

# An optometric approach to patients with sensory integration dysfunction

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## KEYWORDS

Sensory integration;  
Yoked prism;  
Oculomotor  
dysfunction

## Abstract

**BACKGROUND:** Sensory integration dysfunction is a neurologic condition that can cause children to process environmental sensations in an inappropriate way. As a result, they may either seek out strong sensations or avoid even mild sensations. Some of the characteristics of these children may be hyperactivity, poor awareness of pain, high risk taking, listening to loud sounds, clumsiness, poor fine motor skills, poor gross motor skills, poor visual tracking, problems with sequencing, and problems with balance. Sensory integration dysfunction often is related to children with developmental disabilities, autism, and attention deficits.

**METHODS:** Two children from the same family were examined for general eye examinations because of a history of sensory integration problems. J.H., an 11-year-old girl, and her 6-year-old half-brother, A.T., returned to the clinic for visual-perceptual testing: the Test of Variables of Attention (TOVA), the Developmental Eye Movement Test (DEM), and the Visagraph (Compevo AB, Stockholm, Sweden). The use of yoked prisms with these children was also explored.

**RESULTS:** Both children showed oculomotility problems based on the DEM and Visagraph results. Whereas J.H. performed well on the visual-perceptual profile overall, A.T. showed problems in many areas such as reversals, visual spatial relations, visual sequential memory, visual form constancy, and attention. Both children were low hyperopes and showed positive postural and balance changes when tested with yoked prisms.

**CONCLUSIONS:** Children with sensory integration dysfunction can have a number of signs and symptoms that may bring them to the optometrist's office. It is important to thoroughly test their visual, perceptual, and oculomotor systems to determine the best way to help these patients. The use of vision therapy and yoked prisms can be beneficial treatment options for many of these patients.

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Sensory integration dysfunction (SID), also known as *sensory motor integration dysfunction* or *sensory processing disorder*, is a condition caused by a disorganization of the central nervous system.<sup>1-4</sup> It was originally estimated in the late 1970s that 5% to 10% of children had sensory integration problems,<sup>3</sup>

whereas in the late 1990s it was estimated that 12% to 30% of children had these problems.<sup>4</sup> In children with autism spectrum disorders, 80% to 90% show sensory processing disorders.<sup>5,6</sup> The possible causes of SID have been hypothesized as the following: genetic predisposition, prenatal causes, prematurity, birth trauma, congenital central nervous system abnormalities, biochemical disruptions, environmental factors, and inadequate sensory stimulation after birth.<sup>4,7</sup> Thus, there is no certainty of the cause at this time.

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**Table 1**    Symptoms pertinent to optometry

Poor fine motor skills
Poor gross motor skills
Dyspraxia
Poor eye-hand coordination
Poor visual tracking
Abnormal smooth pursuits
Poor eye contact
Poor binocularity
Problems with visual perception
Problems with spatial awareness
Problems with sequencing motor planning
Learning disabilities
Lack of a hand preference by 4 to 5 years of age
Photophobia

What is certain is that the brain in these children becomes unable to integrate sensory messages appropriately. It does not process sensory impulses appropriately, so the child does not get adequate information about the environment or location in the environment.<sup>8</sup> Thus, these children can demonstrate hypersensitivity or hyposensitivity to sensory stimulation. For example, oversensitive children will show withdrawal behaviors when touched, avoidance of textures, and poor coordination and become overstimulated when there is too much activity in their environments. Undersensitive children may appear to be unaware of pain or temperature or may constantly put themselves in dangerous situations without understanding the danger. The child with SID may also exhibit an unusual activity level (either too high or too low), gross and fine motor coordination problems, poor organization, distractibility, poor self-confidence, poor attention, behavioral problems, and delays in speech and language.<sup>3,4,9</sup> The symptoms of particular interest to optometrists are listed in [Table 1](#).<sup>4,10,11,12</sup>

