Sensory Overresponsivity and Anxiety in Children With ADHD

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OBJECTIVE. Approximately 25% of children with attention deficit hyperactivity disorder (ADHD) have a comorbid anxiety disorder. The purpose of this study was to determine whether sensory overresponsivity (SOR) is related to elevated levels of anxiety in children with ADHD.

METHOD. Twenty-four children ages 6 to 10 with ADHD and 24 children without ADHD participated in this study. All parents completed a Revised Children's Manifest Anxiety Scale (RCMAS) with their child. Children in the ADHD group were subdivided into ADHD + SOR and ADHD-only groups using the Sensory Over-Responsivity Inventory.

RESULTS. Children in the ADHD + SOR group were significantly more anxious than both the ADHD-only and non-ADHD (control) groups. Children with ADHD + SOR were also more likely to have clinically significant anxiety (determined by total scores on the RCMAS).

CONCLUSIONS. Occupational therapists treating children with ADHD and SOR should be aware that these children may also have anxiety and discuss options with families for prevention or treatment.

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Despite a wealth of research on *attention deficit hyperactivity disorder (ADHD),* it remains a perplexing and heterogeneous diagnostic group. Approximately 25% of children with ADHD have a comorbid anxiety disorder, with higher rates reported in children with ADHD complicated by comorbid disruptive behavior disorders such as conduct disorder or oppositional defiant disorder (Abikoff, 2002; Angold, Costello, & Erkanli, 1999; Jensen et al., 2001). In addition to having behaviors such as impulsivity and fearlessness that tend to characterize children with ADHD, these children may also manifest behaviors such as moodiness, excessive worry, difficulty shifting attention, and inflexibility. These characteristics are also common in anxiety disorders (Levy, 2004). It is unclear what causes anxiety in children and why some children with ADHD develop patterns of anxiety and others do not. It is important, however, to continue to examine these relationships and to determine which factors might lead to a better understanding of anxiety in this population.

Johnson (1975) theorized that anxiety occurred because of faulty information processing, a hypersensitivity to information, and stimuli in the environment. Ayres (1972) also proposed that deficits in the ability to modulate incoming sensory stimuli lead to the manifestation of distractibility, anxiety, and other stress-related behaviors. A currently proposed taxonomy of sensory processing disorder suggests that *sensory overresponsivity* (SOR; also referred to as *sensory hypersensitivity*) is a type of sensory modulation disorder characterized by responses to sensory stimuli that are faster, longer, or more intense than what would be expected with typical sensory

responsivity (Miller, Anzalone, Lane, Cermak, & Osten, 2007). People may demonstrate overresponsivity to any type of sensory stimuli (e.g., sound, movement, touch), and behavioral responses in the face of adverse stimuli include aggression, fear, avoidance, withdrawal, irritability, or moodiness.

Links between anxiety and sensory responsiveness may be identified not only behaviorally but also in examination of central nervous system structural associations. The hypothalamus, amygdala, and reticular formation provide the most likely targets. Anxious behaviors are associated with activation of the autonomic nervous system and are characterized by commonly observed physiologic changes, such as increased heart rate, increased respiration, pupillary dilation, and appetite suppression (Bear, Connors, & Paradiso, 2007). The *hypothalamus,* which mediates the autonomic nervous system, receives input from the amygdala, which in turn has reciprocal connections with the reticular formation and the frontal cortex (Bear et al., 2007). The *amygdala* not only activates emotions in response to stimuli but is also hypothesized to store emotional memories of past experiences, thoughts, and perceptions that may inhibit the ability of the frontal cortex to moderate the amygdala and inhibit overreaction of emotional responses (Bear et al., 2007). Moreover, the *reticular formation,* which plays a key role in modulating levels of arousal, projects to the amygdala, thereby connecting emotional memory with a person's state of being and readiness to cope with incoming stimuli.

