OBJECTIVE. We explored the associations between sensory processing and classroom emotional, behavioral, and educational outcomes of children with autism spectrum disorder (ASD).

METHOD. Twenty-eight children with ASD (with average-range IQ) were compared with 51 age- and gender-matched typically developing peers on sensory processing and educational outcomes.

RESULTS. For children with ASD, the Short Sensory Profile scores Underresponsive/Seeks Sensation and Auditory Filtering explained 47% of the variance in academic performance, yet estimated intelligence was not a significant predictor of academic performance. Significant negative correlations were found between (1) auditory filtering and inattention to cognitive tasks, (2) tactile hypersensitivity and hyperactivity and inattention, and (3) movement sensitivity and oppositional behavior.

CONCLUSION. A pattern of auditory filtering difficulties, sensory underresponsiveness, and sensory seeking was associated with academic underachievement in the children with ASD. Children who have difficulty processing verbal instructions in noisy environments and who often focus on sensory-seeking behaviors appear more likely to underachieve academically.


Autism spectrum disorder (ASD) is an umbrella term used to describe autistic disorder and milder variants such as Asperger syndrome and pervasive developmental disorders: not otherwise specified (American Academy of Pediatrics, 2001). Diagnostically, people with ASD have social and communication impairments, restricted interests, and repetitive behaviors (American Psychiatric Association, 2000). Although not included in the current diagnostic criteria, studies using caregiver questionnaires have consistently found children with ASD to exhibit atypical behavioral responses to sensory input (Baranek, David, Poe, Stone, & Watson, 2006; Rogers, Hepburn, & Wehner, 2003; Tomchek & Dunn, 2007). Recently developed teacher questionnaires have also differentiated the sensory responses of children with ASD in the classroom from those of typically developing children (Dunn, 2006; Miller Kuhaneck, Henry, & Glennon, 2007). Associations have been found between atypical sensory processing and behavioral and emotional problems (Baker, Lane, Angley, & Young, 2008) and sensory overreactivity and anxiety (Pfeiffer, Kinnealey, Reed, & Herzberg, 2005). The educational progress of children with ASD can be affected by their limited capacity to self-regulate their emotional and behavioral responses and remain on task (Eaves & Ho, 1997). Maladaptive responses to classroom sensory environments have been assumed to underlie some of this behavior (Anderson, 1998; Myles, Cook, Miller, Rinner, & Robbins, 2000). However, the relationship between the atypical sensory responses of children with
People with ASD have been found to be atypically slow in reorienting their attention between visual and auditory stimuli (Courchesne et al., 1994) and between visual stimuli in different spatial locations (Belmonte & Yurgelun-Todd, 2003; Landry & Bryson, 2004; Townsend, Courchesne, & Egas, 1996; Wainwright & Bryson, 1996). Atypical slowness in reorienting attention is thought to contribute to (1) a preference for static, predictable, repetitive sensory stimuli (such as objects) over changing and unpredictable stimuli (such as social partners and social settings; Courchesne et al., 1994) and (2) narrow, overfocused attention on particular sensory stimuli (Gomot et al., 2006; Townsend et al., 1996). Liss, Saulnier, Fein, and Kinsbourne (2006) found significant associations between overfocused attention and sensory hypersensitivity in people with ASD.

A recent review by Mottron, Dawson, Soulieres, Hubert, and Burack (2006) contrasted the relative strengths of people with ASD when performing static visuospatial tasks with their deficits in the perception of neurologically defined complex visual stimuli. For example, they have been found to have intact or enhanced performance on static visuospatial tasks, including block design (Shah & Frith, 1993), reproduction of impossible figures (Mottron, Belleville, & Menard, 1999), and visual search tasks (O’Riordan, Plaisted, Driver, & Baron-Cohen, 2001). These findings contrast with their deficits in the performance of some “complex” motion tasks, including the perception of motion defined by contrast or texture (Bertone, Mottron, Jelenic, & Faubert, 2005), the perception of moving patterns in coherent dot displays (Milne et al., 2002), and the perception of biological movement (Blake, Turner, Smoski, Pozdol, & Stine, 2003). In this context, “complexity” is defined in terms of the hierarchical neural organization of the visual cortex rather than the difficulty of the task. Neurologically “complex” tasks are processed in the anterior regions of the visual cortex, whereas “simple” tasks are processed in the more posterior regions (Bertone et al., 2005).