Although a child may exhibit SID alone, there are many other associated conditions. SID is common in children with autism or the autistic spectrum disorders of Asperger’s syndrome and pervasive developmental disorder.<sup>5,6</sup> It is common in children with attention disorders, learning disabilities, dyspraxia, and fragile X syndrome.<sup>9,10,13</sup> The treatment for SID is multifaceted and is usually led by occupational therapists who diagnose SID using the Sensory Integration and Praxis Tests. However, these children may also need to be involved in speech-language therapy, auditory integration therapy, psychotherapy, physical therapy, and vision therapy. Treatment for SID can be very effective, and these children can learn to adapt and function in a competent manner to live successful and productive lives.<sup>14,15</sup>

**Case reports**

Two siblings, J.H. and A.T., entered our clinic for comprehensive eye examinations and visual perceptual testing. Their mother stated that both of the children had been

diagnosed with SID by a child psychologist and an occupational therapist, and both were being home schooled by their mother. The children had the same mother but 2 different fathers. There was a family history of sensory integration problems with their maternal aunt and reading difficulties with their maternal uncle, and J.H.’s father was reported to have had attention problems. The individual histories and cases are as follows.

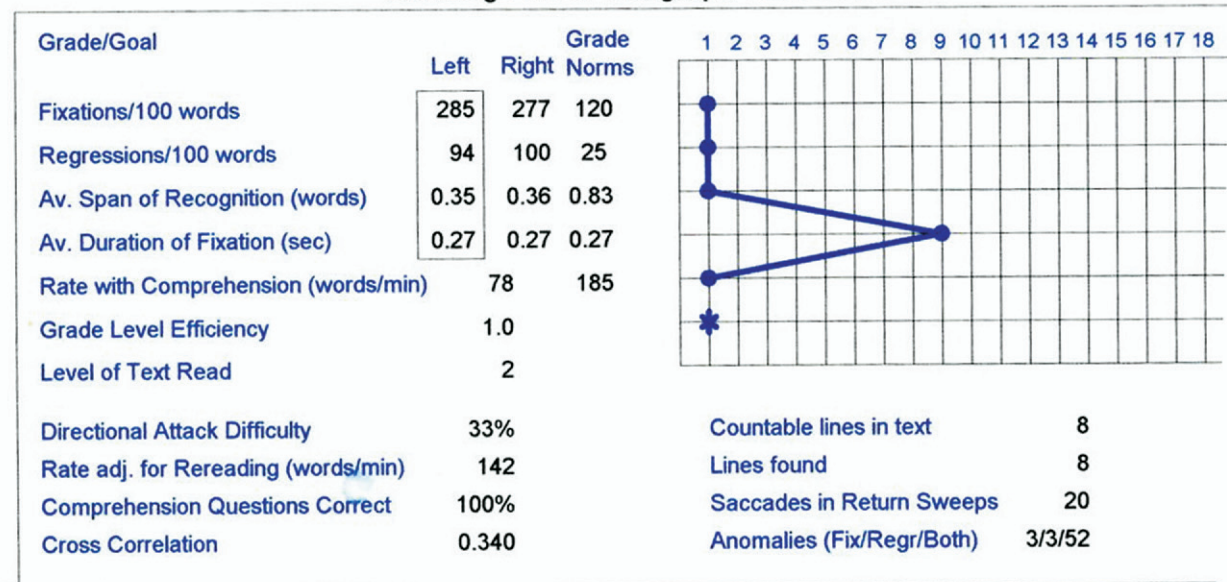
**First patient**

J.H., an 11-year-old girl participating in sixth-grade-level work, had a history of occupational and speech therapy and was being evaluated for dyslexia. Her mother was aware that her daughter had learning disabilities and wanted to rule out vision problems as well. J.H. was reported to have achieved her developmental milestones such as crawling, walking, and talking late for her age (although her mother could not provide a timeframe for when she did accomplish those milestones). She was observed to have trouble finishing projects, difficulty sitting still, and poor attention to task as well as becoming easily frustrated, easily overexcited, and impulsive. She was reported to have errors in copying, poor reading comprehension, avoidance of near work, poor handwriting, poor spelling, letter reversals, and reading below grade level. She often complained of blurred vision, losing her place while reading, confusing similar words, print “running together,” poor coordination, and short-term memory problems. She was currently taking no medications and had known allergies to nitrates only. Her last eye examination was 1 year earlier at another clinic, and no glasses were found to be necessary at that time.

