5) the context of intervention is play; (6) the focus of intervention is on obtaining 'adaptive responses', identified by Ayres as a 'purposeful, goal-directed response to a sensory experience'. Therapy consists of fun activities that range from very simple (responds to passive stimuli or maintains organization during multisensory activities), to moderately challenging games (initiates and sustains an activity requiring familiar movements), to quite complex activities (initiates and executes a complex activity requiring unfamiliar complicated movements requiring exact timing and multiple adaptations). The focus on the adaptive response ensures that each activity is challenging (a little hard for the child) but also that the child succeeds (often with help or scaffolding from the therapist). These activities that meet these criteria provide the 'just right challenge', and provide the best chance of facilitating learning and development.

OT with a sensory integration approach is a unique intervention because it addresses the underlying substrates of dysfunction (e.g., neurological immaturity) rather than just difficulties with skill performance. The therapeutic environment resembles a huge playroom or gymnasium with suspended swings, pillows, mats and large balls, and the equipment taps into the child's inner drive to play. Therapy provides opportunities for engagement in sensory and motor activities rich in tactile, vestibular, and proprioceptive sensations. The therapist uses keen observation skills to detect and interpret the child's behaviors and interests, and then creates a constantly changing playful environment in which the child actively pursues achievable challenges. For example, occupational therapy using a sensory integrative approach for a child with over-responsivity to tactile and vestibular input might include an activity such as climbing up a rope ladder to access a hanging trapeze swing, swinging across the room while holding the trapeze bar, and then 'crashing' into a large ball pit (surrounded by mats and pillows for safety). During this activity, the child is enticed into play that is rich in vestibular (swinging), proprioceptive (climbing), and tactile (ball pit) input and thus through play his or her over-responsivity to sensory stimuli is modulated.

The therapist focuses on the specific adaptive responses needed by each individual – evolving from tolerating the sensory demands, to adapting to the challenges by beginning to organize motor responses. Play serves as the medium to engage the child so that even though the child may be hesitant initially, the urge to play in a colorful, fun environment outweighs hesitation and encourages participation. Ayres called this 'the art of therapy' or the careful process whereby the therapist actively adapts activities to match the child's emerging skills always ensuring that the child has fun. Thus, the child is guided through challenging but fun activities designed that stimulate the sensory systems, challenge the motor system, and facilitate performance of cognitive, attentional, social, and emotional tasks. Ultimately, the child begins to process sensory information in more typical ways and this improved 'sensory integration' provides the foundation for more organized and competent play, self regulation, self esteem, learning, and participation in daily routines. In addition to direct intervention with the child, the therapist also collaborates with and educates the parents, teachers, and others who are involved with the child.

Recent developments in the field have advanced and refined the protocol for using OT with a sensory integrative approach in part because defining intervention in a manner that is replicable is required for treatment effectiveness studies. The existing literature that addresses the effectiveness of intervention is fraught with methodological problems that limit interpretation and utility including the lack of replicable intervention (e.g., a manualized approach). Recently, the collaborative multisite group of occupational therapy clinicians and researchers developed a 'Fidelity to Treatment' measure. This scale outlines the core principles and philosophy of the intervention, and also provides a mechanism to evaluate whether the intervention uses a sensory integrative approach. This tool will be useful in future studies examining the effectiveness of intervention.

Another effort to define the intervention in a replicable, valid manner is the work of Miller and colleagues who have operationalized the principles of the sensory integrative approach into an intervention protocol that guides therapist's clinical reasoning and parent education. This model, 'A SECRET', provides an organizational framework to guide treatment sessions.

A SECRET has seven elements:

- A Attention
- S Sensation
- E Emotion regulation
- C Culture
- R Relationships
- E Environment
- T Tasks

The first three elements – attention, sensation, and emotion regulation – are the individual characteristics

that influence children internally. The last four – culture, relationships, environment, and tasks – are the contextual elements that influence children externally.

Using 'A SECRET', the therapist tries out and then provides a 'toolbox' of strategies for the parent and child using the therapy 'secrets' that increase the child's performance, social participation, and self-confidence/esteem. Finally, other specific goals and priorities of the family are addressed.

Intervention by OTs and other professionals using this approach is not a quick 'fix'. It is a therapeutic program designed to improve the child's ability to neurologically process sensory information improving the quality of the child's life by enhancing his or her ability to learn and play. Treatment can take place in a number of settings: public schools, hospitals and outpatient clinics, and private practices. In all these settings, the role of intervention is to improve the child's ability to interact socially, to regulate him or herself, to maintain self-esteem, and to be independent in their daily living skills. Therapeutic methods in a school-based program compared to a direct service private therapy program are different. The child's treatment experience is significantly influenced by the setting of the therapy.

Evidence Evaluating Effectiveness of Intervention

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 to intervention. About half of the studies demonstrate some type of treatment effectiveness. Two meta-analyses and four research reports have been published summarizing the outcomes of these various studies; some of the syntheses conclude that the approach is effective and other syntheses suggest the intervention was equally effective as other approaches or not effective.

At this point in time, interpretation of the findings of these 80 studies is difficult due to three methodological limitations. The first limitation is defining the independent variable (the treatment) in a manner that is replicable. As this intervention approach is individualized (similar to the way psychotherapy is individualized), standardization of treatment has been a challenge to the researchers. With the development of the 'fidelity to treatment' measure and A SECRET, future intervention studies will be more able to adhere to a manualized treatment approach.

A second limitation is the outcome measures utilized. Previous research used outcomes not specifically related to the proposed changes from intervention. In addition, a quantity of research has been conducted on sensory stimulation rather than embedding it in the context of a full OT program as was originally intended. Ayres always used an 'occupational frame of reference' in providing intervention

(e.g., the goals of therapy were functional abilities and routines, including the 'occupations' of childhood such as sleeping, eating, dressing, playing, interacting with others, learning, and active participation). Studies that do not use this frame of reference do not inform evidence-based practice related to OT using a sensory integrative approach.