Davis, Bockbrader, Murphy, Hetrick, and O’Donnell (2006) also found that children with ASD performed more poorly than typically developing children on motion discrimination but not on form discrimination tasks and that their self-reported visual hypersensitivity correlated significantly with their visual perceptual deficits.

A review by Samson, Mottron, Bouteina, Pascal, and Ciocca (2006) revealed a similar pattern of strengths and deficits in auditory processing. People with ASD have been found to display intact or superior performance when processing neurologically simpler auditory input, such as pure tones (Bonnel et al., 2003; Heaton, 2003), but deficits in the processing of spectrally and temporally complex auditory input, such as the auditory streams in language. For example, they have been found to have difficulty recognizing speech against a background of speechlike noise with complex patterns of pitch and timing (Alcantara, Weisblatt, Moore, & Bolton, 2004) and a diminished capacity to selectively attend to particular sounds in environments with multiple sound sources and complex sounds (Teder-Salejarvi, Pierce, Courchesne, & Hillyard, 2005).

Converging evidence from multiple sources therefore suggests that people with ASD may be challenged by the processing of complex sensory input (e.g., rapid, changing, or unpredictable) and yet have relative strengths in the processing of simple sensory stimuli (e.g., static, repetitive, predictable). Gomot et al. (2006) suggested that because of their difficulty with processing changing or unpredictable stimuli, people with ASD aim to keep their environment as predictable as possible and, therefore, gravitate toward simple repetitive stimuli. People with ASD have been found to engage in stereotypic sensory-seeking behaviors more frequently when they are stressed or presented with aversive stimuli or understimulated (Gal, Dyck, & Passmore, 2002; Willemsen-Swinkels, Buitelaar, Dekker, & Van Engeland, 1998). They may therefore either seek predictable, repetitive sensory input as a means of screening out complex sensory input that is overwhelming or difficult to process or indulge in their preference for predictable, repetitive sensory input when understimulated.

Sensory-seeking behaviors are commonly interpreted as attempts to generate more input to meet a high threshold of response to sensory input or to gain more information from the environment (Dunn, 2001). However, people with ASD frequently present with combinations of sensory under- and overreactivity and sensory-seeking behaviors that might also be explained by hypersensitivity and aversion to rapid, changing, or unpredictable sensory input coupled with preference for predictable, repetitive sensory input. For example, they often react adversely to the unpredictable touch of other people yet enjoy touching others (predictable tactile input) and respond adversely to unpredictable loud noises while enjoying repetitive noise making. They often avoid unfamiliar foods or those with unpredictable tastes (e.g., lumpy) while seeking familiar objects to mouth.

Many people with ASD present with auditory filtering deficits that manifest as both distractibility in the presence...
of background noise (an overreactive response) and failure to respond when spoken to (an underresponsive response). Auditory filtering has consistently been found to be one of the most atypical of the Short Sensory Profile scores in studies of children with ASD (Adamson, O’Hare, & Graham, 2006; Baker et al., 2008; Rogers et al., 2003; Tomchek & Dunn, 2007). “Failure to respond when name is called” has consistently been observed in home videotapes of infants later diagnosed with ASD, suggesting an early difficulty in selectively attending to pertinent auditory input (Osterling, Dawson, & Munson, 2002; Werner, Dawson, Osterling, & Dinno, 2000). Baranek, Boyd, Poe, David, and Watson (2007) found young children with autism to be more likely to be nonresponders to auditory stimuli than children with typical or delayed development.

People with ASD may be able to avoid complex visual input by averting the eyes or narrowing the focus of visual attention and to actively avoid sources of unpredictable tactile input. Environmental auditory input, however, is more difficult to escape. They may therefore be left with the somewhat dysfunctional alternatives of being overwhelmed by complex auditory input or blocking it all out, as aptly described by Temple Grandin (1992): “My hearing is like an open microphone that picks up everything. I have two choices: turn the mike on and get deluged by sound, or shut it off” (p. 107).

