



Attention deficit hyperactivity disorder and sensory modulation disorder: A comparison of behavior and physiology

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ABSTRACT

Children with attention deficit hyperactivity disorder (ADHD) are impulsive, inattentive and hyperactive, while children with sensory modulation disorder (SMD), one subtype of Sensory Processing Disorder, have difficulty responding adaptively to daily sensory experiences. ADHD and SMD are often difficult to distinguish. To differentiate these disorders in children, clinical ADHD, SMD, and dual diagnoses were assessed. All groups had significantly more sensory, attention, activity, impulsivity, and emotional difficulties than typical children, but with distinct profiles. Inattention was greater in ADHD compared to SMD. Dual diagnoses had more sensory-related behaviors than ADHD and more attentional difficulties than SMD. SMD had more sensory issues, somatic complaints, anxiety/depression, and difficulty adapting than ADHD. SMD had greater physiological/electrodermal reactivity to sensory stimuli than ADHD and typical controls. Parent-report measures identifying sensory, attentional, hyperactive, and impulsive difficulties varied in agreement with clinician's diagnoses. Evidence suggests ADHD and SMD are distinct diagnoses.

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1. Introduction

Attention deficit hyperactivity disorder (ADHD) is an early childhood developmental disorder that has received enormous attention in research. Typical characteristics of ADHD are developmentally inappropriate impulsivity, inattention, and hyperactivity (Barkley & Murphy, 1998; Kaplan, Sadock, & Grebb, 1994). ADHD is a costly and prevalent childhood disorder that affects 3–12% of school-aged children (Froehlich et al., 2007; Schachar, 2000) and accounts for approximately half of all pediatric referrals to mental health services (CDC, 2003; Glick, 1997; Goldman, Genel, Bezman, & Slanetz, 1998).

Another early childhood developmental disorder, which has received less attention, is Sensory Processing Disorder (SPD) (Miller, Anzalone, Lane, Cermak, & Osten, 2007). The essential features of SPD are the presence of difficulties in detecting, modulating, interpreting and/or organizing sensory stimuli, which are so severe that it interferes with daily life routines. The presence of sensory symptoms may be as prevalent as ADHD (Ahn, Miller, Milberger, & McIntosh, 2004; Ben-Sasson, Carter, & Briggs-Gowan, 2009; Gouze, Hopkins, Lebailly, & Lavigne, 2009). For decades, large numbers of children have been identified as having sensory-based disorders by occupational therapy clinicians and others. Although, wide-spread skepticism exists among many health professionals about SPD and its treatment (e.g., Arendt, MacLean, & Baumeister, 1988; Hoehn & Baumeister, 1994; Polatajko, Kaplan, & Wilson, 1992; Schaffer, 1984; Vargas & Camilli, 1999), SPD is recognized by both the

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Diagnostic Manual for Infancy and Early Childhood (Interdisciplinary Council on Developmental and Learning Disorders (ICDL-DMIC), 2005) and the Zero to Three Diagnostic Classification of Mental Health and Developmental Disorders of Infancy and Early Childhood: Revised edition (DC:0-3R; Zero to Three, 2005), both of which focus on subtypes of one classic pattern of SPD called sensory modulation disorder (SMD). The prevalence of sensory symptoms is estimated to be 5–16% in the normal population (Ben-Sasson, Hen et al., 2009; Gouze et al., 2009) and 30–80% in individuals with developmental disabilities (Ahn et al., 2004; Baranek, Foster, & Berkson, 1997; Ben-Sasson, Hen et al., 2009; Tomchek & Dunn, 2007).

While evidence suggests that neither ADHD nor SPD are homogeneous conditions, some of the behaviors characteristic of ADHD overlap with those observed in SPD. Therefore, one important question is whether ADHD and SPD are distinct disorders, the same disorder or manifest as co-morbid disorders. The current Diagnostic and Statistical Manual of Mental Disorders (DSM-IV-R, 2000) does not recognize SPD as a separate clinical disorder. However, efforts have been directed toward the inclusion of SPD as a 'novel diagnosis' (D. Pine, personal communication). Additionally, there are questions about the validity of the traditional ADHD subtypes (e.g., Widiger & Samuel, 2005).

Three ADHD subtypes are described in the current DSM-IV-R: predominantly inattentive; predominantly hyperactive and impulsive; and combined inattentive and hyperactive/impulsive. ADHD/hyperactive impulsive (ADHD/HI) is characterized by excessive and situationally inappropriate motor activity (Halperin, Matier, Bedi, Sharma, & Newcorn, 1992) and limited inhibitory control of responses (Barkley, 1997; Chelune, Ferguson, Koon, & Dickey, 1986; Nigg, 2000), whereas ADHD/inattentive (ADHD/I) is characterized by an impaired ability to focus, sustain, and switch attention (Cepeda, Cepeda, & Kramer, 2000; Levine, Busch, & Aufseeser, 1982; Seidel & Joschko, 1990). Some children have both types of ADHD referred to as ADHD/combined (ADHD/C). Children with all types of ADHD face daily challenges with learning and achieving at school, behaving appropriately at home, and participating fully in their communities due to difficulty controlling impulsive behavior, sustaining attention, and regulating activity levels.