Research in both pediatric and adult populations has produced preliminary evidence of links between SOR and anxiety. Pfeiffer (2003) administered the Sensory Profile (Dunn, 1999) and the Adolescent/Adult Sensory Profile (Brown & Dunn, 2002) to parents of 46 children ages 6 to 16 diagnosed with Asperger syndrome. Using a parent report measure of anxiety—the Revised Children's Manifest Anxiety Scale (RCMAS; Reynolds & Richmond, 2005)—Pfeiffer found a significant positive relationship between hypersensitivity (or SOR) and anxiety for the entire group of children (r = .476, p = .001). Neal, Edelmann, and Glachan (2002) also found a positive relationship between self-reported anxiety and sensitivity to environmental stimuli in adults ages 17 to 75 (r = .40, p < .01). Scores from the Highly Sensitive Person Scale (Aron & Aron, 1997) were found to significantly predict anxiety in people classified with agoraphobia (β = .43, p < .0005), anxiety or panic disorder (β = .33, p < .0005), and social phobia (β = .29, p < .0005; Neal et al., 2002). Although limited, other research on reductions in anxiety in response to sensory-based treatment has provided further evidence for the SOR–anxiety connection. Pfeiffer and Kinnealey (2003) found a significant reduction in anxiety in adults with sensory defensiveness

after a sensory-based intervention, whereas Edelson, Edelson, Kerr, and Grandin (1999) demonstrated a moderate reduction in anxiety after a deep-pressure input program for children with autism.

Thus, SOR and anxiety have been linked in several studies, and anxiety and ADHD have been shown to coexist. In addition, SOR, anxiety, and ADHD are associated with similar neurological structures, and those features have been shown to co-occur in some people. A clearer understanding of the links among anxiety, sensory modulation, and deficits of attention may support a better understanding of the dichotomy between children with ADHD only and those with ADHD with comorbid anxiety disorder. It is possible that the inability to modulate sensation may increase anxiety and, therefore, may be an additional factor to consider in the study and treatment of children and adults with ADHD.

The current study investigated whether the presence of SOR is, to some degree, related to elevated levels of anxiety in children with ADHD. The hypothesis for this study was that children with ADHD and SOR would have significantly higher levels of anxiety than children with ADHD only or typical children.

Method

This study was approved by the sponsoring university's institutional review board before we began participant recruitment. A convenience sample of 48 participants between ages 6 and 10 were enrolled in the study. Twenty-four children with a diagnosis of ADHD were recruited under the guidance of the university's division chairperson in the Department of Psychiatry. A control group of 24 children without either ADHD or SOR were recruited through informational flyers posted on the medical and academic campuses of the sponsoring institution and at recreation centers in the metropolitan area. Children with psychological diagnoses other than ADHD, significant motor impairments such as cerebral palsy, or any known endocrine or metabolic dysfunctions were excluded from this study. Because this study was part of a larger study, all children were screened for normal intelligence (IQ > 70) using a two-subtest battery of the Wechsler Abbreviated Scale of Intelligence (Psychological Corporation, 1999).

Parents of all children were screened by phone. This initial contact took 5 to 10 min; the primary purpose was to determine the child's ability and eligibility to participate in the study and answer questions parents might have. After determination of eligibility, parents were mailed the Sensory Over-Responsivity Inventory (SensOR; Miller, 2004); the RCMAS; the informed consent–assent form; and a short form requesting demographic information, such as the child's

age, gender, race, and current medication regimen. All forms were brought to the research laboratory (during Part 2 of the study); consent forms were signed at this time.

Instrumentation and Measures

Sensory Over-Responsivity Scale. The SensOR Inventory (Miller, 2004), a caregiver report tool, was designed to identify people with SOR in one or more of six sensory domains: tactile, auditory, visual, olfactory, taste, and vestibular–proprioceptive. Although Schoen, Miller, and Green (2008) developed both an administered assessment (SensOR Assessment) and a caregiver report scale (SensOR Inventory), the caregiver report scale was the most feasible to use in this study. Both scales were developed in a research edition, subjected to a content validity study, and revised (Version 1.2). Subsequently, a small feasibility study was implemented with children, and scale items were revised a second time (Version 1.3). Version 1.3 was field tested at six sites on a sample of 125 people; of those, 60 were typically developing and 65 were referred with symptoms of SOR. Ninety-one of the 125 people in this sample were children < age 18. Item analysis was conducted, and the pool of items was reduced to include only items with strong correlations within domain or subtest and those that discriminated between groups (Version 1.4).