Classrooms are typically complex sensory environments. Although the advent of interactive learning styles has undoubtedly enhanced the active involvement of students in learning, a negative consequence has been increased sensory challenges in the classroom. Modern classrooms have a high level of visual clutter, and because children are often seated in groups, they are frequently exposed to unpredictable tactile input. The most serious concerns, however, relate to excessive noise in modern classrooms, which is widely believed to adversely affect the attention and behavior of many children (Anderson, 2001). Academic material is usually presented through verbal instruction, which is by nature rapid and transient and thought to be difficult for children with ASD to process (Quill, 1997), especially in the presence of competing background noise (Alcantara et al., 2004).

A paucity of evidence exists on the functional implications of the atypical sensory processing of children with ASD in the classroom. This study aimed to (1) confirm previous research findings that the responses of children with ASD to sensory input differed from those of typically developing children and (2) explore the associations between the sensory-processing patterns of children with and without ASD and their respective classroom emotional, behavioral, and educational outcomes.

Method

A case-control research design was used to compare a group of children with ASD with age- and gender-matched typically developing children.

Participants

All the children with ASD were (1) included in regular education classes (classes taught by regular education teachers where the majority of the children had no special needs), (2) ages 6 to 10 years, and (3) diagnosed with ASD by a pediatrician. Children with ASD were excluded if they had an additional intellectual, hearing, visual, or physical impairment or were currently receiving occupational therapy to address sensory-processing issues. They were screened using the Kaufman Brief Intelligence Test (K–BIT; Kaufman & Kaufman, 1990) to ensure that they met the inclusion criterion of an estimated IQ of 80 or above. Where possible, 2 children with no known developmental disabilities were selected from the class of each child with ASD with the aim of controlling for teacher and teaching styles, classroom environments, and educational programs, although in some instances only 1 matched control child from the same class was able to be recruited. In total, 28 children with ASD (24 boys and 4 girls) and 51 typically developing children (43 boys and 8 girls) participated. The children attended 12 schools with a range of socioeconomic backgrounds (30% low, 4% mid-low, 25% mid-high, 41% high; Australian Bureau of Statistics, 2001).

Procedure

Ethical clearance to conduct the study was obtained from the University of Queensland and Education Queensland. The teachers, children, and parents provided informed written consent.

The independent variable of interest was sensory processing, which was measured using the Short Sensory Profile (SSP; McIntosh, Miller, Shyu, & Dunn, 1999). Symptoms of ASD, IQ, and the sensory aspects of classroom environments were measured because they had the potential to affect classroom emotional, behavioral, and educational outcomes. Symptoms of ASD were measured in the children with ASD using the Gilliam Autism Rating Scale (GARS; Gilliam, 1995) and the Gilliam Asperger’s Disorder Scale (GADS; Gilliam, 2001). To control for difficulties consistent with Asperger syndrome (such as mild social difficulties) in the typically developing children, these children were also assessed using the GADS. The K–BIT was used as an estimate of IQ. Observations of the sensory features of the classroom, including visual clutter, noise levels, and crowding, were recorded, but because of difficulties with the validity
and reliability of these measurements, they are not discussed in this article.

The dependent variables, which included classroom emotional regulation, behavior regulation (including compliance, attention, and social behaviors), and educational outcomes, were measured using two teacher questionnaires: the Conner’s Teacher Rating Scale–Revised Long Version (CTRS–R:L; Conners, 1997) and the Achenbach System of Empirically Based Assessment: Teacher Report Form (ASEBA:TRF; Achenbach & Rescorla, 2001). The teachers were unaware of the parent ratings of sensory processing and the parents were unaware of the teacher ratings of classroom performance. Jill Ashburner administered the K–BIT; either met with or telephoned the parents to clarify the method of completing the Short Sensory Profile, the GARS, and the GADS; and either met with or telephoned the teachers to administer the ASEBA:TRF and the CTRS–R:L. The K–BIT was administered first to ensure that the child had average range IQ. Ashburner was appropriately qualified to administer these assessments.