J.H. was given a comprehensive eye examination at the first visit, visual perceptual testing at the next 2 visits, and the Test of Variables of Attention (TOVA),<sup>16</sup> Visagraph (Compevo AB, Stockholm, Sweden),<sup>17</sup> and performance testing<sup>18,19</sup> with yoked prisms at the fourth visit. Her uncorrected visual acuities were 20/20 in the right eye (O.D.), left eye (O.S.), and both eyes (OU) at distance and near with the Snellen chart. Results of all entrance testing were normal, as was her slit lamp evaluation and dilated fundus evaluation. Her manifest retinoscopy was +0.25 O.D. and O.S. Binocular balance results were +0.50 O.D., O.S. to 20/20 O.D., O.S., and OU. Cycloplegic retinoscopy results were +1.00 O.D. and O.S.

Her abnormal findings included decreased and unequal amplitude of accommodation of 9.00 diopters (D) O.D. and 10.00 D O.S. with the minus lens test, decreased base out prism bar vergence ranges at near (X/14/8), and type IV behavior on the Developmental Eye Movement Test, which suggested a problem with both automaticity of number naming and oculomotor skills.<sup>20</sup> Her Visagraph results (*see Figure 1*) showed excessive fixations and regressions, a slow rate of reading for both numbers and letters, oculomotor grade level efficiency of first grade, and low cross correlation with excessive anomalies. Her TOVA results (*see Figure 2*) showed that her inattention in the second half

## Reading Profile Visagraph version 4.3



## Numbers Profile Visagraph version 4.3

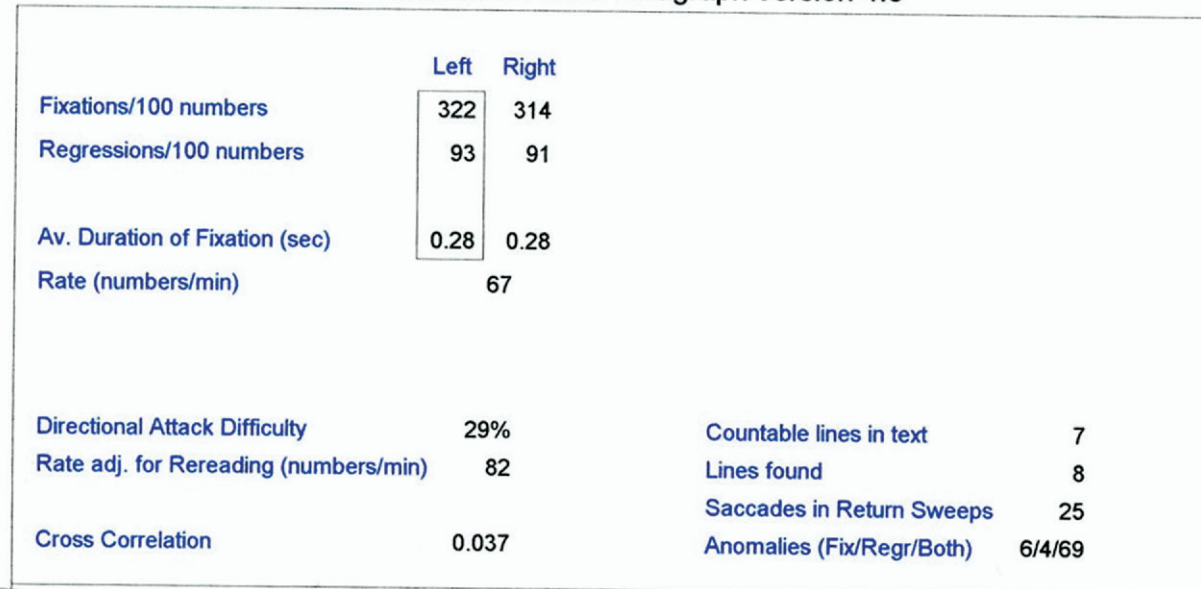


Figure 1 J.H.'s reading and numbers Visagraph profiles.

of the test was 2.98 standard deviations below the mean, her impulsivity results deteriorated in the second half of the test, her response time was slow, and her response time variability was greater than 2 standard deviations below the mean.

