

# Sensory Modulation Dysfunction: Identification in Early Childhood

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For decades, large numbers of infants and toddlers have been identified by occupational therapy clinicians as having sensory-related disorders (Bundy, Lane, & Murray, 2002; Roley, Blanche, & Schaaf, 2001). These disturbances have been termed *sensory integration dysfunction* (Ayres, 1972a; Cermak, Koomar, & Szklut, 1999; Kranowitz, 1998; Parham & Mailloux, 2001). Among psychologists and other mental health experts, there has been widespread recognition of a problem for infants and toddlers that has similar sensory components and is termed *regulatory disorder* (Greenspan & Wieder, 1993; Greenspan, Wieder, & Simons, 1998). It is important to illuminate the similarities and differences between these two diagnostic categories in order to advance toward a broader, more comprehensive understanding of sensory disorders in early childhood, to increase the clinical utility of terms, and to increase effective communication for more focused prevention and intervention.

The overall objective of the chapter is to familiarize mental health professionals with the existence of these sensory problems and to highlight the importance of evaluating sensory processing

difficulties when determining a diagnostic formulation in young children referred for a variety of behavioral difficulties. First, we provide a brief discussion of definitional issues and compare and contrast mental health and occupational therapy perspectives of sensory-related disorders. Second, we provide an overview of the developmental issues relevant to the understanding of sensory-related disorders. Third, we provide a discussion of sensory modulation dysfunction (SMD), including a brief description of related empirical evidence. Finally, we review the clinical implications for assessment of sensory-related disorders and conclude by highlighting the questions that remain to be addressed in future research.

## DEFINITIONAL ISSUES

This section clarifies the definition of various terms used in the area of sensory-related disorders within the field of occupational therapy (OT) and by the National Center for Clinical Infant Programs (NCCIP). Within OT, this classification scheme was developed in relation to a condition

termed sensory integration dysfunction (DSI; Fisher & Murray, 1991). Within NCCIP, descriptions of sensory and motor processes are found under a condition termed regulatory disorders (Zero to Three, 1994). The development of classification schemes for DSI and for regulatory disorders developed in parallel; they continue to evolve independently. Though conceptually related, the DC:0-3 scheme and the DSI patterns of dysfunction have not previously been compared in the literature.

### Sensory Integration Dysfunction

Ayres (1972a), an occupational therapist and educational psychologist, first proposed use of the term *sensory integration dysfunction*. This pattern of disturbance has also been called dysfunction in sensory integration, and a recent consensus paper recommended use of the abbreviation DSI to avoid confusion with SIDS, sudden infant death syndrome (Miller & Lane, 2000). Ayres proposed that DSI is a multifaceted problem including the following discrete patterns of dysfunction differentiated by Lane, Miller, and Hanft (2000):

1. *Sensory detection dysfunction*, difficulty with awareness or registration of incoming sensory signals. Difficulties with sensory detection are observed in children who seek an unusual amount of sensation (for example, smelling everyday objects such as doorknobs) or who do not appear to feel even highly salient sensation (for example, they touch a hot surface and do not feel pain).

2. *Sensory modulation dysfunction*, difficulty modulating and regulating the degree, intensity, and nature of responses to sensory input in a graded and adaptive manner, so that an optimal range of performance and adaptation to life challenges is maintained (for example, overresponding to an unexpected tap on the shoulder with aggressive lashing out or by withdrawing).

3. *Sensory discrimination dysfunction*, difficulty perceiving the particular characteristics of objects without seeing them (for example, stereognosis is the ability to know what you are touching or feeling without vision, such as knowing you are handling keys in your pocket).

4. *Postural dysfunction*, difficulty maintaining functional body patterns (for example, normal

muscle tone, awareness of body position, and movement through space (Lane et al., 2000).

5. *Dyspraxia*, difficulty with the conceptualization, organization, and execution of nonhabitual motor tasks. Praxis is engaged when the demands of the action are novel or challenging (nonautomatic) and require ideation, planning, modification, or self-monitoring for their adaptive execution. This problem is believed to have a sensory component in some children observed, as problems executing fine motor, gross motor, or visual motor tasks combine with inadequate perception of the underlying sensory demands of the tasks.

The second pattern above, SMD, is one of the primary patterns of DSI found in infants and young children and therefore is highlighted in this chapter (Ayres, 1966, 1972a, 1979, 1989; Fisher, Murray, & Bundy, 1991; Lane, 2002; Parham & Mailloux, 2001). While everyone experiences difficulty modulating their response to sensory input at some moments in life, to be considered SMD, these difficulties in regulating responses to sensation must be so severe that normal daily routines are impaired. People with SMD may also have other patterns of DSI.

While theoretical descriptions of SMD in children ages birth to 3 years appear in the literature (Schaaf, 2001; Williamson & Anzalone, 2001), there are only a few empirical references validating the disorder, all with children ages 4 years and older (McIntosh, Miller, Shyu, & Hagerman, 1999; Miller et al., 1999; Miller, Reisman, McIntosh, & Simon, 2001). In infants and toddlers, the sensory processing difficulties associated with SMD often present as sleep disorders, eating disorders, problems with organized play, and emotional outbursts after sensory input (Williamson & Anzalone, 2001). More research is needed to differentiate normal developmental variations in early patterns of sleeping, eating, playing, and emotion regulation from behavioral patterns of SMD.

### Regulatory Disorders in the DC:0-3

The National Center for Clinical Infant Programs, Zero to Three has developed a taxonomy for infant and toddler diagnostic classification of devel-

opmental disorders, the *Diagnostic Classification of Mental Health and Developmental Disorders of Infancy and Early Childhood* (DC:0-3; Zero to Three, 1994). This classification, which is becoming widely used by clinicians, was developed through systematic observation and theoretical consolidation by expert clinicians (see chapter 8).

According to the DC:0-3, regulatory disorders present in infancy and toddlerhood as an inability to regulate behaviors and responses in the domains of physiology, sensation, attention, motor, and affective processes (DeGangi, 2000). Children show difficulties in modulating and integrating physiological, sensory, motor, attentional, or emotional processes to achieve an organized, calm, and alert state (Greenspan & Wieder, 1993). These difficulties, which are thought to represent constitutional and maturational characteristics, can interfere with both cognitive (learning) and social (relationship) domains.

The DC:0-3 scheme identifies four types of regulatory disorders:

1. *Type I: Hypersensitive.* These children are overresponsive to a variety of stimuli. Two behavioral patterns are described: (a) fearful/cautious and (b) negative/defiant. The former category includes compromised visual-spatial processing abilities, whereas the latter category does not. Children in both categories have sensorimotor patterns that are overresponsive to tactile, auditory, and visual stimuli.

2. *Type II: Underreactive.* These children are underresponsive to a variety of stimuli. The two behavioral patterns are (a) withdrawn/difficult to engage and (b) self-absorbed. The former category co-occurs with apathy, depression, limited responsivity to sensation, and impoverished motor exploration. Dyspraxia and auditory/verbal processing problems may occur, but visual-spatial skills are intact. The second category, self-absorbed, includes inattentive, distractible, and preoccupied behaviors with a preponderance of solitary play that may be rich in fantasy. These children have decreased auditory and verbal skills, particularly receptive language, and may or may not have other sensorimotor problems.

3. *Type III: Motorically disorganized, impulsive.* These children crave sensory input and have poorly controlled behavior. The two behavioral

patterns are (a) aggressive/fearless and (b) impulsive/disorganized. These children have extremely high activity levels, seeking extraordinary touch contact and deep pressure stimulation. The child may intrude on others' space and materials. They exhibit poor motor planning and organization that may be interpreted as aggression. Sensory underresponsivity is hypothesized to relate to craving input and to poor motor modulation and planning.

4. *Type IV: Other.* The category is for children who meet criteria for regulatory disorder but are not described by types I, II, or III.

