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Comparing the executive attention of adult females with ADHD to that of females with sensory modulation disorder (SMD) under aversive and non-aversive auditory conditions



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ABSTRACT

Certain behavioral expressions of sensory modulation disorder (SMD) such as distractibility, hyperactivity, and impulsivity are often similar to those of attention deficit/hyperactivity disorder (ADHD) in pediatric and adult populations. There is also a high comorbidity rate between these two diagnoses and absence of research regarding the objective neuropsychological differentiation between them. In the present study we employed a factorial design which enabled us to: (a) systematically examine the effects of SMD and ADHD on executive attention in a sample of adult females using a Stroop-like task, and (b) measure the effect of aversive conditions (sounds) on executive attention. The experimental measures used were the *Stroop-like Location – Direction Task (SLDT)* to assess executive attention and the battery of aversiveness to sounds (BAS), a standardized measure of aversive sounds that was developed for this study and enabled individual customization of aversive auditory sounds. Results revealed, as expected, a specific core deficit in executive attention for the ADHD factor. In addition to that, the present study provides an important, pioneering finding of SMD impairment in a unique combination of a cognitively demanding task with aversive sounds, providing preliminary objective evidence differentiating SMD from ADHD.

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1. Introduction

1.1. Sensory modulation disorder

Sensory modulation disorder (SMD) refers to an individual's difficulty to respond in a graded and adaptive manner to the degree, nature, or intensity of sensory information (Miller, Anzalone, Lane, Cermak, & Osten, 2007). In Sensory Over-Responsivity (SOR), a subtype of SMD, sensations are experienced too intensely, for a longer duration than is typical and may result in atypical behaviors such as “fight or flight” and defensive reactions to non-noxious sensations (Ayres, 1979; Dunn, 1999; Kinnealey, Oliver, & Wilbarger, 1995; McIntosh, Miller, Shyu, & Hagerman 1999; Miller, Nielsen, & Schoen, 2012; Parham & Mailloux, 1996). These behaviors – a reflection of poor modulation – influence attention, cognitive processing,

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arousal, and emotional stability (Dunn, 1997; Lane, 2002; Parham & Mailloux, 1996). Possible attentional or cognitive manifestations of poor sensory modulation include distractibility, impulsiveness, disorganization, and hyperactivity. Accompanying emotional states include anxiety, depression, anger, hostility, lability and poor self-regulation (Ayres, 1972; Cohn, Miller, & Tickle-Degnen, 2000; Miller, Reisman, McIntosh, & Simon, 2001). Modulation of sensory input is critical to an individual's ability to engage in daily occupations (Lane, 2002). Children with SMD have been reported to have problems with functional performance in activities such as dressing, meal and bath time, play, and social interactions. SMD can profoundly and negatively impact a child and family's quality of life, engagement in social interactions, participation in daily routines, self-regulation and self-esteem (Bar-Shalita, Vatine, & Parush, 2008; Brett-Green, Miller, Schoen, & Nielsen, 2010; McIntosh et al., 1999).

The prevalence of SMD in the general pediatric population is estimated to be five to 16% (Ben-Sasson, Carter, & Briggs-Gowan, 2009; Gouze, Hopkins, Lebailly, & Lavigne, 2009) and 30–80% in individuals with developmental disabilities (Ahn, Miller, Milberger, & McIntosh, 2004; Ben-Sasson, Hen, et al., 2009). Overresponsiveness characterizes 80% of referred children with SMD (Reynolds & Lane, 2008). The prevalence of SMD in the adult population is unknown. Nonetheless, there is evidence that manifestations of SMD during childhood/adolescence continue into adulthood (Brown, Tollefson, Dunn, Cromwell, & Filion, 2001; Oliver, 1990).

Empirical research on the physiological manifestations of SMD is relatively new and quite limited. Most research in this area was conducted on children with SOR. Current research on the underlying neurobiology of SMD implicates primary sensory cortical areas and higher-order multisensory integration cortical regions as well as abnormal CNS microstructure (Bar-Shalita, Vatine, Seltzer, & Parush, 2009b; Brett-Green et al., 2010; Davies & Gavin, 2007; Davies, Chang, & Gavin, 2009; McIntosh et al., 1999; Miller et al., 2012; Owen et al., 2013; Schaaf, Miller, Seawell, & O'Keefe, 2003).