Version 1.4 of the SensOR Inventory is a 76-item questionnaire with items falling into eight sensory categories: tactile–textures, tactile–activities of daily living, auditory settings, auditory–specific, visual, olfactory, movement–proprioceptive, and food–textures/eating. Items are further grouped into tactile (tactile–textures + tactile–activities of daily living), auditory (auditory settings + auditory–specific), visual, olfactory, gustatory (food–textures/eating), and vestibular–proprioceptive (movement–proprioceptive) domains. Internal consistency reliability was high within each domain (Cronbach's α = .65 to .88). In addition, the SensOR Inventory was shown to have strong construct validity, distinguishing between people with SOR and typical responsiveness with each domain (p < .001 for each domain; Schoen et al., 2008). For this investigation, participants were identified as having SOR through extensive clinical assessment by experienced occupational therapists. Although these findings are admittedly preliminary, this tool was deemed most appropriate for the current study because it allowed the examiners to specifically identify children with the overresponsive type of sensory modulation dysfunction. Currently published sensory-processing tools do not clearly distinguish between overresponsiveness and underresponsiveness.

For the current study, parents or caregivers completed the SensOR Inventory. Each item was scored as a 1 if behaviors or activities "bothered" their child or as a 0 if the behav-

iors or activities were not bothersome. Items include tags in clothing, cutting toenails or fingernails, fluorescent lights, slimy or lumpy foods, sirens or alarms, and going on amusement park rides. Subtest and total scores were added by the examiner and compared with scores obtained from a typically developing sample.

Scores on the SensOR were used to divide the ADHD children into ADHDs (ADHD + SOR) and ADHDt (ADHD without SOR) categories. Children with ADHD whose SensOR scores were >2 standard deviations above the mean in at least one sensory domain were categorized into the ADHDs group. All other children were categorized into the ADHDt group.

Revised Children's Manifest Anxiety Scale. The RCMAS (Reynolds & Richmond, 2005) is a 37-item self-report tool used to measure anxiety in children ages 6 to 19. It includes 28 items that measure traits related to anxiety and 9 items that make up a lie scale or social desirability score (e.g., "I am *always* good"). High lie scale scores may reflect inaccurate self-report, idealized sense of self, or inattention during the questionnaire process, providing a safeguard for child report. Anxiety scale items include prompts such as "I worry a lot of the time," "I often feel sick to my stomach," and "I am nervous a lot." No items on the RCMAS relate directly to sensory stimuli or responses to sensory stimuli. Two items overlap with diagnostic symptoms of ADHD: "I wiggle in my seat a lot" and "It's hard for me to keep my mind on my schoolwork." Higher scores on the RCMAS indicate greater levels of anxiety.

Muris, Merckelbach, Ollendick, King, and Bogie (2002) found high internal consistency reliability for the RCMAS Total Anxiety score (Cronbach's α = .89) and the three subscales: physiological anxiety (α = .69), worry/oversensitivity (α = 0.84), and social concerns/concentration (α = .72). Turgeon and Chartrand (2003) found test–retest reliability after a 6-month period to be significant for all three RCMAS subscales (rs = .52 to .68, $p \leq$ .01). Muris et al. (2002) also found that the total scores for the RCMAS were highly correlated with scores from the State–Trait Anxiety Inventory for Children (r = .88), the Multidimensional Anxiety Scale for Children (r = .76), the Screen for Child Anxiety Related Emotional Disorders, and the Spence Children's Anxiety Scale (r = .76).

It is suggested by test developers that for children at the Grade 1 to 2 level, or who are functioning intellectually at that range, questions on the RCMAS should be read aloud to the child. For children in Grades 3 and higher, administrators can provide explanations for words the child does not understand (Reynolds & Richmond, 2005). To ensure consistency in data collection, all parents were asked to complete the RCMAS with their child, reading questions aloud while

the child circled "Yes" or "No" in response to the prompt. Parents brought the completed RCMAS to the testing laboratory in a sealed and numbered envelope. As noted previously, Reynolds and Richmond (2005) cautioned that questionnaires with high lie scale scores (standard score >13) may be indicative of inaccurate self-report, idealized sense of self, or inattention during the questionnaire process. No children in the current study scored >13 on the lie scale; therefore, all RCMAS scores were considered valid for analysis.

Statistical Analysis

The hypothesis for this study stated that children in the ADHDs group would have significantly higher levels of anxiety than children in the ADHDt or control (typical or TYP) groups. This hypothesis was tested in two ways. First, an analysis of variance (ANOVA) was used to look for aggregate differences among the three group means. A Tukey's Studentized Range Test (Urdan, 2005), which adjusts for multiple testing post hoc, was subsequently used to identify group differences.