#### Overlap Between DC:0-3 and SMD Classification Taxonomies

The sensory and motor processes described under the rubric of regulatory disorder parallel the behavioral descriptions of DSI (Roley et al., 2001). The behavioral manifestations of these patterns of dysfunction are similar. In addition, there appears to be much overlap with respect to subtypes. The overlap between the subtypes of SMD and regulatory disorders is reflected in table 13.1.

#### DEVELOPMENTAL ISSUES

A young child's emotional and behavioral distress, particularly if it is persistent, is potentially quite challenging for parents and clinicians. In infancy and early childhood, the source of the distress may relate to sensory, emotional, and attentional dysregulation. At present, however, there is very little empirical data that can guide a clear demarcation between these three related domains of functioning. Nonetheless, a careful screening of sensory, emotional, and attentional systems may be clinically useful in understanding sensitivity to sensory stimuli in relation to emotional reactivity.

#### Emotion Regulation and Sensory Processing

To understand the developmental perspective of emotion regulation as it relates to sensory processing, it is necessary to briefly summarize theo-

**Table 13.1** Overlap Between Regulatory Disorder and SMD Categorizations

Regulatory Disorder Categorization		SMD Categorization
401: Type I	Hyperreactive	Oversensitive/active
402: Type II	Underreactive	Undersensitive/passive
403: Type III	Motorically disorganized, impulsive	Undersensitive/active (SMD) and/or dyspraxia (DSI)

ries of emotion and the relation between emotion and behavioral adaptation. This brief review provides a framework for the later discussion of emotion regulation and dysregulation as it relates to SMD.

### *Theories of Emotion Regulation*

Various disciplines refer to emotions as configurations of feelings, intentions, and actions; some theories focus only on one or another of these components, while others consider the entire emotion process. Cognitive theories of emotion (Lazarus, 1991; Scherer, 1984) are particularly relevant because they provide an understanding of the role of sensory processing in the emotion generation process. While not specifically developmental, core principles of the cognitive perspective can be adapted to the emotional experience of infants, toddlers, and young children.

Different emotional states correspond to distinct mental and bodily experiences. For most individuals, the experiences of joy and fear are easily discriminated, but for some, the experiences of fear, anger, or sadness are not so clearly different. For infants and toddlers, who have not yet had the opportunity to fully develop a differentiated emotional repertoire, this may be especially true. Distress may be experienced as a blend of fear and anger, creating confusing behavioral signals for caregivers. With development comes an emerging emotional competence that includes the child's ability to verbally differentiate and label emotional experiences (Saarni, 1990).

An emotional state is also fundamentally a state of *action readiness* (Frijda, Kuipers, & ter Schure, 1989). When people like something, the emotion of joy readies them to approach. When they are frustrated, they are similarly ready to approach, but also to attack and remove the frustra-

tion. When they are afraid, they prepare to leave. This description suggests a primitive, automatic process that fits what is observed in young children when they like, dislike, or fear what is happening in their environment. They often act quickly, without pause, on the emotional impulses that arise from contact with particular sensations. Throughout early childhood, adults socialize children to slow down this impulse to act and to adapt to culturally accepted modes of expressing their joy, frustration, and fear (Saarni, 1990).

Emotions arise only when we appraise something in the environment as important to our goals (Lazarus, 1991). If something is not important, an emotion will not arise. For example, a 4-month-old infant typically does not react with distress when a stranger approaches because he or she has not yet developed the pattern of responses that signal the crystallization of specific attachments, whereas a 10-month-old who has developed attachments and a concomitant stranger anxiety will react with distress. This appraisal process is thought to be highly automatic, especially in relation to sensory stimuli, and is evident in the infant's reactions to the smell of its mother's breast milk within several days after birth (Scherer, 1984). Kandel and Schwartz (1991) call this appraisal a "valuation" that filters information, allowing some information in and excluding other information.

Sensory nerves feed the amygdala, one of the central areas in the brain where the emotion appraisal process arises, through subcortical as well as neocortical pathways (LeDoux, 1993). Nerve signals from the amygdala are directly linked to the autonomic nervous system, the part of the nervous system responsible for heart and respiration rates and the release of various hormones that prepare the body for action. Autonomic re-

sponses associated with emotion are evident in infancy as early as the newborn period (Fox, 1989; Fox & Davidson, 1986).

Hence, bodily sensations may be the first conscious signal that something is awry or feels good. An emotionally distressed child commonly reports a stomachache or other physical ailments. Adults often socialize the young child's experience, interpreting for the child the cause of these internal bodily sensations and feelings. For children and adults whose bodily sensations are well regulated, socialization of emotion happens smoothly. For example, the exhilaration of happiness in reuniting with someone will be expressed through smiling, positive vocalizations, and embracing. However, for a child who is hypersensitive to touch, embracing may be uncomfortable. While this child might initially appear happy by smiling and vocalizing during reunion, when the embrace occurs, the child may withdraw from contact or even cry. This confusing set of behaviors may lead parents to feel hurt or confused, possibly initiating a complex maladaptive interaction process.

#### *Emotion Regulation and Behavioral Adaptation*

The child's signaling of his or her experience of an event is the beginning of the adaptation process. To the extent that sensory experiences are commonly shared in a culture (e.g., strong odors are disliked; hugging creates pleasure), adults will accurately interpret a child's responses. However, when an individual's sensory experiences are unusual, either in terms of their source (e.g., aversion to being held) or in terms of the threshold of perception as noxious, adults may misinterpret the child's response. For example, avoidance of sensory stimulation may be interpreted as fear, and the child may be allowed to avoid many situations to reduce his or her distress. Seeking of sensory stimulation may be misread as out-of-control behavior, and the child may be punished. Thus, children with SMD may detect sensory information at too high or low a level, thus triggering emotional processes that are not appropriate to the context of specific tasks, environments, or cultures. Most individuals do not react emotionally to sensory stimuli experienced in the low to middle range. However, individuals who experi-

ence lights as too bright, sounds as too loud, or wind as too powerful may try to avoid these experiences or may experience strong emotional reactions or distress in these situations.

A child's adaptive functioning is supported when sensory stimuli are not overwhelming and when emotions are well regulated. Cole, Michel, and Teti (1994) define emotion regulation as "the ability to respond to the on-going demands of experience with a range of emotions in a manner that is socially tolerable and sufficiently flexible to permit spontaneous reactions as well as the ability to delay spontaneous reactions as needed" (p. 76). Emotions are considered dysregulated if interference with other functions (e.g., sustained attention, activating memory, or interacting with others) occurs. For example, children with attention deficit disorder have poor peer relations in part because of their poorly timed and excessive expression of positive affect (Cole et al., 1994). Thus, both regulated and dysregulated emotions are attempts to control behavior and communicate intentions to others.

Achieving consistent emotion regulation is a major developmental task, largely accomplished by school age, but unreliable in early childhood. Cole et al. (1994) describe two major types of emotion dysregulation: underregulation and overregulation. Underregulated behaviors tend to be overly expressive or extreme and require others to assist the child to maintain control, by soothing or limiting the child's exposure to events that give rise to strong emotions. Overregulated emotions are held in tightly, as in the freezing response, and the child may need assistance from others to express what they experience. Both underregulated and overregulated emotions lead to compromises in the child's ability to respond flexibly in certain contexts and may place the child at risk for psychopathology. When difficulties in emotion regulation become pervasive, across multiple contexts and long periods of time, treatment for an emotional disorder may be considered.

We now turn our focus specifically to the characteristics of SMD. We describe the following: (a) behavioral description of SMD subtypes, (b) a conceptual model of SMD, and (c) recent research that examines the empirical evidence of the existence of SMD as a syndrome, including a

parent rating scale to detect SMD and a psychophysiological laboratory procedure to confirm the behavioral diagnosis.