**Instrumentation**

The SSP (McIntosh et al., 1999) is a 38-item abridged version of the Sensory Profile (Dunn, 1999). It provides a total score and the following section scores: Tactile Sensitivity, Taste/Smell Sensitivity, Movement Sensitivity, Underresponsive/Seeks Sensation, Auditory Filtering, Low Energy/Weak, and Visual/Auditory Sensitivity. Parents or caregivers rate the frequency with which their child demonstrates behaviors on a 5-point scale ranging from “always” to “never.” The scores are categorized as typical, probably different, or definitely different. Higher scores indicate more atypical sensory processing. Internal reliability of the test total and sections range from .70 to .90 (Cronbach’s α). Construct validity was established using electrodermal responses to sensory input (McIntosh et al., 1999).

The GARS is a caregiver questionnaire that determines the likelihood of people ages 3 to 22 years having autism. Oswald (1998) reported that the GARS has quite good reliability and validity (internal consistency of each subscale ranged from .88 to .93, the intrarater reliability correlation coefficient for the total scale was .88, test–retest reliability correlation coefficient was .88, and content validity supported by item–subscale total correlations ranged from .61 to .69).

The GADS is a caregiver questionnaire that determines the likelihood of people ages 3 to 22 years having Asperger syndrome. The GADS total scale demonstrates moderate to strong reliability (coefficients range from .87 to .95) for different diagnostic groups including people with autistic disorder, no known disability, and people with other disabilities. Good test–retest reliability (.93) was reported. A positive correlation between the GADS and the GARS provided evidence of concurrent validity.

The K–BIT is a brief measure of verbal and nonverbal intelligence for people ages 4 to 90 years. Similar to full-scale IQ tests, the K–BIT IQ composite score was normed to have a mean of 100 and standard deviation of 15. The K–BIT IQ Composite Score has excellent internal consistency (.89 to .94) and test–retest reliability (.92) and correlates positively with full-scale IQ tests such as the Wechsler Intelligence Scale for Children–Revised (Wechsler, 1974).

The CTRS–R:L describes the attention, social, and emotional behaviors of children in the classroom. The teacher rates the 59 items using a 4-point scale ranging from 0 (“not at all true”) to 3 (“very much true”). The items are grouped into the following scales: oppositional; cognitive problems/inattention; hyperactivity; anxious/shy; perfectionism and social problems; Conners’ Global Index: restless/impulsive; Conners’ Global Index: emotional liability; Conners’ Global Index: total; DSM–IV: inattention; DSM–IV: hyperactive/impulsive; and DSM–IV: total. Higher scores indicate more problematic behaviors. Several large, nationwide studies used to examine the factor structure of the CTRS–R:L are detailed in the manual (Conners, 1997). Internal consistency estimates ranged from .72 to .95, and 6- to 8-week test–retest reliabilities ranged from .47 to .92.

The ASEBA:TRF describes children’s school function as seen by teachers. Students are rated on 113 items grouped into eight syndrome scales (anxious/depressed, withdrawn/depressed, somatic complaints, rule-breaking behavior, aggressive behavior, social problems, thought problems, and attention problems) using a 3-point scale ranging from 0 (“not true”) to 2 (“very true or often true”). Higher scores indicate more problematic behaviors. The ASEBA:TRF academic performance score is based on mean of the student’s ratings in each subject on a scale ranging from “far below grade” to “far above grade,” with higher scores indicating better academic performance. Test–retest reliability coefficients of the ASEBA:TRF have a mean of .90. Internal consistency was supported by alpha coefficients of .90 for the ASEBA: TRF total score and .72 to .95 for the syndrome scales. Construct validity of the ASEBA: TRF is supported by correlations with similar scales such as the Conners’ Teacher Rating Scale–Revised (Conners, 1997).

**Selection of Dependent Variables**

Participants were assessed using the ASEBA:TRF and the CTRS–R:L to capture a wide range of classroom emotional, behavioral, and educational outcomes. Correlations between the two instruments suggested that some scales measure
similar constructs (Achenbach & Rescorla, 2001). When the scales were highly correlated, only one was used for analysis. The selected dependent variables are listed in Table 1.