Sensory modulation problems in adults are present, in most cases, since childhood and throughout the course of life (May-Benson, 2011; Oliver, 1990). Research on adults with SMD-SOR is scarce. Existing studies have shown that the emotional and cognitive energy invested by adults in order to cope with the symptoms of SMD are very extensive (Kinnealey & Fuiiek, 1999; Kinnealey et al., 1995; Pfeiffer & Kinnealey, 2003). There are specific reports on the association between adults with SMD-SOR and mental health issues such as anxiety, depression, social-emotional issues, autonomic nervous system reactivity, and decreased coping strategies (Jerome & Liss, 2005; Kinnealey & Fuiiek, 1999; Liss, Timmel, Baxley, & Killingsworth, 2005). Adults who are overresponsive to sensory stimuli, especially overresponsiveness in the somatosensory and auditory systems, frequently describe their daily life as irritating, overwhelming, disorganizing, and distracting. These experiences can negatively affect their social interactions, participation and engagement in everyday occupations (Kinnealey et al., 1995; Kinnealey, Koenig, & Smith, 2011). Interestingly, in a large Israeli study conducted by Engel-Yeger (2012) significant differences were found between genders in the Adolescent/Adult Sensory Profile scores. Women obtained significantly higher scores than men in Sensation Seeking, Sensory Sensitivity and Sensation Avoiding.

Empirical evidence regarding the underlying neurobiology of adults with SMD is practically non-existent. To date, only two studies explored the psychophysical abnormalities of adults with SMD (Bar-Shalita, Vatine, Parush, Deutsch, & Seltzer, 2012; Bar-Shalita, Vatine, Yarnitsky, Parush, & Weissman-Fogel, 2014).

Certain features of SMD, such as distractibility, hyperactivity, and impulsivity (Ayres, 1972; Cohn et al., 2000; Miller et al., 2001; Parham & Mailloux, 1996; Wilbarger & Wilbarger, 1991) are the defining features of attention deficit hyperactivity disorder (ADHD) as classified in the Diagnostic and Statistical Manual of Mental Disorders ([*DSM-IV-TR*] APA, 2000; [*DSM-5*] APA, 2013).

1.2. Attention deficit hyperactivity disorder

Attention deficit hyperactivity disorder (ADHD) is among the most common and widely researched early childhood developmental disorders. The typical characteristics of ADHD are developmentally inappropriate impulsivity, inattention and hyperactivity and it is prevalent in three to 12% of school aged children (Froehlich et al., 2007; Schachar, 2000). Children with ADHD make up 30–40% of referrals to child mental health practitioners (Barkley, 1997). ADHD is not “outgrown” in adulthood. *DSM-5* specifies that ADHD occurs in about 2.5% of adults (APA, 2013) with a ratio of approximately 1.6 males:1 female in the general population.

The diagnostic criteria for ADHD in *DSM-5* are similar to those in *DSM-IV-TR*. The same 18 symptoms are used as in *DSM-IV-TR*, and continue to be divided into two symptom domains (inattention and hyperactivity/impulsivity), of which at least six symptoms in one domain are required for diagnosis. However, several changes have been made in *DSM-5*. One of these changes is the onset criterion which has been changed to the presentation of symptoms prior to age 12 (APA, 2013). The definition of ADHD has been updated to include a lower threshold of symptoms for older adolescents and adults (at least five, instead of six in *DSM-IV-TR*). This revision is based on nearly two decades of research showing that ADHD, although a disorder that begins in childhood, can continue through adulthood for some people (APA, 2013).

Neuropsychological deficits are frequently described in adults with ADHD in domains such as memory, attention, and executive functions (Barkley, Murphy, & Kwasnik, 1996; Bush et al., 1999; Corbett & Stanczak, 1999; Downey, Stelson, Pomerleau, & Giordani, 1997; Epstein, Conners, Sitarenios, & Erhardt, 1998; Epstein, Johnson, Varia, & Conners, 2001; Johnson et al., 2001; Murphy, Barkley, & Bush, 2001; Murphy, 2002a; Murphy, 2002b). Results of a meta-analytic review (Hervey, Epstein, & Curry, 2004) did not indicate a domain-specific neuropsychological deficit, although it was found that, compared to other domains, adults with ADHD differed more than adults without ADHD in the attentional domain.

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