## RESEARCH ON SENSORY MODULATION DISORDER

A recent initiative developed a consensus of terminology related to children with DSI (Hanft, Miller, & Lane, 2000; Lane et al., 2000; Miller & Lane, 2000). Clarifying terminology was perceived as a starting point for clear communication within the field, as well as across other related disciplines. Particular emphasis was placed on differentiating between the normal processes of sensory functioning, and the abnormal processes and behaviors associated with DSI, with SMD representing only one of several patterns of DSI.

Individuals respond to sensations along a spectrum, and for an individual to have SMD, not only must abnormal emotional and behavioral responses to sensation be observed, but adaptive functioning must also be impaired. Typically, children with SMD have responses that are so impaired that significant daily life challenges occur. For example, a mother in our study commented, "My family is in jail. We can't go anywhere together because we never know when Johnny will fall apart. We have stopped going to church, and we never go to a movie or shopping together, since one of us has to stay home with him." More research is needed to document not only emotional and behavioral responses characteristic of SMD but also levels of impaired functioning that co-occur.

SMD has been described in a variety of chapters and newsletter manuscripts, but in only a few peer-reviewed publications (see, for example, Ayres, 1972a; Bundy et al., 2002; Fisher et al., 1991; Kimball, 1993; Kinnealey & Miller, 1993; Parham & Mailloux, 2001; Roley et al., 2001). As research generally has grown in this area, the concept of sensory modulation dysfunction has evolved. It began with definitions based strictly on behavioral descriptions of children by clinicians (Ayres, 1972a) and with factor analytic studies (Ayres, 1969, 1972c, 1977) of standardized neuropsychological scales, such as the South-

ern California Sensory Integration Test (Ayres, 1972b) and the Sensory Integration and Praxis Scale (Ayres, 1989). More recently, conceptions of SMD have broadened to include physiological constructs related to functioning, emphasizing the role of the autonomic nervous system in regulating underlying processes responsible for sensory responsivity (McIntosh, Miller, Shyu, & Hagerman, 1999; Miller et al., 1999; Parush, 1993; Parush et al., 1997; Schaaf, 2001; Schaaf, Miller, Sewell, & O'Keefe, 2003).

## Subtypes of SMD

Two primary types of SMD have emerged in the OT literature based on different types of behaviors presented by children. They developed as an outgrowth of clinical observations, similar to the way that the DC:0-3 schemes developed. The types are oversensitive and undersensitive to sensory stimulation (Dunn, 1999; Koomar & Bundy, 2002; Lane, 2002). Behaviors of children who are oversensitive include fight, fright, and freeze responses. Behaviors of children who are undersensitive include sensation seeking and lack of awareness of sensation. Table 13.2 details behaviors (and sensory-related examples) associated with the two behaviorally derived primary subtypes of SMD.

Our research team has organized these responses in a 2 × 2 conceptual framework, in a clarification of the model proposed by Dunn (1997). This new conceptualization highlights both passive and active categories in the oversensitive and undersensitive behavioral responses to sensory stimulation. The framework is presented in table 13.3.

While table 13.3 highlights two subtypes of SMD, some children have *fluctuating SMD*, with responses that are at times oversensitive and, at other times, undersensitive. These fluctuations may occur in response to external circumstances or may be related to different responses in various sensory systems. For example, a child may demonstrate sensory seeking in one domain (e.g., movement) while exhibiting sensory avoiding in another domain (e.g., tactile). To guide both empirical and clinical work, a conceptual model is needed that can address the complex, internal

**Table 13.2 Behaviors Associated with Two Primary Types of SMD**

Oversensitive to Sensation	Undersensitive to Sensation
<i>Flight</i> —may withdraw from sensation (e.g., may run and hide under a table with ears covered when they hear a vacuum or a fire engine)	<i>Overfocused</i> —children persevere on tasks; shifting attention between tasks or environments is difficult (e.g., take physical prompt to move from one task to another; may watch a video over and over and become overfocused on it so that you have to touch them to get their attention)
<i>Fight</i> —children become highly aroused with sensation and may become aggressive (e.g., when standing in line with other children and jostled, may hit person behind them in line)	<i>Unaware</i> —May respond lethargically when presented with normal levels of stimuli, needing intense stimulus over a long period to notice stimulus (e.g., may not notice pain when they fall down; may seem withdrawn or in their own world unless stimulus is intense)
<i>Freeze</i> —Distressed by sensation; may over-respond to low levels of stimulation (e.g., may freeze in seat and show severe distress when they hear fire bell in fire drill at school)	<i>Seeks</i> —May need an atypically large or long duration of sensation to feel the stimulus (e.g., can spin or swing "forever" without really seeming to feel it; jump, run, crash into walls or jump on mattresses for long periods of time)

processes involved in SMD as well as the external stimulation.

**A Conceptual Model of SMD**

Miller, Reisman, McIntosh, and Simon (2001) developed a conceptual model of SMD to depict the internal and external factors affecting children with SMD (see figure 13.1).

The model embodies ideas from a long tradition of developmental literature on the importance of context as it influences children's development (Bronfenbrenner, 1979; Cole, 1985; Vygotsky, 1962). The external dimensions of this

conceptual model reflect the contextual elements that affect the way in which SMD manifests at a particular moment. SMD occurs when a mismatch exists between what is expected of a child and what he or she can do (Bates & Wachs, 1994; Chess & Thomas, 1995; DeGangi, 2000). Table 13.4 reflects the limitations in functional participation that can result from SMD (e.g., problems at home, at school, and in the community).

The conceptual model also incorporates internal dimensions of SMD. The dimensions, represented by the three circular levels in figure 13.1, represent sensation, attention, and emotion, each divided into quadrants: oversensitive, normal sen-

**Table 13.3 Active and Passive Behavioral Response Characteristics for Two SMD Subtypes**

	Oversensitive Behaviors	Undersensitive Behaviors
Active behavioral response	<i>Defensive</i> : moves away or strikes out with stimulation	<i>Seeks stimulation</i> : constantly pursues sensory input
Passive behavioral response	<i>Anxious</i> : becomes quiet, worried, or withdraws from sensory stimulation	<i>Unaware</i> : lethargic; uninterested unless stimulation is intense

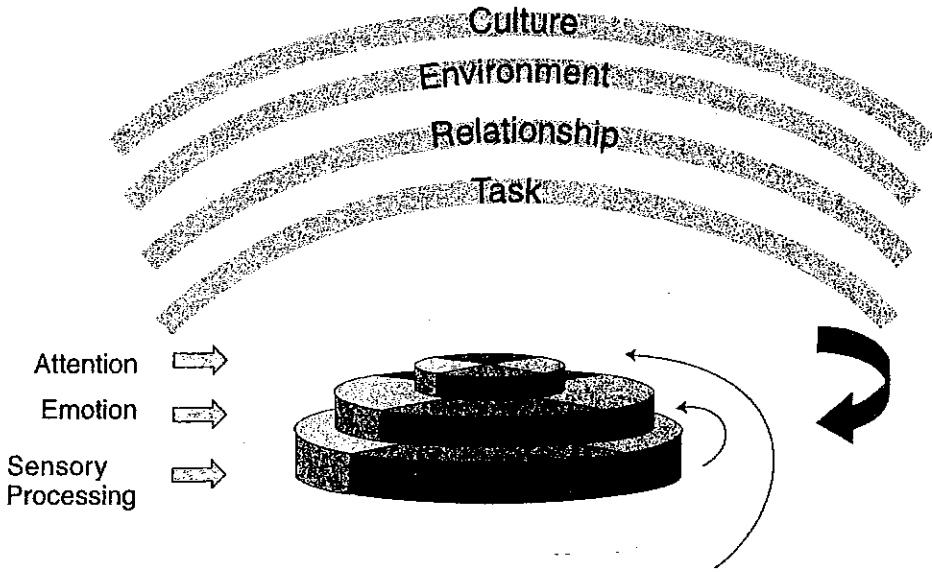


Figure 13.1 Ecological model of sensory modulation.

sitivity, undersensitive, and fluctuating sensitivity. The internal dimensions describe individual differences among persons in the following areas:

1. *Sensation*—the ability to receive and manage sensory information resulting in appropriate responses
2. *Emotion*—the ability to accurately perceive emotional cues and regulate affective and behavioral responses
3. *Attention*—the ability to sustain performance and inhibit impulsivity for task completion and effective interpersonal relationships

This model draws on the classic formulation of temperament by Chess and Thomas (1984), who relied on variations in sensation, emotion, and attention to describe the typical styles of responding in early childhood. Findings from the MacArthur Longitudinal Twin Study (Emde, Plomin, & Hewitt, 2001) suggest that there are genetic influences on emotion expression and attention in infancy and early childhood. However, little is known about the constitutional basis of sensation.