A visual perceptual evaluation was performed including the Piaget Right-Left Awareness Test,<sup>21</sup> the Gardner Reversals Frequency Test,<sup>22</sup> the Test of Visual Perceptual Skills Test-Revised (TVPS),<sup>23</sup> the Visual Motor and Speed subtest of the Detroit test of Learning Aptitude,<sup>24</sup> the Wepman Auditory Discrimination Test,<sup>25</sup> the Wepman Auditory Memory Span Test,<sup>26</sup> the Auditory Visual Integration Test,<sup>27</sup> and the Slosson Intelligence Test (see Table 2).<sup>28</sup> All results

were appropriate for her age, except for a mild deficit in the sequential memory subtest of the TVPS. Performance testing with yoked prisms was performed to find out if there was any behavioral adaptation that would occur with the use of a prism prescription, because prisms are known to cause changes in body posture and spatial localization ability.<sup>18,19</sup> In this case, performance testing consisted of J.H. walking a straight line on a balance beam while wearing 5 prism diopters (PD) of yoked prism base up, down, right, and left. She felt the most comfortable and exhibited the best balance and posture while walking on the beam with base up prism. She then was shown smaller

Results Table (Tabulated Raw data)		Quarter				Half		Total
		1	2	3	4	1	2	
Omission Errors	%	0.00%	2.78%	4.76%	2.38%	1.39%	3.57%	3.09%
(Inattention)	#	0	1	6	3	1	9	10
Commission Errors	%	1.59%	0.00%	36.36%	50.00%	0.79%	43.28%	9.72%
(Impulsivity)	#	2	0	12	17	2	29	31
Response Time	msec	610	604	519	445	607	482	511
RT Variability	msec	274	202	246	185	241	221	232

Figure 2    J.H.'s TOVA results.

increments of yoked prism to assess her comfort levels while walking around the room and performing near tasks, and J.H. preferred 1 PD of yoked prism base up over any other combination.

Simple hyperopia, accommodative insufficiency, oculomotor dysfunction, and a mild sequential memory deficit were diagnosed. Based on the results of the TOVA, she also appeared to have attention problems, which were to be addressed with her pediatrician. Glasses were recommended with the final prescription of +0.50 D spheres (based on her binocular balance and trial framing the patient) O.D., O.S. with 1 PD base up yoked prism. J.H. was to wear the glasses full time and was to return to the clinic in 6 weeks for follow-up. She was also to begin visual therapy after her follow-up visit in 6 weeks.

At her follow-up examination, J.H. and her mother reported that she was wearing the glasses full time and that she liked the glasses. She was reportedly doing better academically while wearing the prescription. Upon retesting while wearing her glasses, J.H. exhibited better results on the Visagraph (*see Figure 3*) with a reduced number of excessive fixations and regressions, an improved rate of reading numbers and letters (122 versus 78), an oculomotor grade level efficiency of second grade, and an improved cross correlation with fewer anomalies. The TOVA (*see Figure 4*) results with the glasses on were also improved with the impulsivity results in both halves within 1 standard deviation from the mean, the response time normal overall, and the response time variability improved to less than 1 standard deviation from the mean. She was to begin vision therapy as the next step in her treatment because of the oculomotor dysfunction and the accommodative insufficiency and was to continue to wear the glasses full time.

Second patient

A.T., a 6-year-old boy participating in first-grade work, had a history of occupational therapy. He was reported to have reached his developmental milestones on time. His report from the occupational therapist stated that he had decreased fine and gross motor skills, poor visual motor skills, and a poor attention span. A.T.'s mother stated that he was im-