Data Analysis

Independent-sample t-tests for equality of means were used to determine differences between the ASD and typically developing groups with regard to estimated intelligence; age (to ensure that the groups were well matched); sensory processing; and classroom emotional, behavioral, and educational outcomes. A conservative alpha level of .01 was set to account for the increased risk of Type I error resulting from multiple comparisons in the same data set. Homogeneity of variance was not assumed because of the unequal sample sizes. Associations between the measures of sensory processing, autistic symptoms, intelligence, and classroom environmental variables and classroom emotional, behavioral, and educational outcomes were initially explored using a correlational analysis. All significant correlations were further examined using scatter plots to determine linearity and identify outliers. Q–Q plots of the residuals were used to check the normality of the distributions (Moore & McCabe, 2000). Pearson correlation coefficients are reported except where the data were not normally distributed, in which case Spearman’s nonparametric measures are reported. Significant correlations were further explored using a stepwise backward-elimination multiple regression analysis, which is used when more than one explanatory variable is predictive of a single response variable (Moore & McCabe, 2000). Potentially explanatory variables were entered into the multiple regression analysis on the basis of a significant correlation with the dependent variable or because theoretically, a variable would be expected to correlate with the dependent variable (e.g., IQ would be expected to correlate with academic performance).

Results

No significant between-group differences were found in age ($t = 0.71, p = .48, df = 62.10$) or K–BIT scores ($t = 0.78, p = .44, df = 66.72$), thus confirming the matching of the two groups on these variables. The K–BIT scores ranged from 82 to 124 with a mean of 103.5 ($SD = 10.24$) in the ASD group and 84 to 144 with a mean of 105.76 ($SD = 12.81$) in the typically developing group. Significant group differences were found on all SSP factor scores and total score ($p < .001$) with the exception of Movement Sensitivity ($t = –2.46, p = .016, df = 57.98$). Of the children with ASD, 79% had SSP total scores in the definitely different range (DD) and 18% in the probably different range (PD), compared with 2% DD and 2% PD in the typically developing group. Significant group differences were found on all of the CTRS–R:L and ASEBA:TRF scores ($p < .001$). Because there were such significant differences between the two groups on measures of both sensory processing and classroom emotional, behavioral, and educational outcomes, analyses were undertaken for each group separately.

Children With ASD

Scores on the GADS indicated that 26 (93%) of the children diagnosed with ASD had a high probability of having Asperger’s syndrome, whereas scores on the GARS indicated

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Table 1. CTRS–R:L and ASEBA:TRF Scales That Relate to Classroom Emotional, Behavioral, and Education Outcomes

<table>
<thead>
<tr>
<th>Construct</th>
<th>CTRS–R:L</th>
<th>ASEBA:TRF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emotional regulation</td>
<td>Anxious/shy</td>
<td>Anxious/depressed</td>
</tr>
<tr>
<td></td>
<td>Conners’ Global Index: Emotional lability</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Conners’ Global Index: Perfectionism</td>
<td></td>
</tr>
<tr>
<td>Behavioral regulation</td>
<td>Oppositional</td>
<td>Rule-breaking behavior</td>
</tr>
<tr>
<td></td>
<td>Conners’ Global Index: Emotional lability</td>
<td></td>
</tr>
<tr>
<td>Attention</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inattentive symptoms</td>
<td>DSM–IV Inattentive</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cognitive problems/inattention</td>
<td></td>
</tr>
<tr>
<td>Hyperactive/impulsive symptoms</td>
<td>Hyperactivity</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Conners’ Global Index: Restless/impulsive</td>
<td></td>
</tr>
<tr>
<td></td>
<td>DSM–IV Hyperactive/impulsive</td>
<td></td>
</tr>
<tr>
<td>Combined inattentive and hyperactive symptoms</td>
<td>Conners’ ADHD Index</td>
<td></td>
</tr>
<tr>
<td></td>
<td>DSM–IV total</td>
<td></td>
</tr>
<tr>
<td>Cognitive problems</td>
<td>Cognitive problems/inattention</td>
<td>Thought problems</td>
</tr>
<tr>
<td>Social behaviors</td>
<td>Social problems</td>
<td>Social problems</td>
</tr>
<tr>
<td>General problematic behavior</td>
<td>Conners’ Global Index</td>
<td>Total score</td>
</tr>
<tr>
<td>Educational outcomes</td>
<td></td>
<td>Adaptive functioning score</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Academic performance scale</td>
</tr>
</tbody>
</table>