Second, a Fisher's exact test (Munro, 2005) was performed to compare scores on the RCMAS for the three groups using a clinical cutoff standard. This test is similar to a Pearson's chi square in that it is based on differences between observed and expected frequencies. The Fisher's exact test was chosen over chi square because of the small sample size and expected low frequency of clinically significant anxiety in the typical population in the current study. As suggested by Stallard, Velleman, Langsford, and Baldwin (2001), a cutoff point of 19 of 28 was used to distinguish children experiencing clinically significant levels of anxiety. The value of 19 served as the expected measure used in the analysis to determine whether group differences exist above and below this clinical cutoff point. We predicted that the number of children with scores >19 would exceed expectation in the ADHDs group but not in the ADHDt or TYP groups. Incorporating both statistical methods made it possible to examine not only whether anxiety levels were higher in one group but also whether those levels were of clinical significance.

Results

Sample Characteristics

Demographic information and IQ scores for the sample are presented in Table 1. No children in the control group (TYP) had a diagnosis of ADHD, other psychological diagnoses, below-normal IQ, or scores on the SensOR indicative of overresponsivity (n = 24). Twenty-four children with a diagnosis of ADHD, no other psychological diagnosis, and

Table 1. Demographics for Total Sample

Factor	TYP (n = 24)	ADHDs (n = 13)	ADHDt (n = 11)
Age (months; mean ± SD)	102.9 ± 18.1	107.9 ± 17	104.9 ± 18.8
IQ (mean ± SD)	109.7 ± 15.6	96.8 ± 16	110.8 ± 19.8
Gender			
Female	13	5	4
Male	11	8	7
Ethnicity			
Non-Hispanic	22	12	10
Other	2	1	1
Race			
White	14	12	10
African American	10		1
American Indian/Alaskan Native		1	

Note. TYP = typical; ADHDs = children with attention deficit hyperactivity disorder (ADHD) and sensory overresponsivity (SOR); ADHDt = children with ADHD and no SOR; *SD* = standard deviation.

IQ within a typical range formed the ADHD groups. Of this group, 13 met the criteria for SOR on the basis of SensOR scores and were therefore designated to the ADHDs group; the remaining 11 children with ADHD were placed in the ADHDt group. Mean SensOR scores and standard deviations for all three groups are presented in Table 2.

No significant differences in age or IQ were found across the three groups (Table 1). It is worth noting that many of the children in the ADHDs group (n = 13) tallied SensOR scores outside of 2 standard deviations in multiple sensory domains. Sixty-two percent of children in the ADHDs group presented with tactile overresponsivity, whereas 54% scored as having auditory overresponsivity. None of the participants reported sensitivity to movement.

Anxiety Scores by Group

Children in the ADHDs group were predicted to have significantly higher levels of anxiety than children in the ADHDt or TYP groups. Mean scores and standard deviations for the RCMAS are presented in Table 3. Mean scores across groups are presented graphically in Figure 1. The RCMAS scores in the domains of total anxiety, physiological anxiety, worry/oversensitivity, and social concerns and confidence were compared using a one-way analysis of variance to determine group differences. Results indicated significant differences across all three groups ($p \leq .001$, $\eta^2 = .292–.490$) in all domains of the RCMAS (Table 4). No differences between groups were found for the lie scale score ($p = .259$), and no data were excluded because of high lie scale scores. Secondary analysis comparing individual groups indicated that children in the ADHDs group had significantly higher levels of total anxiety ($p \leq .001$) and significantly higher scores on all subscales of the RCMAS ($p \leq .001$) than typical children (TYP). Children in the ADHDs group also had

Table 2. Means and Standard Deviations for SensOR Across Study Groups

SensOR Domains (N = items on scale)	Tactile (n = 28)	Auditory (n = 20)	Taste (n = 9)	Smell (n = 5)	Visual (n = 5)	Movement (n = 9)
ADHDs	10.2 ± 4.0	5.4 ± 4.0	3.3 ± 2.9	1.4 ± 1.3	0.62 ± 1.0	1.1 ± 1.0
TYP	3.0 ± 3.2	1.6 ± 1.6	1.1 ± 1.2	0.13 ± 0.34	0.17 ± 0.38	0.38 ± 0.88
ADHDt	2.6 ± 2.2	1.8 ± 1.5	1.4 ± 1.1	0.00 ± 0.00	0.36 ± 0.50	0.45 ± 0.69