Table 13.5 reflects the individual impairments that can occur from limitations in the three inter-

nal dimensions. These impairments may occur in isolation but are frequently combined (e.g., a difficulty in sensation may co-occur with an attention or emotion problem).

By considering both internal and external dimensions of SMD, one may predict certain mismatches between children's innate disposition and how they react to the external dimensions of their world. In the temperament literature, such mismatches are associated with poor functioning of the parent-child dyad; however, little empirical research has been conducted on the consequence of temperamental mismatches or the relation of temperament and sensory responsivity; thus, at present the concept primarily has clinical utility.

#### The Need for More Research on Regulatory Disorders and SMD

Behavioral descriptions of regulatory disorder are similar to those of SMD. Yet, little empirical evidence differentiates the two classifications. Given the strong similarity in subtypes noted in table 13.1, children in the 0 to 3 age group with dysfunction might be given either or both diagnoses. The empirical evidence comparing validity and

**Table 13.4 Functional Participation Limitations Related to Mismatch Between Child's Capacities and External Dimensions**

External Dimensions	Behaviors Observed in Child
Relationship expectations	Child with SMD cannot tolerate expected closeness in relationships; is unable to make and keep friends; fights with siblings and peers; poor participation in family routines and outings.
Task expectations	Child with SMD needs specified conditions to complete tasks (e.g., structuring the task to have small steps to reduce its complexity).
Environmental expectations	Child with SMD requires specific environment to maintain appropriate arousal level (e.g., creating a quiet, nondistracting space in which to work). May have severe difficulties at school because environment causes inattention and/or aggression.
Cultural expectations	Child with SMD responds negatively to demands of the general culture (i.e., cannot comfortably attend birthday parties, go to community celebrations such as parades, participate in team sports, go to church, libraries, parks, etc.).

clinical utility of both categories, regulatory disorder and SMD, is lacking.

Although DC:0-3 appears to be a reasonable clinical taxonomy, little data exist related to the validity of the separate groupings in the taxonomy. The DC:0-3 classification scheme discusses the relative importance of physiology, sensation, attention, and motor processes to dysregulated behavior but does not demonstrate these abnormalities empirically. Thus, the constitutional and neurodevelopmental bases of regulatory disorders

have not yet been validated. The DC:0-3 case summary book focuses on affective and psychosocial aspects of the disorder, and the presumed underlying, neurodevelopmental processes are not addressed (Lieberman, Wieder, & Fenichel, 1997). The DC:0-3 developers discuss the need to refine the diagnostic system (Zero to Three, 1994); however, this has not been accomplished to date. Given the relative novelty of Axis I (400) regulatory disorders, empirical research in this domain is particularly required. Elements of syndrome validation such as the contributions of etiology (i.e., genetics, environment, brain mechanisms), developmental trajectory, and treatment effects (Pennington, 1991) are not specified in DC:0-3 or the DC:0-3 case summary book. Future empirical work should specify these aspects of regulatory disorder so that the convergent and discriminant validity of the syndrome can be evaluated.

Empirical evidence related to SMD is also lacking, although a spurt in research has begun to correct this deficiency (Ahn, Miller, Milberger, & McIntosh, in press; Miller et al., 1999, 2001; Mangeot et al., 2001; Ognibene, McIntosh, Miller, & Raad, 2003; Schaaf et al., 2003). More research is needed to better characterize SMD in

**Table 13.5 Functional Limitations in SMD Related to Internal Dimensions**

Internal Dimension	Impairment Observed in Behavior
Sensory symptoms	Severe over- or undersensitivity to tactile, movement, taste, smell, auditory, or visual stimuli
Emotional symptoms	Aggression, anger, dysregulation, tearfulness, withdrawal, anxiety, depression
Attentional symptoms	Poor sustained attention, poor impulse control, hyperactivity; over-focused and unable to transition

relation to emotional and behavioral patterns of dysregulation in the early years. Neither researchers using the DC:0-3 categorization nor those using the SMD classification taxonomy have provided research or theoretical information describing the relation between regulatory disorders and SMD, perhaps because the two diagnostic classifications began at about the same time in different professional milieus, and each was unaware of the other until publication. Research bridging the gap between these two distinct but related conceptualizations would be useful to elucidate whether or not the terms are referring to the same processes and behaviors.

### PRELIMINARY STUDIES OF SMD

We currently are studying SMD at the Sensory Treatment And Research (STAR) Processing Center at The Children's Hospital and the University of Colorado Health Sciences Center in Denver, Colorado. We have collected pilot data on sensory, emotional, and attentional functioning of children with SMD compared to typically developing children on (a) psychometric indicators of sensory functioning and (b) psychophysiological indicators of sensory functioning. To implement the work, we needed to develop appropriate measures of sensory responsivity.

#### Measures

##### *Parent Report Measure for Sensory Responsivity*

We have developed a parent-report screening measure of functional sensory behaviors that discriminates between children who are developing normally and children with SMD. We started our scale development using 125 items from the Sensory Profile (SP; Dunn, 1999). Since emotional and fine motor domains were included in the original SP and 51% of the SP items did not load on factors, we conducted content analysis, item analysis, and factor analysis to create a shorter tool (38 items) that focused only on the construct of sensory responsivity, called the Short Sensory Profile (SSP; McIntosh, Miller, Shyu, & Dunn,

1999). Sample items for each of the seven subtests of SSP are provided in table 13.6. The SSP has a stable factor structure, reflecting the various sensory constructs hypothesized by the literature to be affected in SMD. Four subtests measure aspects of active oversensitivity: Tactile Sensitivity, Movement Sensitivity, Auditory/Visual Sensitivity, and Taste/Smell Sensitivity. One subtest, Auditory Filtering, relates to filtering sensory information. One subtest, Underresponsive/Seeks Sensation, is related to active sensory seeking. One subtest, Low Energy/Weak, relates to passive undersensitivity. Two subtests, Auditory Filtering and Underresponsive/Seeks Sensation, correlate highly with items on *DSM-IV* behavioral descriptions for ADHD (Ognibene, 2002). Figure 13.2 demonstrates the difference in performance between children with and without SMD on all seven subtests of the SSP ( $p < .01$ ) (McIntosh, Miller, Shyu, & Dunn, 1999). We are currently developing more comprehensive assessments (parent, teacher, and clinician) of SMD behaviors with more items representing each quadrant, depicted in table 13.3 (Miller & Schoen, 2003; Moulton, 2002).

##### *Physiological Laboratory Paradigm to Measure SMD*

We also developed a psychophysiological laboratory paradigm, the Sensory Challenge Protocol, to measure sensory reactivity, and tested its reliability and validity (Mangeot et al., 2001; McIntosh, Miller, Shyu, & Hagerman, 1999; Miller et al., 1999, 2001). In this laboratory paradigm, a child between 3 and 8 years of age enters a room decorated like a "pretend space ship." The child watches a short segment from the film *Apollo 13* while we attach electrodes. We measure physiological reactivity in three conditions: (a) a baseline condition of physiological reactivity for 2 minutes when no stimulus is presented, (b) a sensory challenge condition where the experimenter presents a series of 50 sensory stimuli in a controlled manner (i.e., ten 3-second sensory stimuli are presented in each of five sensory domains: olfactory, auditory, visual, tactile, and vestibular), and (c) a 2-minute recovery condition of physiological reactivity while the child watches a simple cartoon.