Few studies establish a theoretical basis for their hypotheses, asking a global question instead, for example, 'does sensory integrative treatment work?' can be seen as a simplistic and atheoretical question. The last limitation of previous studies is that multiple outcome measures are utilized with no good explanation of how the outcomes relate to the suspected effects of treatment, for example, a 'fishing expedition' approach, hoping to find 'something' that might be statistically significant. This results in low power to detect significant changes.

The collaborative multisite occupational therapy research team that developed the 'fidelity to treatment' measure 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 allowing comparison of achievement across diverse functional outcomes. GAS in combination with physiologic outcome measures is envisioned to provide a method of measuring effectiveness that will increase the integrity, strength, and replicability of effectiveness studies.

The final limitation relates to the homogeneity of the samples studied. Previous researchers have not defined a homogenous sample. The heterogeneity of samples in previous research increased the within group variability and again the probability of finding significant group differences was reduced. Now with the 'short sensory profile' and the physiologic paradigm, the 'sensory challenge protocol', highly selective inclusion criteria, can be utilized to select specific sensory processing subtypes for study samples. Building on this work, future studies can define samples in a manner that allows replication across sites.

The limitations in previous studies have resulted in a lack of consensus regarding the effectiveness of OT using an SI approach. Given the current constraints 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 additional work is needed before valid conclusions about the effectiveness of this intervention approach can be derived.

Conclusion

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 the effectiveness of occupational therapy in ameliorating SPD. Hence, a clear and exciting call to action exists. We and others are implementing a series of studies to elucidate the underlying mechanisms of the impairment, to define the phenotypic characteristics of the disorder, to discriminate the disorder from other developmental disorders (ADHD and autism), and to evaluate the effectiveness of OT 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 that will increase rigorous scientific data and move the field forward. Scientists and practitioners are collaborating to conduct research that leads to more specific diagnoses and more effective interventions, thereby improving the lives of children with SPD and their families.

See also: ADHD: Genetic Influences; Autism Spectrum Disorders; Developmental Disabilities: Cognitive; Fragile X Syndrome; Perceptual Development.

Suggested Readings

- Ayres AJ (1972) *Sensory Integration and Learning Disorders*. Los Angeles: Western Psychological Services.
- Ayres AJ (1979) *Sensory Integration and the Child*. Los Angeles: Western Psychological Corporation.
- Bundy AC, Lane SJ, and Murray EA (2003) *Sensory Integration Theory and Practice*. Philadelphia: F.A. Davis.
- Kranowitz C (2005) *The Out of Sync Child*. (Revised). New York: Penguin.
- Miller LJ (2006) *Sensational Kids: Help and Hope for Children with Sensory Processing Disorder*. New York: Putnam.

- Miller LJ, McIntosh DN, McGrath J, *et al.* (1999) Electrodermal responses to sensory stimuli in individuals with fragile X syndrome: A preliminary report. *American Journal of Medical Genetics* 83(4): 268–279.
- Parham D and Mailloux Z (1995) Sensory integrative principles in intervention with children with autistic disorder. In: Case-Smith J, Allen AS, and Pratt PN (eds.) *Occupational Therapy for Children*, pp. 329–382. St. Louis, MO: Mosby.
- Schaaf RC and SmithRoley S (2006) *Sensory Integration: Applying Clinical Reasoning to Diverse Populations*. Tucson, AZ: The Psychological Corporation.
- Smith Roley S, Blanche E, and Schaaf RC (eds.) (2001) *Understanding the Nature of Sensory Integration with Diverse Populations*. San Antonio, TX: The Psychological Corporation.

Relevant Websites

- <http://www.abilitations.com> – Abilitations.
- <http://www.aota.org> – American Occupational Association.
- <http://www.icdl.com> – Interdisciplinary Council on Developmental and Learning Disorders.
- <http://www.KIDFoundation.org> – KID Foundation.
- <http://www.neurolearning.com> – Neurological Concepts.
- <http://www.out-of-sync-child.com> – Out of Sync Child.
- <http://www.sierf.org> – Sensory Integration Education and Research Foundation.
- <http://www.sensory-processing-disorder.com> – Sensory Processing Disorder Resource Center.
- <http://www.sensorycomfort.com> – Sensory Products.
- <http://www.sensoryresources.com> – Sensory Resources.
- <http://www.genjereb.com> – Sensory Tools.
- <http://www.southpawenterprises.com> – Southpaw.
- <http://www.spdnetwork.org> – SPD Network.
- <http://www.seriweb.com> – Special Education Resources on the Internet.
- <http://www.Sifocus.com> – The international magazine dedicated to improving sensory integration.
- <http://www.spinkids.org> – This site raises awareness of sensory processing disorder.

Separation and Stranger Anxiety

A Scher and J Harel, University of Haifa, Haifa, Israel

© 2008 Elsevier Inc. All rights reserved.

Glossary

Anxiety – The psychological and physiological reaction to an anticipated danger, real or imagined.

Distress – An intense negative reaction to adverse events. The reaction may be emotional and/or physical.

Person and object permanence – The understanding that people and objects continue to exist when they are not directly observed.

Separation anxiety – A distress reaction in response to separation from the primary caregiver.

Separation anxiety disorder (SAD) – Developmentally inappropriate and excessive anxiety concerning actual or anticipated separation from the caregiver, most often the parents.

Stranger anxiety – The fearful, distressed response that infants exhibit when approached by an unfamiliar person, in the second half of the first year.