Note. Scores reflect the number of item prompts that were "bothersome" to the child. Scores at or above 10 in tactile, 5 in auditory, 4 in taste, 2 in olfactory, 2 in visual, and 4 in movement were outside of 2 standard deviations and qualified the child as having sensory overresponsivity (SOR). ADHDs = attention deficit hyperactivity disorder (ADHD) + SOR; TYP = typical; ADHDt = ADHD without SOR; SensOR = Sensory Over-Responsivity Inventory.

significantly higher scores than children in the ADHDt group for total anxiety (p = .006) and physiological anxiety (p = .001). Children in the ADHDt group scored significantly higher than those in the TYP group for total anxiety (p = .047) and social concerns and confidence (p = .004) as well.

Anxiety between groups was further investigated by determining whether clinically significant levels of anxiety were observed in any of the study groups. Stallard et al. (2001) suggested that a cutoff point of 19 be used to distinguish children experiencing clinically significant levels of anxiety from those who were not. The number of children with clinically significant anxiety levels exceeded expectation (Fisher's exact test, p < .001) in the ADHDs group (46.2%) but not in the ADHDt (9%) or TYP (0%) groups (Table 5).

Discussion

In support of previous research (Schatz & Rostain, 2006), we found that children with ADHD are more likely to have higher levels of anxiety than children without ADHD. This finding was not unexpected. Of interest, the current study findings suggest that children with ADHD and comorbid SOR are more likely to demonstrate higher levels of anxiety than children with or without ADHD who do not have SOR. More important, this pattern was evident not only in their total levels of anxiety but also in their physiological responses to anxiety. Thus, it might be expected that children with ADHD and SOR would more often complain of feeling sick to their stomach or having difficulty sleeping at night when faced with anxiety-producing circumstances. Moreover, there was an increased incidence of clinically significant levels of anxiety in children with ADHD and SOR that characterized the ADHD + SOR group and differentiated them from the other two study groups. This linkage among ADHD, SOR, and anxiety adds a new dimension to our understanding of ADHD and suggests that SOR may be worth greater examination in children with ADHD.

The link between SOR and anxiety was not unexpected; it was the overresponsive behaviors that both Ayres (1972) and Johnson (1975) originally linked to anxiety more than 30 years ago. Findings from the current study mirror those found in children with Asperger syndrome by Pfeiffer (2003),

Table 3. Means and Standard Deviations (SDs) for Revised Children's Manifest Anxiety Scale Scores

		N	Mean	SD	Standard Error	95% Confidence Interval for Mean	
						Lower Bound	Upper Bound
RTA	TYP	24	6.2917	4.08049	0.83293	4.5686	8.0147
	ADHDs	13	18.6154	6.95867	1.92999	14.4103	22.8205
	ADHDt	11	11.2727	6.11704	1.84436	7.1632	15.3822
RPA	TYP	24	2.5833	1.99819	0.40788	1.7396	3.4271
	ADHDs	13	6.5385	2.50384	0.69444	5.0254	8.0515
	ADHDt	11	3.1818	1.88776	0.56918	1.9136	4.4500
RWO	TYP	24	2.6667	2.09900	0.42846	1.7803	3.5530
	ADHDs	13	7.0000	3.80789	1.05612	4.6989	9.3011
	ADHDt	11	4.8182	3.42982	1.03413	2.5140	7.1224
RSCC	TYP	24	1.0417	1.19707	0.24435	0.5362	1.5471
	ADHDs	13	4.7692	1.78670	0.49554	3.6895	5.8489
	ADHDt	11	3.1818	2.52262	0.76060	1.4871	4.8765
	Total	48	2.5417	2.34256	0.33812	1.8615	3.2219