Table 13.6 Short Sensory Profile Subtests and Example Items

Domain	Sample Items
1. Tactile sensitivity	1. Reacts emotionally or aggressively to touch 2. Has difficulty standing in line or close to other people
2. Taste/smell sensitivity	1. Picky eater, especially regarding food textures 2. Limits self to particular food textures/temperatures
3. Movement sensitivity	1. Fears falling or heights 2. Becomes anxious or distressed when feet leave the ground
4. Underresponsive/ seeks sensation	1. Becomes overly excitable during movement activity 2. Jumps from one activity to another so that it interferes with play
5. Auditory filtering	1. Has difficulty paying attention 2. Is distracted or has trouble functioning if there is a lot of noise around
6. Low energy/weak	1. Poor endurance/tires easily 2. Has a weak grasp
7. Visual/auditory sensitivity	1. Responds negatively to unexpected or loud noises 2. Covers eyes or squints to protect eyes from light

Two physiological measures are collected continuously through the baseline, challenge, and recovery conditions that provide data related to the degree to which the child responds to the sensory stimuli. The measures are called (1) *electrodermal reactivity* (EDR), a marker of sympathetic nervous system activity, and (2) *vagal tone* (VT), a marker of parasympathetic nervous system functioning.

Using the Sensory Challenge Protocol, we compared EDR and VT for typically developing children and children clinically diagnosed with

Typically developing children and children clinically diagnosed with

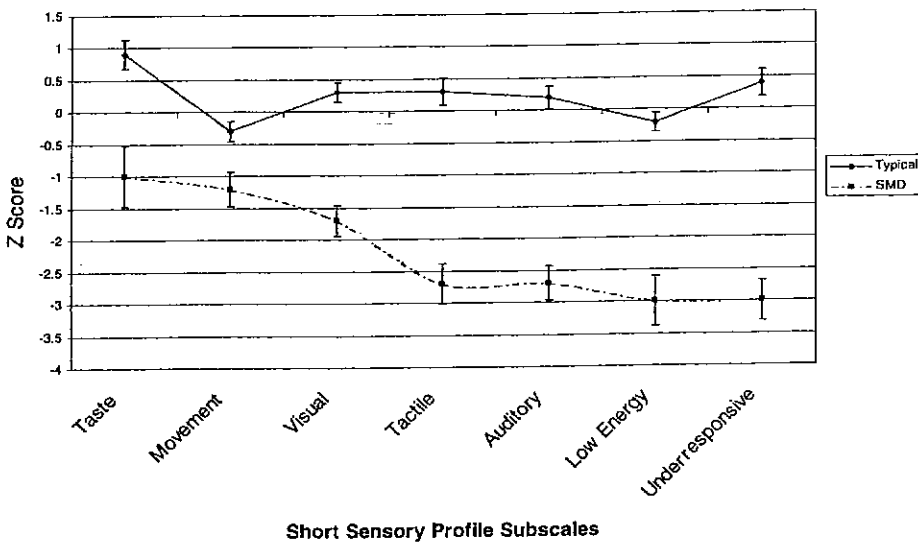


Figure 13.2 Typically developing children compared to children with SMD on the short sensory profile.

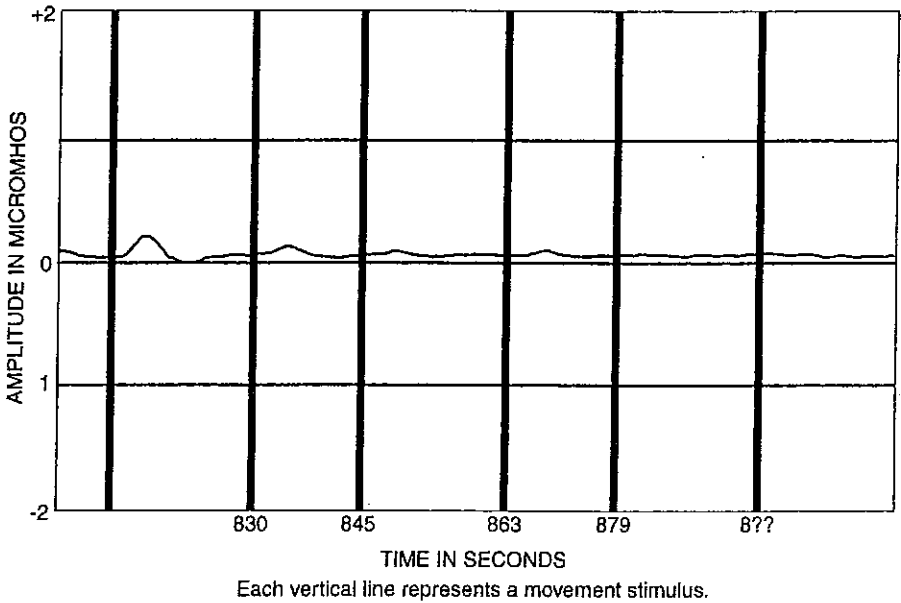


Figure 13.3 EDR for typically developing child.

SMD ( $n = 38$ ). Figures 13.3 and 13.4 display a short segment of the EDR profiles of two children. In both figures, the bold vertical lines represent the sensory stimulus administered for 3 seconds. Time is represented along the horizontal axis at the bottom of the illustration. The curving line in the figure represents the child's electrodermal response to the stimuli. In figure 13.3, the response of a typically developing child is displayed. The child is seen to orient to the first stimulus (curved line goes up in amplitude after the first vertical line) and notices the second stimulus (curved line slopes upward after the second vertical line, although not as high as after stimulus 1), and then the responses are seen to diminish or habituate.

A segment from the profile of a child with SMD is seen in figure 13.4. The child's response is quite different from the response of the typically developing child. This child experiences a stronger reaction (higher amplitude), more continuous reactions (multiple peaks), and poor cessation of reaction over time (does not habituate after multiple trials of identical stimuli).

Differences between typically developing children ( $n = 19$ ) and children referred with SMD ( $n = 19$ ) were significant ( $p < .01$ ), with large ef-

fect sizes ( $>.80$ ; Cohen, 1992) on the three EDR variables, amplitude, frequency, and habituation (McIntosh, Miler, Shyu, & Hagerman, 1999). Figure 13.5 depicts group differences between children with SMD and typically developing children on EDR.

In a preliminary study, the vagal tone patterns of 49 children with SMD were examined (Schaaf, 2001; Schaaf et al., 2003). Two atypical subgroups of children with SMD appeared; one with extremely low VT and one with extremely high VT (some children with SMD had normal VT in response to sensory stimulation across time). Cross-validation of this data with a larger sample is currently under way.

#### Association of Sensation, Emotion, and Attention in SMD

In this section, we present preliminary findings on the relation of symptoms within the internal domains specified in the model presented above: sensation, emotion, and attention. We have collected pilot data on associations among sensation, attention, and emotion in children with and without SMD. Our findings suggest that the three domains are interconnected.