One primary pattern within SPD is sensory modulation disorder (SMD), which is characterized by difficulty regulating and organizing responses to sensory input. SMD includes three subtypes delineated by a recent nosology (Miller, Anzalone, et al., 2007) as well as in two developmental diagnostic manuals for young children (ICDL-DMIC, 2005; Zero to Three, 2005): Sensory-Over-Responsivity (SOR), Sensory-Under-Responsivity (SUR), and Sensory-Seeking/Craving (SS/C). Children with SOR feel sensations too intensely, for a longer duration than is typical and/or may over-respond with atypical behaviors such as temper tantrums, screaming or moving away from stimulation. Often these children try to keep their behaviors under control at school where they are exposed to multisensory input, only to become dysregulated when they come home. SUR describes children who respond less to or take longer to respond to input. These children often appear withdrawn or seem to be "in their own world." They have difficulty listening, following directions, knowing where their body is in space, and initiating movement. SS/C describes children who seek out high intensity or increased duration of sensory stimulation. They have behaviors such as constantly being on the move, falling down or crashing into people or the floor, staring at optical interests for an extended time period, or craving touch so much that they are in everyone else's space and face continually in an effort to gain more sensory information. Identification of SMD/SPD is only made when the resulting behaviors significantly affect a child's daily life (Bar-Shalita, Vatine, & Parush, 2008; Parham & Johnson-Ecker, 2000).

The overlap of symptoms in children with SMD and ADHD makes it difficult to differentiate the two disorders. For example, children with SMD who are SS/C often have attentional difficulties, poor impulse control, and hyperactivity (Mulligan, 1996; Smith Roley, 2006). Likewise, children with ADHD may have sensory symptoms characteristic of SMD (Ahn et al., 2004). For example, problems with sensory-over-responsivity (Barkley & Murphy, 1998; Lucker, Geffner, & Koch, 1996), especially in the somatosensory system (Castellanos et al., 1996; Parush, Sohmer, Steinberg, & Kaitz, 1997, 2007; Reynolds & Lane, 2008, 2009; Shochat, Tzischinsky, & Engel-Yeger, 2009) have frequently been reported in children with ADHD. Additionally, some behavioral descriptors for ADHD and SMD are strikingly similar. SS/C and ADHD/HI both include poor impulse control, inappropriate movement and touch; sensory over-responsivity and ADHD/I both include behaviors such as distractibility and difficulty focusing; and sensory under-responsivity and ADHD/I both include being unaware when spoken to or asked to follow directions.

Although some behavioral characteristics of ADHD and SMD overlap, we hypothesize that the physiological reactions to sensory stimuli differs between children with ADHD and those with SMD. Sympathetic markers of nervous system function, assessed using electrodermal activity (EDA), have been used to characterize "flight or flight" reactions of children with SMD in response to sensory stimuli (McIntosh, Miller, Shyu, & Hagerman, 1999). EDA evaluates the skin's electrical conductance associated with changes in eccrine sweat gland activity in reaction to novel, startling or threatening stimuli, aggressive or defensive feelings (Fowles, 1986), and positive and negative emotional events (Andreassi, 1986). EDA includes measures of arousal (e.g., tonic skin conductance level), and reaction to stimuli (e.g., phasic skin conductance responses). Children with SMD are reported to exhibit large EDA responses to sensory stimuli, suggesting stronger physiological reactivity compared to typically developing children (McIntosh, Miller, Shyu, & Hagerman, 1999; Miller, Reisman, McIntosh, & Simon, 2001).

EDA has also been used to characterize children with ADHD. Early studies suggest that children with ADHD show smaller phasic reactivity to stimuli compared to typically developing children (Rosenthal & Allen, 1978; Spring, Greenberg, Scott, & Hopwood, 1974; Zahn, Abate, Little, & Wender, 1975). However, recent research suggests a disagreement remains as to whether the physiological reactivity of children with ADHD is smaller (Mangeot et al., 2001; Shibagaki, Yamanaka, & Furuya, 1993) or the same (Herpertz et al., 2003) as typically developing children. Likewise, studies differ on whether tonic arousal is lower in ADHD children (Beauchaine, Katkin, Strassberg, & Snarr, 2001; Lawrence et al., 2005; Lazzaro et al., 1999; Shibagaki & Yamanaka, 1990) or similar (Pliszka, Hatch, Borcharding, & Rogness, 1993; Rapoport et al., 1980; Satterfield, Schell, Backs,

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