Note. RTA = total anxiety, RPA = physiological anxiety, RWO = worry oversensitivity, RSCC = social concerns and confidence; TYP = typical; ADHDs = attention deficit hyperactivity disorder (ADHD) + sensory overresponsivity (SOR); ADHDt = ADHD without SOR.
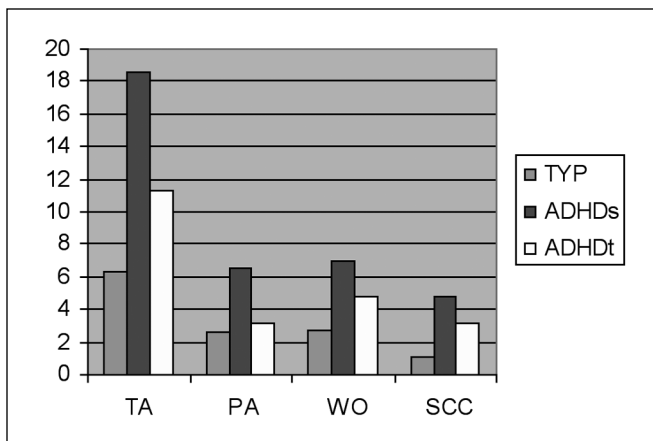
Figure 1. Revised Children's Manifest Anxiety Scale scores by group.

Note. TA = total anxiety, PA = physiological anxiety, WO = worry oversensitivity, SCC = social concerns and confidence, TYP = typical; ADHDs = attention deficit hyperactivity disorder (ADHD) + sensory overresponsivity (SOR); ADHDt = ADHD without SOR.

Table 4. Analysis of Revised Children's Manifest Anxiety Scale Scores

Scale	df	F	p	η	η²
Total anxiety scale score	2,45	21.6	<.001ᵃ	.700	.490
Physiological anxiety	2,45	15.2	<.001ᵇ	.635	.404
Worry oversensitivity	2,45	9.3	<.001ᶜ	.540	.292
Social concerns	2,45	20.5	<.001ᵈ	.691	.477
Lie scale score	2,45	1.39	.259	.242	.058

Note. TYP = typical; ADHDs = attention deficit hyperactivity disorder (ADHD) + sensory overresponsivity (SOR); ADHDt = ADHD without SOR.
ᵃPairwise comparisons using Tukey's Studentized Range Test adjusting for multiple testing indicated that all three groups were different from each other.
ᵇPairwise comparisons using Tukey's Studentized Range Test adjusting for multiple testing indicated that the mean for the ADHDs group was different from those for the ADHDt and the TYP groups.
ᶜPairwise comparisons using Tukey's Studentized Range Test adjusting for multiple testing indicated that the mean for the ADHDs group was different from that for the TYP group.
ᵈPairwise comparisons using Tukey's Studentized Range Test adjusting for multiple testing indicated that the mean for the TYP group was different from those for the ADHDs and ADHDt groups.

which linked SOR to anxiety. The relation among SOR, anxiety, and ADHD adds to this growing body of literature. It warrants further investigation both in populations with other diagnoses and in people with SOR in the absence of comorbid diagnoses.

There is an increasing need to understand the linkage between external (environmental) and internal (individual) factors to understand behavior. SOR may contribute to a collective group of early identifiable factors, both within the child and within the environment, which could be used to predict future development of internalizing behavior disorders, such as anxiety, across many diagnostic groups. The current study was not predictive in nature, but it demonstrated relationships that lend themselves to future predictive analysis. Although some people may be physiologically predisposed to react to sensations in a certain way (e.g., overresponding to sensation), it will ultimately be a combination of their inherent genetic predisposition and their environmental experiences that determine functional outcomes and potential manifestation of adult and adolescent psychopathology (Kendler & Prescott, 2006).

Occupational therapists are well placed to influence both environmental and personal factors, and understanding the diagnostic complexity of the children can only enhance treatment effectiveness. Environmental factors of at-risk children can be addressed by means or mechanisms of environmental sensory modifications, parent education, and work with parents and caregivers on establishing habits and routines that match their child's specific needs; specific needs will be driven by diagnostic and behavioral features of the child. In addition, sensory integration theory suggests that the neural mechanisms of sensory modulation are adaptable (Lane, 2002), so that with direct treatment of the child, sensory reactivity may be diminished, potentially blocking

causal pathways leading to the development of more severe psychiatric disorders.

Limitations

This study had several limitations that must be considered in relation to these findings. Recruitment for this study was challenging, and the final sample size for each group was relatively small, limiting generalizability. Recruitment of children with ADHD and no other comorbid diagnosis was particularly difficult. Several children were referred to the study but had to be excluded because of comorbid diagnoses such as bipolar disorder, obsessive–compulsive disorder, or pervasive developmental disorder. Subdividing the group of children with ADHD into children with and without SOR, a process that was necessary for this study, further decreased the sample size within each group.