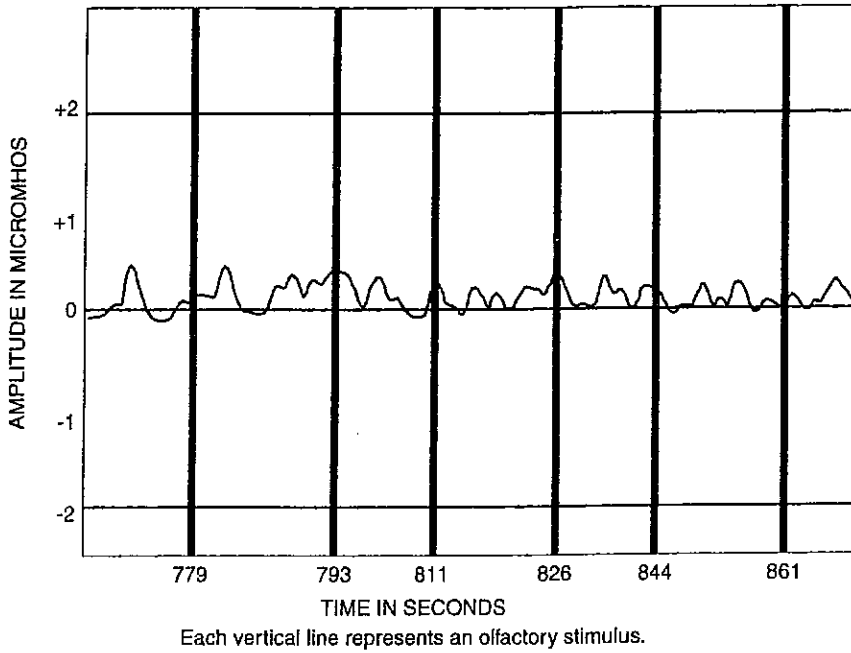


Figure 13.4 EDR for child with SMD.

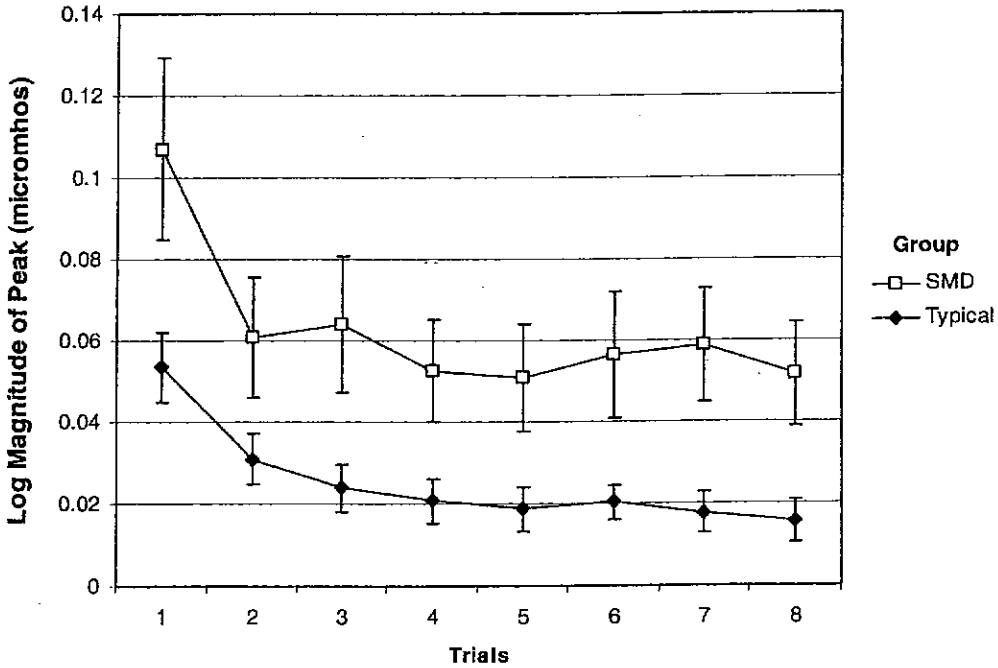


Figure 13.5 EDR amplitude differences between children with SMD and typically developing children. Each trial represents the mean value of that order of stimuli for all sensory domains summed (e.g., trial 1 = olfactory stimulus 1 plus auditory stimulus 1 plus visual stimulus 1 plus tactile stimulus 1 plus vestibular stimulus 1 divided by 5).

In a set of pilot studies, we assessed sensation, attention, and emotion in a group of 16 typically developing children and 33 children with SMD ages 3 to 7 years. Controls were typically developing children who were screened by parent report and were reported to have no birth trauma, have positive educational experiences, were not receiving special therapeutic services, and have age-appropriate relationships. Children with SMD met three criteria: scores greater than  $-3$  standard deviations below the mean on the Short Sensory Profile, hyperreactive EDR, and clinician recommendation after a comprehensive evaluation as detailed in Miller et al. (2001) and McIntosh, Miller, Shyu, and Hagerman (1999). All children had normal intelligence quotients and no *DSM-IV* diagnoses. This inclusion criterion ruled out children with co-occurring comorbid diagnosis such as autistic disorder and/or fragile X syndrome; however, children in the sample may have comorbid attentional and anxiety disorders. We administered the psychophysiological laboratory tests described earlier (McIntosh, Miller, Shyu, & Hagerman, 1999; Miller et al., 1999, 2001). In addition, parent report measures of emotional responses, attentional abilities, and sensory processing were administered.

For this study, we used information from three standardized parent rating scales:

- The Short Sensory Profile (McIntosh, Miller, Shyu, & Dunn, 1999), all subtests: (1) Tactile, (2) Taste/Smell, (3) Visual/Auditory, (4) Movement Sensitivity, (5) Under-Responsive/Seeks Sensation, (6) Auditory Filtering, and (7) Low Energy/Weak
- The Leiter International Performance Scale-Revised (Roid & Miller, 1997), parent rating on three subtests: (1) Attention, (2) Impulsivity, and (3) Activity Level
- The Child Behavior Checklist (Achenbach, 1991), all subtests: (1) Withdrawn, (2) Somatic Complaints, (3) Anxious/Depressed, (4) Social Problems, (5) Thought Problems, (6) Attention Problems, (7) Sex Problems, (8) Delinquent Problems, and (9) Aggressive Behavior

Canonical correlation was used to predict a combination of several criterion variables from several predictor variables. We selected this tech-

nique because we were undertaking exploration of relationships among a large number of measures to assess our three domains (Gall, Borg, & Gall, 1996). Three sets of analyses were conducted to evaluate the associations among all three domains (sensation, attention, and emotion). The first set of analyses evaluated sensation and attention; the second set evaluated emotion and attention; and the third set evaluated sensation and emotion. In these analyses, each of the three domains was consistently correlated with each of the other two domains.

#### *Sensation and Attention*

The first set of analyses assessed the relation of sensation to attention. All sensory and attention subscales were correlated to the first root ( $r = .44$ ), indicating that poor performance on all sensory subtests is associated with poor attention, impulsivity, and hyperactivity. Interpretation of root 2 ( $r = .63$ ) indicates that the sensory subtests Low Energy/Weak, Movement Sensitivity, and Tactile Sensitivity were positively associated with only the inattention variable, and were negatively correlated with the hyperactivity variable. This preliminary data suggests that children with low scores in all sensory domains are likely to have problems with attention in general and may be at risk for ADHD. The second root indicates that those children with only low energy and movement/tactile sensitivity may be at risk for ADHD inattentive subtype. Caution must be used in interpreting results, as sample size is limited. While these data are exploratory, our findings suggest that sensation-related functioning may be linked to risk for attention-related disorders.

#### *Emotion and Attention*

The second set of analyses used canonical correlation to examine the relation between emotion and attention subtests. Only one root was found in this young age group, demonstrating that a general relation between all emotion and attention subtests exists. Not surprisingly, children with attention difficulties are likely to have socioemotional difficulties as well. This finding is consistent with other studies linking attention problems with socioemotional difficulties (for a discussion

of socioemotional difficulties associated with attentional disturbances, see chapter 20).

### *Sensation and Emotion*

The third set of analyses evaluated the relation between sensory and emotion variables. One significant root was found, indicating a relation between all sensory and emotion subscales. Thus, children with sensory problems in all areas were likely to have emotional problems in all areas. As with studies 1 and 2, interpretation is limited by the exploratory nature of the investigation and the small sample size.

Preliminary data suggest that some children with sensory processing difficulties in the early years may be at risk for the development of attention and emotion-related disorders. They also highlight the importance of examining sensory processing problems in children when attention and emotion-related problems are present.