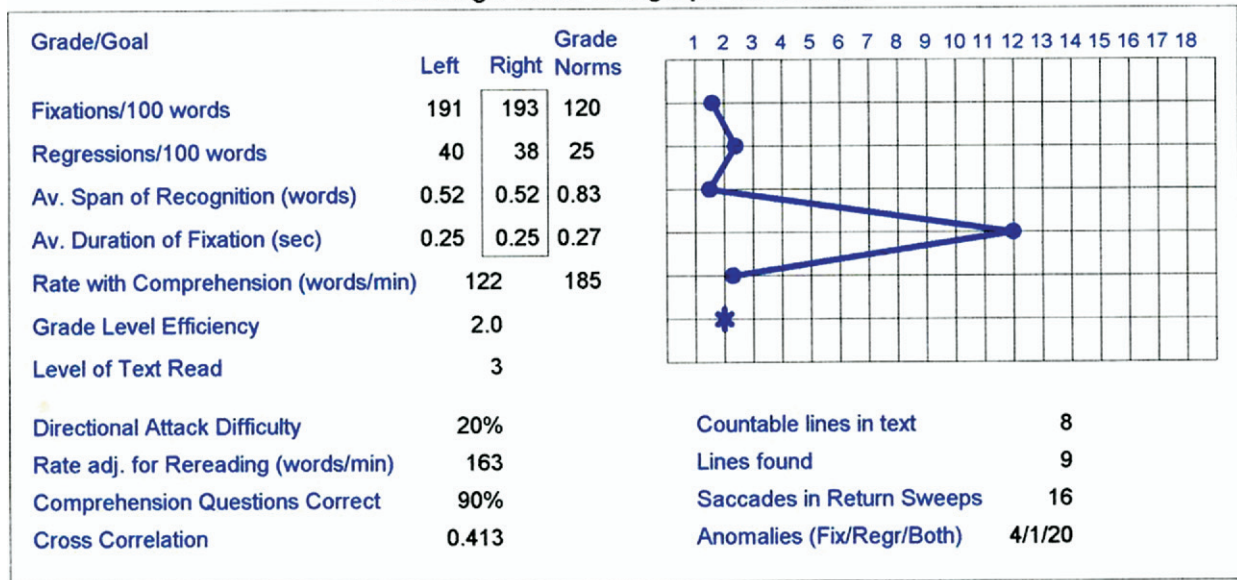
pulsive, easily overexcited, craved attention, exhibited difficulty sitting still, and had trouble finishing projects. He was reported to have poor printing, poor spelling, and poor reading comprehension and was reading below grade level. His last eye examination was reported to be 1 year before, with no glasses recommended at that time. A.T. had no visual complaints.

A.T. was given a comprehensive eye examination, visual perceptual testing, TOVA, Visagraph, and performance testing with yoked prism in 4 visits. His entering visual acuities were 20/20 O.D., O.S. at distance and near. Results of the slit lamp and dilated fundus examinations were normal. All entrance and efficiency test results were normal, except for the following: he exhibited poor pursuits and poor saccades O.D., O.S., OU and a type III response on the Developmental Eye Movement Test, which suggests a difficulty in the automaticity of number naming skills. His manifest retinoscopy was +1.50 -0.25 X 180 O.D., +1.25 -0.50 X 180 O.S. Binocular balance results were +1.00 O.D. and O.S. Cycloplegic retinoscopy results were +1.50

Table 2    J.H.'s Visual Perceptual Test results		
Assessment tool	Age equivalent	Percentile ranks
Piaget Right-Left Awareness Test	11	
Gardner Reversal Frequency Test		
Execution	11	
Recognition	11	50
TVPS		
Visual discrimination	>12-11	73
Visual memory	>12-11	79
Visual spatial relations	>12-11	88
Visual form constancy	>12-11	88
Visual sequential memory	8-5	16
Visual figure ground	>12-11	93
Visual closure	>12-11	91
Detroit Test of Learning Aptitude		
Visual speed	12-0	
Visual precision	10-9	
Wepman Auditory Discrimination	11	
Wepman Auditory Memory Span	11	
Auditory Visual Integration Test		50
Slosson Intelligence Test-Revised	11-0	25