Table 5. Analysis of Revised Children's Manifest Anxiety Scale Total Anxiety Scores Above a Cut Value of 19

Frequency	TYP	ADHDs	ADHDt	Total
RTA ≤ 19	24 (20.5) 100%	7 (11.1) 53.8%	10 (9.4) 91%	41
RTA > 19	0 (3.5) 0%	6 (1.9) 46.2%	1 (1.6) 9%	7
	24	13	11	48

Note. The values in parentheses are the expected cell counts in the independence case. The *p* associated with detecting a group difference using a Fisher's exact test was *p* < .001. There are more children in the typical group with RTA < 19 than would be expected if the factors were independent (24 vs. 20.5); there are more children in the ADHD + SOR group with RTA > 19 than would be expected if the factors were independent (6 vs. 1.9); the observed counts are closer to those expected under independence in the ADHD-only group. RTA = total anxiety, TYP = typical; ADHDs = attention deficit hyperactivity disorder (ADHD) + sensory overresponsivity (SOR); ADHDt = ADHD without SOR.

Generalizability of the findings is also compromised because the sample did not fully represent minority racial and ethnic groups. All recruitment materials were printed in English only and therefore may have limited the participation of children from non–English-speaking households. Income and parental education data were not collected with other demographics for this study; information regarding socioeconomic status was not available.

Use of the SensOR must also be viewed as a limitation in this study. The instrument was chosen because it clearly identifies children with SOR as distinguished from both children with typical sensory responsivity and children with sensory underresponsivity. Moreover, development of the SensOR was rigorous, and the psychometrics of the tool appear sound, having been subjected to peer review (Schoen et al., 2008). However, this tool has not yet been published and, therefore, has not been widely used.

Despite these limitations, group differences were found. In addition, η^2 values for mean group differences were generally moderate. This finding suggests that the groups identified in this study differed meaningfully on parameters of interest. Thus, although these results must be considered preliminary, they warrant additional investigation.

Implications for Occupational Therapy

Occupational therapists treating children with ADHD should be aware that some of these children will also demonstrate SOR, whereas others will not. This awareness must influence their approach to intervention. Moreover, they must be cognizant of the likelihood that children with ADHD and SOR are at risk for comorbid anxiety disorders and discuss with families options for prevention or treatment. Occupational therapists may play a role in helping children develop techniques for relaxation or for communicating effectively with teachers or parents when they are feeling overwhelmed. It is likely that many children will have already developed coping behaviors, such as escape or avoidance, which are potentially maladaptive. Occupational therapists may need to work with children and families to reduce these behaviors or to find more adaptive replacement behaviors that facilitate optimal engagement and participation. In some children with SOR, anxiety levels may be significant enough that a referral to a psychologist or psychiatrist is necessary, and occupational therapists can work with families to find a provider who will understand the needs of these complex children.

Directions for Future Research

Future studies investigating the nature of comorbidity and development of anxiety should consider the child's sensory-processing abilities. Researchers need to thoughtfully categorize their diagnostic populations (potentially by sensory reactivity patterns) and avoid lumping individuals into heterogeneous groups. Specific sensory reactivity patterns should be examined because they may be associated with a greater risk of developing, or co-occurring with, other psychological disorders.

In the end, the more we understand the complexity of children involved in treatment, the more effective treatment can be. Consequently, future research should assess both the effectiveness of and client satisfaction with occupational therapy interventions for children with ADHD. Such studies should further consider the impact of both anxiety and SOR in moderating treatment outcomes. ▲

Acknowledgments

References

Abikoff, H. B. (2002). Observed classroom behavior of children with ADHD: Relationship to gender and comorbidity. *Journal of Abnormal Psychology, 30*(4), 1–20.

Angold, A., Costello, E. J., & Erkanli, A. (1999). Comorbidity. *Journal of the American Academy of Child and Adolescent Psychiatry, 40*(1), 57–87.

Aron, E. N., & Aron, A. (1997). Sensory-processing sensitivity and its relation to introversion and emotionality. *Journal of Personality and Social Psychology, 73*(2), 345–368.

Ayres, A. J. (1972). *Sensory integration and learning disorders.* Los Angeles: Western Psychological Services.

Bear, M. F., Connors, B. W., & Paradiso, M. A. (Eds.). (2007). *Neuroscience: Exploring the brain* (3rd ed.). Philadelphia: Lippincott Williams & Wilkins.