### CLINICAL IMPLICATIONS AND DIRECTIONS FOR FUTURE RESEARCH

As increasing numbers of children are referred for attentional and emotional difficulties at increasingly young ages, the importance of identifying early precursors or risk factors associated with these disturbances takes on some urgency. Though our work suggests that sensory problems co-occur with problems in attention and emotion, only rarely is sensory functioning considered in the evaluation and treatment of children in child psychology clinics.

Our findings and conceptual model suggest that sensory-related problems may be critically important in understanding, conceptualizing, and diagnosing early emotional and behavioral disorders in young children. Though many clinically related questions remain in differentiating SMD from emotion regulation and attention problems, and specifically differentiating SMD and regulatory disorder classifications of disabilities in infants and toddlers, clinicians can begin to explore this area on a case-by-case basis by including measures of sensory responsivity in their evaluations of children referred with regulatory disor-

ders, emotion regulation disorders, and attention disorders (see tables 13.7 and 13.8 for a list of evaluations that assess or screen sensory processing in young children).

Our research focuses on children with sensory modulation dysfunction. Our work and the preliminary findings reviewed here raise several questions for future research. First, can normal developmental variations in early patterns of sleep, eating, play, emotion, and attention regulation be differentiated from behavioral patterns in SMD? Second, can sensory responsivity profiles be used to identify risk for and diagnosis of attentional (and attentional subtypes) and affective disorders in young children? Third, can a reliable method to differentiate the sensory, emotion, and attentional aspects of dysregulated behavior in young children be established? Fourth, can we develop ways to assess the compatibility or incompatibility (i.e., mismatch) between the child's internal sensory-related characteristics and the external/contextual factors that influence the child's development? In addition, future empirical research is needed to validate and differentiate SMD and regulatory disorder.

### SUMMARY AND CONCLUSION

In this chapter, we have discussed the overlap between two diagnostic classification systems that describe children who have atypical responses to sensory stimulation: regulatory disorders and sensory modulation dysfunction. We have detailed the definitions of these two syndromes and compared and contrasted behaviors described by each. Our overall objective was to familiarize mental health professionals with sensory modulation dysfunction and to highlight the importance of evaluating sensory processing disorders in a comprehensive assessment of problems in infants and young children referred for a variety of behavioral difficulties.

This chapter also provides a conceptual model for the association among sensation, attention, and emotion, and preliminary empirical evidence evaluating the relations among the three dimensions. It is hoped that the conceptual model and preliminary empirical findings presented here on sensory-related problems will generate hypothe-

Table 13.7 Assessments That Directly Evaluate Sensory Integration Functioning

Name	Age and Population Characteristics	Components Measured	Format and Subtests	Source
Brazelton Neonatal Behavioral Rating Scale (Second Edition)	0-1 month	Personal and social skills; gross and fine motor reflexes; tactile and vestibular senses	Informal/structured, quantified observation	Brazelton, T. B. (1984). <i>Brazelton Neonatal Behavioral Rating Scale</i> (2nd ed.). Philadelphia: J.B. Lippincott.
Clinical observations of sensory integration dysfunction*				Dunn, W. (1981). <i>Clinical observations of sensory integration dysfunction</i> . Bethesda, MD: American Occupational Therapy Association.
DeGangi-Berk Test of Sensory Integration	3-5 years	Vestibular-based sensory integrative functions of postural control, bilateral motor integration, and reflex integration	Criterion-referenced, quantified observations, limited validity data provided	Berk, R. A., & DeGangi, G. A. (1983). <i>DeGangi-Berk Test of Sensory Integration</i> . Los Angeles: Western Psychological Services.
Developmental Test of Visual-Motor Integration	3-7; preschool to adult	Visual-motor integration (e.g., copying geometric forms and shapes)	Norm referenced. One version of the test for ages 3 to 7; second version for preschool children through adults. Subtests include VMI Visual Perception and VMI Motor Coordination	Beery, K., & Buktenica, N. (1997). <i>Developmental Test of Visual-Motor Integration</i> . Cleveland, OH: Modern Curriculum Press.
Early Coping Inventory: A measure of adaptive behavior	4-36 months	Sensorimotor organization, reactivity, self-initiation during situational coping	48-item observation instrument	Zeitlin, S., Williamson, G. G., & Szczepanski, M. A. (1988). <i>Early Coping Inventory: A measure of adaptive behavior</i> . Bensenville, IN: Scholastic Testing Service.
Infant/Toddler Sensory Profile	Birth to 36 months	Measure sensory processing abilities and profile the effect of sensory processing on functional performance in the daily life of a child	Parent questionnaire Birth to 6 months: 36 items 7 to 36 months: 48 items	Dunn, W. (2002). <i>Infant/Toddler Sensory Profile</i> . San Antonio, TX: Psychological Corporation.
Infant-Toddler Symptom Checklist	7-30 months	Regulatory disorders and sensory processing during functional activities	Parent questionnaire; five age-range checklists	DeGangi, G. A., & Poisson, S. (1995). <i>Infant-Toddler Symptom Checklist</i> . San Antonio, TX: Therapy Skill Builders.

Miller Assessment for Preschoolers (MAP)	2 years, 9 months–5 years, 8 months	Difficulties in praxis	Developmental screening test	Müller, L. J. (1988). <i>Miller Assessment for Preschoolers (MAP)</i> . San Antonio, TX: Psychological Corporation.
Sensorimotor History Questionnaire for Preschoolers	3–4 year olds	Sensory integration and self-regulation	51-item questionnaire with five subscales that prescreen problems in self-regulation, sensory processing of touch and movement, motor planning, emotional maturity, and behavioral control	DeGangi, G. A., & Balzer-Martin, L. (1999). The Sensorimotor History Questionnaire for Preschoolers. <i>Journal of Developmental and Learning Disorders</i> , 3(1), 59–83.
Sensory Integration and Praxis Test	4.6–8.11 years School-aged children who are relatively high functioning	Sensory and perceptual function	17 subtests; sensory and perceptual function in visual perceptual, visual, vestibular and postural, and somatosensory domains	Ayres, A. J. (1989). <i>Sensory integration and praxis tests</i> . Los Angeles: Western Psychological Services.
Sensory Profile	5–10 years (supplementary information on 3- and 5-year-olds)	Sensory processing, modulation, behavioral, and emotional responses	Parent questionnaire with 125 items; divides into 9 factor groupings and/or 14 subtests by domain	Dunn, W. (1999). <i>The Sensory Profile</i> . San Antonio, TX: Psychological Corporation.
Short Sensory Profile	3–10 years	Functional aspects of sensory dysfunction	38-item questionnaire with 7 subtests that screen sensory dysfunction	McIntosh, D. N., Miller, L. J., Shyu, V., & Dunn, W. (1999). Overview of the Short Sensory Profile. In W. Dunn (Ed.), <i>The Sensory Profile: Examiner's Manual</i> (pp. 59–73). San Antonio, TX: Psychological Corporation.
Test of Attention in Infants	7–30 months	Sustained attentional behaviors	5 age-specific versions; 4 subtests measure sustained attention to visual, auditory, tactile, and multisensory inputs	DeGangi, G. A. <i>Test of Attention in Infants</i> . Rockville, MD: Reginald S. Lourie Center for Infants and Young Children.
Test of Sensory Functions in Infants	4–18 months	Regulatory disorders, developmental delay, risk for learning disorders	Diagnostic, criterion referenced. Subtests include reactivity to tactile deep pressure and vestibular stimulation, adaptive motor functions, visual-tactile integration, ocular-motor control	DeGangi, G. A., & Greenspan, S. I. (1989). <i>Test of Sensory Functions in Infants</i> . Los Angeles: Western Psychological Corporation.