that 7 (25%) had an average to above average probability of having ASD. In the ASD group, the most atypical SSP factor score was auditory filtering (75% DD, 21% PD), followed by underresponsiveness/seeks sensation (72% DD, 21% PD), low energy/weak (64% DD, 18% PD), visual/auditory sensitivity (43% DD, 25% PD), taste/smell sensitivity (43% DD, 21% PD), tactile sensitivity (29% DD, 46% PD), and movement sensitivity (3% DD, 29% PD). Correlation matrices of SSP scores and the CTRS-R:L and ASEBA:TRF scores are presented in Tables 2 and 3, respectively. In cases of possible statistical anomalies, further analyses were conducted. For example, the scatter plot between movement sensitivity and CTRS-R:L oppositional suggested clustering of both scores at close to ceiling levels. When this correlation was recalculated using Spearman’s nonparametric correlation coefficient, it continued to be significant \( r = -0.51, p = 0.003 \). The scatter plot between auditory filtering and the ASEBA: TRF scores: anxious/depressed suggested the influence of an outlier. When recalculated without the outlier, this correlation was not significant \( r = 0.44, p = 0.01 \).

None of the other independent variables, including the GADS, GARS, and the K-BIT, correlated significantly with any of the CTRS–R:L and the ASEBA:TRF scores. Multiple regression analyses suggested that the SSP scores underresponsiveness/seeks sensation and auditory filtering explained 47% of the variance in ASEBA:TRF academic performance, whereas the K-BIT, GARS, and GADS scores were not significant predictors. Together, tactile sensitivity and auditory filtering explained 36% of the variance in CTRS-R:L DSM–IV inattention and 37% of the variance in CTRS-R:L cognitive problems/inattention, whereas underresponsiveness/seeks sensation, K-BIT, GARS, and GADS scores were not significant predictors. None of the SSP scores correlated with the K-BIT score. There were significant negative correlations between the SSP: Total score and the GADS Asperger’s disorder quotient \( r = -0.56, p = 0.002 \), between visual/auditory sensitivity and the GADS Asperger’s disorder quotient \( r = -0.48, p = 0.01 \), and between underresponsive/seeks sensation and the GARS autism quotient \( r = -0.53, p = 0.003 \).

**Control Group**

No significant correlations were found between any of the SSP scores and the CTRS-R:L and the ASEBA:TRF scores. The K-BIT score was moderately correlated with the ASEBA: TRF score for academic performance \( r = 0.53, p < 0.001 \).

**Discussion**

There were highly significant group differences on all SSP section scores with the exception of movement sensitivity, thus confirming previous research findings that the responses of children with ASD to sensory input differ from those of typically developing children (the first aim of the study). In the children with ASD, the associations between SSP total score and the GADS suggested that atypical sensory processing is associated with symptoms of Asperger’s syndrome. The association between SSP: underresponsiveness/seeks sensation and the GARS may relate to the tendency of children with autism to withdraw and engage in sensory-seeking behaviors. Sensory processing was unrelated to estimated IQ, which is consistent with the findings of Rogers et al. (2003).

**Factors Associated With Classroom Emotional, Behavioral, and Educational Outcomes**

In the typically developing group, the only significant association was between estimated IQ and academic performance,

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**Table 2. Correlation Matrix (Pearson Correlation Coefficients) Between SSP Scores and the CTRS–R:L Scores in Children With ASD (N = 28)**