Brown, C. E., & Dunn, W. (2002). *Adolescent/Adult Sensory Profile users manual.* San Antonio, TX: Psychological Corporation.

Dunn, W. (1999). *Sensory Profile users manual.* San Antonio, TX: Psychological Corporation.

Edelson, S. M., Edelson, M. G., Kerr, D. C., & Grandin, T. (1999). Behavioral and physiological effects of deep pressure on children with autism: A pilot study evaluating the efficacy of Grandin's hug machine. *American Journal of Occupational Therapy, 53*(2), 145–152.

Jensen, P. S., Hinshaw, S. P., Kraemer, H. C., Lenora, N., Newcorn, J. H., Abikoff, H. B., et al. (2001). ADHD comorbidity findings from the MTA study: Comparing comorbid subgroups. *Journal of the American Academy of Child and Adolescent Psychiatry, 40*(2), 147–158.

Johnson, F. N. (1975). Depression: Some proposals for future research. *Practical Journal for Psychiatrists, Neurologists, and Neurosurgeons, 36,* 228–232.

Kendler, K. S., & Prescott, C. A. (2006). *Genes, environment, and psychopathology.* New York: Guilford Press.

Lane, S. J. (2002). Sensory modulation. In A. C. Bundy, S. J. Lane, & E. A. Murray (Eds.), *Sensory integration theory and practice* (2nd ed., pp. 101–122). Philadelphia: F. A. Davis.

Levy, F. (2004). Synaptic gating and ADHD: A biological theory of comorbidity of ADHD and anxiety. *Neuropsychopharmacology, 29,* 1589–1596.

Miller, L. J. (2004). *Sensory Over-Responsivity Scale: Examiner's manual (Version 2).* Unpublished manuscript.

Miller, L. J., Anzalone, M. E., Lane, S. J., Cermak, S. A., & Osten, E. T. (2007). Concept evolution in sensory integration: A proposed nosology for diagnosis. *American Journal of Occupational Therapy, 61*(2), 135–140.

Munro, B. H. (2005). *Statistical methods for health care research* (5th ed.). Philadelphia: Lippincott Williams & Wilkins.

Muris, P., Merckelbach, H., Ollendick, T., King, N., & Bogie, N. (2002). Three traditional and three new childhood anxiety questionnaires: Their reliability and validity in a normal adolescent sample. *Behavior Research and Therapy, 40,* 753–772.

Neal, J., Edelmann, R. J., & Glachan, M. (2002). Behavioral inhibition and symptoms of anxiety and depression: Is there a specific relationship with social phobia? *British Journal of Clinical Psychology, 41,* 361–374.

Pfeiffer, B., & Kinnealey, M. (2003). Treatment of sensory defensiveness in adults. *Occupational Therapy International, 10*(3), 175–184.

Pfeiffer, E. (2003). Sensory modulation and affective disorders in children and adolescents with Asperger's syndrome. *ProQuest Information and Learning Company,* i–141. UMI Microfilm. (UMI No. 3099904.)

Psychological Corporation. (1999). *Wechsler Abbreviated Scale of Intelligence manual.* San Antonio, TX: Harcourt Assessment.

Reynolds, C. R., & Richmond, B. O. (2005). *Revised Children's Manifest Anxiety Scale (RCMAS)* (9th ed.). Los Angeles: Western Psychological Services.

Schatz, D. B., & Rostain, A. L. (2006). ADHD with comorbid anxiety: A review of the current literature. *Journal of Attention Disorders, 10*(2), 141–149.

Schoen, S. A., Miller, L. J., & Green, K. E. (2008). Pilot study of the Sensory Over-Responsivity Scales: Assessment and inventory. *American Journal of Occupational Therapy, 62*(4), 393–406.

Stallard, P., Velleman, R., Langsford, J., & Baldwin, S. (2001). Coping and psychological distress in children involved in road traffic accidents. *British Journal of Clinical Psychology, 40*(2), 197–208.

Turgeon, L., & Chartrand, E. (2003). Reliability and validity of the Revised Children's Manifest Anxiety Scale in a French Canadian sample. *Psychological Assessment, 15*(3), 378–383.

Urdan, T. C. (2005). One way analysis of variance. In *Statistics in plain English* (2nd ed., pp. 101–114). London: Routledge.