(continued)

Table 13.7 Continued

Name	Age and Population Characteristics	Components Measured	Format and Subtests	Source
Toddler and Infant Motor Evaluation (T.I.M.E.)	4-42 months	Quality of movement; links motor abilities to functional abilities, life roles, and occupations	Examiner-guided parent-child play in a natural environment. Five primary subtests measure mobility, stability, motor organization, social and emotional abilities, and functional performance. Three clinical subtests: quality rating, component analysis, and atypical positions	Miller, L. J., & Roid, G. H. (1993). <i>Toddler-Infant Motor Evaluation (T.I.M.E.)</i> . San Antonio, TX: Psychological Corporation
Touch Inventory for Elementary School-Aged Children	Elementary school-aged children	Screens for tactile defensiveness	26-question screening tool (individual self-report)	Royeen, C. B., & Fortune, J. C. (1990). Touch Inventory for Elementary School-Aged Children. <i>American Journal of Occupational Therapy, 44</i> , 165-170.
Touch Inventory for Preschoolers	Preschool-age children	Screening tool for tactile defensiveness	46 questions to be completed by teachers or guardians of the subject	Royeen, C. B. (1987). Touch Inventory for Preschoolers. <i>Physical and Occupational Therapy in Pediatrics, 7</i> (1), 29-40.
Evaluation of Sensory Processing Version 4				Parham, D. (2002). Evaluation of Sensory Processing. In A. C. Bundy, E. A. Murray, & S. J. Lane (Eds.), <i>Sensory Integration: Theory &amp; Practice</i> (2nd ed., pp. 193-196). Philadelphia: F. A. Davis.

\*Many versions of sets of checklists summarizing "clinical observations" (e.g., soft neurological signs of sensory disorders) exist. The most commonly used observational checklist is taught during the sensory integration and praxis (SIPT) intensive training courses sponsored by the SIPT publisher, Western Psychological Services. The compendium by Dunn is noted here as it is published, whereas the WPS clinical observation checklist is not published.

**Table 13.8 Other Assessments Typically Administered While Sensory Integration Functions Are Observed Throughout the Evaluation**

Name	Age and Population Characteristics	Components Measured	Format and Subtests	Source
Bayley Scales of Infant Development (second edition)	2 mos.-2.5 years	Infant visual recognition memory, habituation of attention to visual stimuli, visual preference and acuity, quality of movement, sensory integration, perceptual-motor integration, fine motor reflexes	Norm-referenced for 14 age groups; administration involves having child respond to a series of stimuli	Bayley, N. (1993, 1984, 1969). <i>Bayley Scales of Infant Development</i> (2nd ed.). San Antonio, TX: Psychological Corporation.
Brigance Diagnostic Inventory of Early Development	0-7 years	Communication, cognition, self-help, gross motor, fine motor	Criterion referenced, 200-item test, 11 sections. Questions answered by oral or written responses, or by pointing to a picture.	Brigance, A. H. (1978). <i>Brigance Diagnostic Inventory of Early Development</i> . North Billerica, MA: Curriculum Associates.
Bruininks-Oseretsky Test of Motor Proficiency	4.5-14 years	Gross motor, praxis, fine motor, visual-motor integration	Norm referenced; 8 subtests assess gross and fine motor development. 46-item complete battery or 14-item short form	Bruininks, R. H. (1978). <i>Bruininks-Oseretsky Test of Motor Proficiency</i> . Circle Pines, MN: American Guidance Service.
Developmental programming for infants and young children	0-6 years	Personal and social skills, communication, cognition, self-help, gross motor, fine motor, visual-motor integration	Criterion referenced, made up of 6 scales, which assess developmental norms in perception/fine motor, self-care, language, etc.	Rogers, S. J., & D'Eugenio, D. B. (1977). <i>Developmental programming for infants and young children</i> . University of Michigan.
Erhardt Developmental Prehension Assessment	0-6 years	Praxis, reflexes, fine motor; visual motor integration	Criterion referenced, informally structured, quantified observations	Erhardt, R. P. (1989, 1982). <i>Erhardt Developmental Prehension Assessment</i> . San Antonio, TX: Therapy Skill Builders.
FirstSTEP (screening test for evaluating preschoolers)	2 years, 9 months-6 years, 2 months	Identifies presence of developmental risk by assessing cognition, communication and language, motor, social-emotional, and adaptive functioning	Norm referenced for ages 2 to 9; domains include cognition, language, and motor; checklists include adaptive, social-emotional, and parent/teacher scales	Miller, L. J. (1993). <i>The FirstSTEP (screening test for evaluating preschoolers)</i> . San Antonio, TX: Psychological Corporation.

(continued)

Table 13.8 Continued

Name	Age and Population Characteristics	Components Measured	Format and Subtests	Source
Gesell Preschool Test	2.5-6 years	Personal social skills, communication, gross motor, fine motor	Norm referenced. Contains a variety of tasks and activities, including oral, paper and pencil, and building block sections.	Ames, L. B., Gillespie, C., Haines, J., & Ilg, F. L. (1986). <i>Gesell Preschool Test</i> . Rosemont, NH: Programs for Education.
Hawaii Early Learning Profile	0-36 months	Personal social skills, communication, cognition, self-help, gross motor, fine motor, visual-motor integration	Criterion referenced: curriculum-based, not standardized. Includes 7 developmental domains, most of which are further divided into sequential subareas of development.	Furuno, S., O'Reilly, L., Hosaka, C. M., Inatsuka, T. T., Allman, T. L., & Zeisloft, B. (1985, 1979). <i>Hawaii Early Learning Profile</i> . Palo Alto, CA: VORT Corporation.
Learning Accomplishment Profile-Revised	36-72 months	Personal social skills, communication, cognition, self-help, gross motor, fine motor	Criterion referenced	Sanford, A. R., & Zelman, J. G. (1981). <i>Learning Accomplishment Profile-Revised</i> . Winston-Salem, NC: Kaplan Press.
Motor-Free Visual Perceptual Test	4-11 years	Visual-motor integration	Norm referenced; individually administered, multiple-choice test. Five aspects of visual perception covered: spatial relationships, visual discrimination, figure-ground discrimination, visual closure, and visual memory.	Colaruso, R. P., & Hammill, D. D. (1996). <i>Motor-Free Visual Perceptual Test</i> . San Rafael, CA: Academic Therapy Publications.

Movement Assessment of Infants	0-12 months	Gross motor and reflexes	Informal/structured, quantified observations	Chandler, L. S., Andrews, M. S., & Swanson, M. W. (1980). <i>Movement assessment of infants</i> . Rolling Bay, WA: Movement Assessment of Infants.
Peabody Developmental Motor Scales (second edition)	7 years	Gross motor, praxis, fine motor, visual-motor integration	Norm and criterion referenced. Two components: Gross Motor Scale and Fine Motor Scale	Folio, M. R., & Fewell, R. R. (2000, 1983). <i>Peabody Developmental Motor Scales</i> (2nd ed.). Austin, TX: PRO-ED.
Test of Visual Motor Skills	2-13 years	Visual-motor integration and functioning	Norm referenced; assesses design copying skill	Gardner, M. F. (1986). <i>Test of Visual Motor Skills</i> . San Francisco, CA: Children's Hospital of San Francisco.
Test of Visual Perceptual Skills	4-12 years	Visual perception	Norm referenced. Subtests include visual discrimination, visual closure, visual memory, and visual-spatial relations. Items in subtests increase in difficulty.	Gardner, M. F. (1992). <i>Test of Visual-Perceptual Skills</i> . Burlingame, CA: Psychological and Educational Publications.

ses for future work in this area. While a plethora of research questions about evaluation tools remain, the inclusion of sensory processing as one aspect of a comprehensive diagnostic assessment of young children is imperative. Regardless of the diagnostic label (e.g., SMD or regulatory disorder), early identification of sensory-related problems, evaluation of related environmental and contextual domains, and appropriate sensory-based intervention can have dramatic and global effects on young children and aid their families in understanding and coping with behaviors that result from sensory dysfunction.

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# **Handbook of Infant, Toddler, and Preschool Mental Health Assessment**

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