## Reading Profile Visagraph version 4.3



## Numbers Profile Visagraph version 4.3

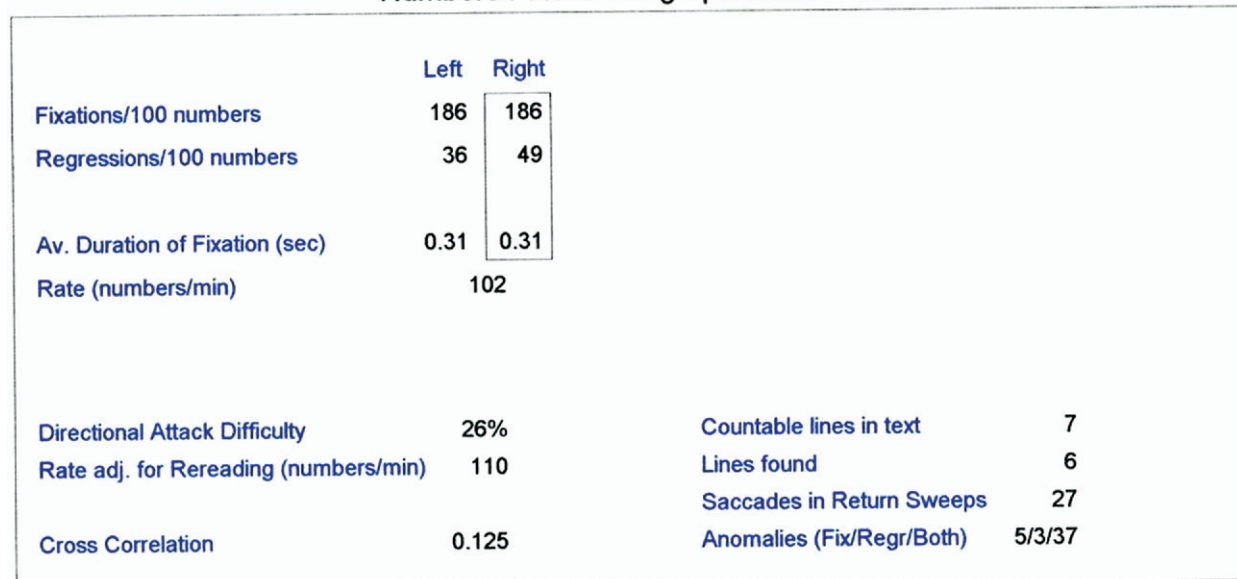


Figure 3 J.H.'s Visagraph profile after wearing prism lenses.

−0.25 X 090 O.D., +1.25 −0.25 X 090 O.S. The Visagraph results showed an excessive number of fixations and regressions for his age, very slow rate of identifying numbers, low cross correlation and excessive anomalies, slow saccadic excursion rate, and excessive fixation drifts. He was unable to do the Reading Visagraph Profile because he was unable to read at this time. His TOVA results showed inattention to be greater than 1 standard deviation below the mean on the first half and greater than 2 standard deviations below the mean on the second half of the test. All of his impulsivity results were greater than 1.5 standard deviations below the mean. His response time was 1.5 standard devi-

ations below the mean, and his response time variability was greater than 2 standard deviations below the mean in both halves of the test.

A.T. was given a visual perceptual evaluation using the tests listed for the first patient, and the results were as follows and as listed in Table 3. A.T. exhibited mild deficits on the Gardner Reversal Frequency Recognition Subtest, the Visual Discrimination subtest of the TVPS, the Beery Visual Motor Integration Test, the Wepman Auditory Discrimination Test, and the Wepman Auditory Memory Span test. He exhibited severe deficits on the Spatial Relations subtest of the TVPS, the Sequential Memory subtest of the

Results Table (Tabulated Raw data)		Quarter				Half		Total
		1	2	3	4	1	2	
Omission Errors	%	0.00%	11.11%	15.87%	3.97%	5.56%	9.92%	8.95%
(Inattention)	#	0	4	20	5	4	25	29
Commission Errors	%	0.79%	1.59%	16.67%	37.14%	1.19%	26.76%	6.81%
(Impulsivity)	#	1	2	6	13	3	19	22
Response Time	msec	532	594	482	410	561	444	472
RT Variability	msec	141	144	180	172	145	179	179

Figure 4 J.H.'s TOVA results after wearing prism lenses.

TVPS, and the WOLD Sentence Copy Test. His Slosson Intelligence Test score was in the normal range. His performance testing with yoked prism (as performed with J.H.) showed that A.T. preferred the 1 PD base down yoked prism, and the base down yoked prism seemed to make a large improvement in his posture and balance. He stood taller with his shoulders held back and was able to balance much better when walking on the balance beam with the base down yoked prisms on. This improvement was in contrast to performance without wearing prism or wearing yoked prism base up, base right, or base left.