<table>
<thead>
<tr>
<th>SSP</th>
<th>Oppen</th>
<th>Cognitive Problems/Inattention</th>
<th>Hyperactivity</th>
<th>Anxious/ Shy</th>
<th>Perfectionism</th>
<th>Social Problems</th>
<th><strong>Conners’ ADHD Index</strong></th>
<th>DSM-IV Hyperactive/ Impulsive</th>
<th>DSM-IV Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tactile sensitivity</td>
<td>-.45</td>
<td>-.48**</td>
<td>-.46</td>
<td>.03</td>
<td>.06</td>
<td>.03</td>
<td>-.40</td>
<td>-.45</td>
<td>-.37</td>
</tr>
<tr>
<td>Taste/smell sensitivity</td>
<td>-.33</td>
<td>-.28</td>
<td>-.11</td>
<td>.10</td>
<td>-.04</td>
<td>.01</td>
<td>-.06</td>
<td>-.11</td>
<td>-.07</td>
</tr>
<tr>
<td>Movement sensitivity</td>
<td>-.49*</td>
<td>-.32</td>
<td>-.23</td>
<td>-.17</td>
<td>-.04</td>
<td>-.01</td>
<td>-.31</td>
<td>-.34</td>
<td>-.24</td>
</tr>
<tr>
<td>Underresponsive/seeks sensation</td>
<td>-.08</td>
<td>-.48**</td>
<td>-.15</td>
<td>-.12</td>
<td>-.18</td>
<td>-.32*</td>
<td>-.17</td>
<td>-.11</td>
<td>-.03</td>
</tr>
<tr>
<td>Auditory filtering</td>
<td>-.07</td>
<td>-.49**</td>
<td>-.06</td>
<td>.03</td>
<td>.23</td>
<td>-.44*</td>
<td>-.16</td>
<td>-.05</td>
<td>.13</td>
</tr>
<tr>
<td>Low energy/weak</td>
<td>-.12</td>
<td>-.22</td>
<td>-.15</td>
<td>-.14</td>
<td>-.10</td>
<td>-.11</td>
<td>-.21</td>
<td>-.19</td>
<td>-.02</td>
</tr>
<tr>
<td>Visual/auditory sensitivity</td>
<td>-.23</td>
<td>-.22</td>
<td>-.35</td>
<td>-.16</td>
<td>.03</td>
<td>.04</td>
<td>-.19</td>
<td>-.24</td>
<td>-.37</td>
</tr>
<tr>
<td>Total score</td>
<td>-.37</td>
<td>-.60**</td>
<td>-.31</td>
<td>-.02</td>
<td>.07</td>
<td>-.21</td>
<td>-.31</td>
<td>-.32*</td>
<td>-.17</td>
</tr>
</tbody>
</table>

*Correlation is significant at the .05 level (two-tailed).
**Correlation is significant at the .01 level (two-tailed).

*Note. SSP = Short Sensory Profile; CTRS–R:L = Conners’ Teacher Rating Scale–Revised: Long Version; ADHD = attention deficit/hyperactivity disorder; DSM–IV = Diagnostic and Statistical Manual of Mental Disorders (4th ed.).
as might be expected. In the ASD group, underresponsive/seeks sensation and auditory filtering were significantly negatively associated with academic performance and attention to cognitive tasks (CTRS–R:L cognitive/inattention). Because estimated intelligence was not a significant predictor of academic performance, these specific sensory-processing difficulties appeared to contribute significantly to academic underachievement. Children with ASD who have difficulty tuning in to verbal instructions in the presence of background noise and who often focus on sensory-seeking behaviors appear more likely to underachieve academically. It is possible that these children find auditory input overwhelming or difficult to process and instead seek predictable repetitive input that they are able to control. The high prevalence of auditory filtering difficulties and underresponsive and sensory-seeking behaviors as measured by the SSP was consistent with previous findings (Adamson et al., 2006; Baker et al., 2008; Rogers et al., 2003; Tomchek & Dunn, 2007). High levels of tactile sensitivity were associated with a range of attention difficulties, including inattentive and hyperactive symptoms, whereas reduced auditory filtering was more highly associated with poor attention to cognitive tasks, possibly reflecting an inability to focus on educational input in noisy environments.

Implications for Practice

Auditory filtering difficulties were associated with deficits in learning and attention and therefore appeared to be very functionally disabling in the children with ASD. Overreliance on verbal instructions may be reduced by using the visual strategies often recommended for children with ASD (Quill, 1997). Alcantara et al. (2004) found that children with ASD require speech to be 2 to 3.5 dB louder than typically developing peers to enable comprehension in the presence of background noise, and Teder-Salejarvi et al. (2005) suggested that children with ASD may benefit from an acoustically simplified setting. The effect of amplification of the teacher’s voice and improvements to classroom acoustics should therefore be investigated.

Because these findings suggest that children with tactile sensitivity are more likely to be inattentive and distractible in the classroom, interventions that reduce unpredictable tactile input, such as positioning these children at a distance from classmates, also warrant further exploration. Because the combined impact of complex sensory input in different modalities may be cumulative, it may be advantageous to simplify classroom sensory environments by (1) enhancing the salience of instructions while minimizing competing input, (2) increasing the predictability of activities, and (3) presenting information at a reduced pace.