According to the results of his testing, A.T. had compound hyperopic astigmatism, oculomotor dysfunction, and visual perceptual dysfunctions diagnosed. He was also referred to his pediatrician for probable attention problems because his mother felt comfortable addressing these issues with their current doctor. The final prescription recommended for A.T. was +1.00 sphere O.D., O.S. with 1 PD base down yoked prism to be worn full time. He was also to begin vision therapy after his follow-up visit in 6 weeks for the oculomotor dysfunction.

At his follow-up visit, A.T. was reported to constantly put his glasses on and then take them off. His mother reported that he rarely kept them on longer than 15 minutes at a time, but he did not complain of any problems while wearing the glasses. A.T.'s mother felt that his failure to wear the glasses regularly was a sensory issue in that he did not like the "feeling" of the glasses on his head. She stated that he never kept any glasses on, including plano sunglasses or plano "costume" glasses. Upon retesting while wearing the glasses, A.T. did not show significant improvements on the Visagraph or the TOVA. Because of his inability to wear the glasses and lack of improvement on the testing, he was to discontinue wear of the glasses but to begin vision therapy.

Discussion

J.H. and A.T.'s mother was extremely eager to have both of her children thoroughly evaluated by an optometrist to determine the extent of help that we might be able to provide. Even though the children had both been given eye

examinations previously at another eye care facility and no treatment had been recommended, the mother felt that there was definitely a visual problem in both of the children, particularly related to their difficulties with visual tracking. Because each SID child can exhibit very different symptoms, from the extremely hyperactive, hypersensitive child to the very inactive hyposensitive child, it is important to evaluate all aspects of the visual system in each child. J.H. was a much easier child to evaluate than A.T. She was older

Table 3 A.T.'s Visual Perceptual Test results

Assessment tool	Age equivalent	Percentile ranks
Piaget Right-Left Awareness Test	6	6
Gardner Reversal Frequency Test		
Execution	6-0 on reversals <5-0 on unknowns	
Recognition		15
TVPS		
Visual discrimination	4-5	8
Visual memory	6-2	45
Visual spatial relations	<4-0	1
Visual form constancy	4-10	25
Visual sequential memory	<4-0	1
Visual figure ground	8-2	81
Visual closure	5-4	25
Beery Visual Motor Integration Test	5-2	13
Detroit Test of Learning Aptitude		
Visual speed	6-3	
Visual precision	6-0	
WOLD Sentence Copy Test	<2nd grade	
Wepman Auditory Discrimination		16
Wepman Auditory Memory Span	Mildly below average	
Auditory Visual Integration Test		20
Slosson Intelligence Test-Revised	5-3	19

and more responsive in general and had already made great strides with her occupational therapist. A.T., on the other hand, was quite hyperactive throughout all of the testing.

Children with SID often exhibit poor visual tracking and poor ocular motility during examination. In a study by Horowitz et al.<sup>11</sup> using electro-oculograph recordings, children with SID showed more saccadic intrusions during smooth pursuit tasks, and the investigators believe that "the basic factors of orienting, adequate attention, trunk and head stability are critical to smooth pursuits."<sup>11</sup> Children with autism, who often have some sort of sensory integration dysfunction, are known to have poor eye contact, poor ability to fixate, excessive visual searching, and poor overall visual function.<sup>18</sup> It is extremely important that the SID child have a full ocular motility assessment, including observation of fixations, gross pursuit movements, and gross saccadic movements, as well as the Developmental Eye Movement Test and an automated visual tracking test, such as the Visagraph.

According to Bowan,<sup>12</sup> "visual and perceptual problems are always problems of sensory and sensorimotor integration." Autistic children, who often are characterized as having unusual sensory responses, are known to exhibit difficulties with visual perceptual integration, especially when evaluated with a complex motion discrimination paradigm. Thus, they integrate complex perceptual information less efficiently.<sup>29</sup> These children also are less sensitive to global motion when evaluated using motion and form perception.<sup>30</sup> According to Kranowitz,<sup>4</sup> children with SID may have vestibular dysfunctions that lead to visual-spatial processing problems, such as problems with visual discrimination, visual figure-ground, form constancy, position in space, spatial awareness, and directionality. Thus, a thorough visual perceptual evaluation is always indicated. Although J.H. performed extremely well on this series of tests, showing only 1 area of difficulty with visual sequential memory, A.T. exhibited significant visual-perceptual difficulties. This shows how different SID can manifest; however, because J.H. is 5 years older than A.T., maturity, attention, and the amount of occupational therapy received may all be factors in this discrepancy as well.