Limitations and Recommendations for Further Research

Because this was the first study to investigate the relationship between sensory processing and classroom emotional, behavioral, and educational outcomes in children with ASD, replication of these findings is essential. The choice of assessments used in this study was limited by budgetary constraints. The reliability of the caregiver and teacher questionnaires may have been affected by a lack of objectivity of the raters. More valid and reliable measurements may have been achieved by using a full-scale IQ test, the Autism Diagnostic Observation Schedule (Lord et al., 2000), and Autism Diagnostic Interview–Revised (Lord, Rutter, & Le Couteur, 1994). The measurement of sensory processing would be strengthened by the addition of a direct observational scale or electrodigital testing. Studies that use direct observations in the classroom may provide more detailed information about specific sensory conditions that trigger emotional responses or challenging behaviors that interfere with learning.

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</thead>
<tbody>
<tr>
<td>Tactile sensitivity</td>
<td>.06</td>
<td>.05</td>
<td>–.12</td>
<td>–.14</td>
<td>–.27</td>
<td>–.25</td>
<td>.21</td>
</tr>
<tr>
<td>Taste/smell sensitivity</td>
<td>–.04</td>
<td>–.03</td>
<td>–.13</td>
<td>–.06</td>
<td>–.17</td>
<td>–.16</td>
<td>–.05</td>
</tr>
<tr>
<td>Movement sensitivity</td>
<td>.02</td>
<td>–.07</td>
<td>–.21</td>
<td>–.23</td>
<td>–.37</td>
<td>–.42*</td>
<td>.02</td>
</tr>
<tr>
<td>Underresponsive/seeks sensation</td>
<td>.30</td>
<td>–.30</td>
<td>–.12</td>
<td>–.39*</td>
<td>–.02</td>
<td>–.17</td>
<td>.62**</td>
</tr>
<tr>
<td>Auditory filtering</td>
<td><strong>.56</strong></td>
<td>–.30</td>
<td>.13</td>
<td>–.05</td>
<td>.11</td>
<td>.01</td>
<td><strong>.60</strong></td>
</tr>
<tr>
<td>Low energy/weak</td>
<td>.37</td>
<td>.07</td>
<td>.21</td>
<td>.04</td>
<td>.19</td>
<td>.21</td>
<td>.14</td>
</tr>
<tr>
<td>Visual/auditory sensitivity</td>
<td>–.07</td>
<td>–.14</td>
<td>–.11</td>
<td>–.01</td>
<td>–.06</td>
<td>–.14</td>
<td>.12</td>
</tr>
<tr>
<td>Total score</td>
<td>.37</td>
<td>.20</td>
<td>.02</td>
<td>–.13</td>
<td>–.02</td>
<td>.11</td>
<td>.45*</td>
</tr>
</tbody>
</table>

Note. ASD = autism spectrum disorder; SSP = Short Sensory Profile; ASEBA:TRF = Achenbach System of Empirically Based Assessment: Teacher Report Form.

*Correlation is significant at the .05 level (two-tailed).

**Correlation is significant at the .01 level (two-tailed).
The involvement of investigators with a background in audiology or speech–language pathology would allow more detailed investigation of auditory processing, particularly differentiation of the impact of auditory filtering and language difficulties. Qualitative methods may be used to capture the valuable insights of students with ASD with respect to their experience of the sensory aspects of classrooms. Finding a valid means of measuring the sensory features of the classroom is likely to be problematic in future studies because they are, by nature, highly variable, complex, and subject to moment-to-moment variation.

Because atypical sensory processing has been found in children with various developmental difficulties such as attention deficit hyperactivity disorder (Dunn & Bennett, 2002; Mangeot et al., 2001; Miller, Reisman, McIntosh, & Simon, 2001), the inclusion of children with other developmental difficulties may help tease out which functional outcomes relate to the core features of specific diagnoses and which relate to the sensory processing issues that they have in common. Future studies using careful matching procedures could also include children with ASD with intellectual impairments. Finally, the significant association between auditory filtering difficulties and academic underachievement could further explore the nature of auditory filtering difficulties in children with ASD and to investigate the effectiveness of strategies that reduce the reliance of verbal instruction or improve classroom acoustics. ▲

Acknowledgments

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References