Yoked prisms often are used with autistic patients to cause a shift in motor and sensory organization in the cortex.<sup>18</sup> The use of low power plus lenses with a small amount of yoked vertical prism has been shown to improve spatial awareness, orientation, and body posture.<sup>31,32</sup> This is thought to occur because the lenses help to reorganize visual function by affecting both visual motor and visual sensory processes.<sup>33,34</sup> In a young patient with significant sensory motor and visual perceptual problems, Warshowsky and Fitzgerald<sup>35</sup> showed positive improvements in the visual system as well as overall gross motor abilities and sensory motor integration functions while wearing low plus lenses with vertical yoked prism. The prisms may be prescribed to the patient for full- or part-time wear or they may be worn during vision therapy sessions. On performance testing with yoked prisms, A.T. exhibited much more significant pos-

tural shifts than did J.H.; however, during retesting of the Visagraph and TOVA, J.H. was the one who seemed to be doing significantly better while wearing the prisms. This may again be because of the difference in the nature of the children's type of SID or the fact that J.H. wore the glasses more consistently overall. However, we feel the biggest reason that A.T. did not show improvement with the glasses on was because of his poor attention to tasks overall. It is important to note that J.H. continued to wear her glasses regularly after the initial 6-week visit and felt that her school performance, based on her parent's report, was improved when wearing the glasses.

Occupational therapy, using a sensory integrative approach, is the most common treatment for SID patients and has been shown to be effective in more than 80 studies.<sup>13</sup> In general, sensory integration therapy from an occupational therapy basis consists of vestibular, proprioceptive, and tactile stimuli presented to the patient while the patient is in motion. The patient is able to control the amount of stimuli, and they learn to make this decision with the help of the therapist. Balls, swings, balancing apparatus, textured materials, rockers, and brushes are some of the equipment used in this therapy.<sup>11,36</sup> Sensory integration therapy, even without the addition of vision therapy, has been shown to improve both smooth pursuits and organization speed.<sup>11</sup> The interaction of both occupational therapy and vision therapy together has been shown to improve pursuits, saccades, convergence, fusional reserves, accommodative facility, visual perception, and reading skills in a child with sensory integration issues and dyspraxia.<sup>10</sup>

The type of vision therapy activities that are needed to work with sensory integration issues would begin with activities that involve gross motor skills, such as walking on a balance beam, chalkboard circles, and angels in the snow.<sup>37</sup> According to Bowan,<sup>12</sup> "an adequate motor base that underlies vision and speech skills reinforces and enhances the skills that are built upon them." The patient should be provided with a quiet environment with limited distractions and little clutter. As therapy progresses, more sensory input can be added, such as a metronome for auditory integration.<sup>9</sup> Activities that stimulate the visual system in new ways should be incorporated early on in therapy as well. The use of red/green glasses with white targets seems to be very well received with autistic patients exhibiting sensory problems.<sup>18</sup> Although it is likely that J.H. and A.T. would have made significant improvements with vision therapy, particularly in addressing the oculomotility dysfunction<sup>10</sup> and accommodative insufficiency,<sup>38</sup> their mother was unable to pursue vision therapy at the time because of an uncertain financial situation. There often are variables in patient care that are out of the control of the professional that can inhibit a patient from achieving the highest level of success; however, the ability to improve the patient's situation with the use of lenses and/or prisms should always be an option.



## Conclusion

Because the cause of SID is unknown, and it is associated with conditions like autism and attention deficit disorder, which are increasing in frequency, it is also likely to continue to increase in frequency with time. It is important for optometrists to work together with occupational therapists, speech/language therapists, pediatricians, and psychologists to provide these children with the full range of care that they need to improve. A thorough optometric evaluation including the use of the DEM, Visagraph, TOVA, and visual-perceptual testing is necessary. It is also important to fully investigate the potential benefits of yoked prism and vision therapy for these patients, which optometrists are uniquely qualified to provide.

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