Article ▸ Visual Perception – More Than Meets the Eye

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ABSTRACT

Background: Sensory integration dysfunction is a disorder that involves impairment in processing data from the various senses, including the vestibular and proprioceptive systems. Individuals with sensory integration dysfunction may have problems with motor planning and positional awareness. Sensory integration dysfunction may cause significant problems with organizing sensation both from self and the environment, which affects nearly all activities of daily living. Integration between vision, vestibular, and motor systems is required for an individual to move effectively through space. Poor integration of these sensory modalities may also lead to difficulty with classroom learning and therefore inadequate success in school.

Case Report: A 9-year-old white female who was diagnosed with sensory integration dysfunction at an early age presented for a comprehensive eye examination. She was having difficulty with math, reading, and writing. There was a concern raised about the possibility of tracking problems. Refractive status was non-contributory. Further testing revealed an oculomotor dysfunction, as well as laterality and directionality confusion and significant perceptual delays. The patient entered into a vision therapy program where she excelled.

Discussion: While vision therapy programs that solely address core functions like accommodation and vergence are successful when appropriate, practitioners are well advised to employ a multisensory approach that includes an integrative component for more complex cases.

Keywords: sensory integration disorder, perceptual, parquetry blocks, tactile

Introduction

"We think, we perceive, and we remember more of the world than we actually do, and different people experience the same inputs differently."[1] The above quote was intended to caution physicians concerning the concept of perceptual mismatch, especially how it may lead to patient miscommunication. However, for a child with sensory integration dysfunction (SID), this is less an astute observation and more a literal truth. SID, also known as sensory processing disorder (SPD), involves impairment in processing data from the different senses, including the vestibular and proprioceptive systems, in an integrated way. Children with SID typically have one or more senses that either over- or under-react to stimulation. It can be associated with comorbid neurological disorders including attention-deficit (hyperactive) disorder, autism, and speech delays. It can also be found concomitantly with fetal alcohol syndrome, premature birth, Down syndrome, and cerebral palsy, though the precise etiology of SID is still unknown.[2]

To understand why assimilating sensory information in real time is essential for humans,

imagine riding a bicycle. What different sensory and motor systems must come into play when an individual executes this task? First, the oculomotor component has to point the two eyes accurately and plan eye movements in conjunction with peripheral awareness in order to know where the body is going. It then must integrate information from the vestibular apparatus to guide the body in a precise pattern. Finally, it must coordinate with the motor system, trusting that both sides of the body will work in unison to propel the bike forward while remaining upright. As you may recognize, execution of this task with elegance requires the neurological integration and participation of multiple systems.

As a whole, children with SID may demonstrate problems with motor planning and positional awareness due to lack of neurological integration. If one considers that "touch aids vision, vision aids balance, balance aids body awareness, body awareness aids movement, and movement aids learning," deficits in sensory integration can be quite detrimental. This helps to explain how SID may impact classroom learning and school success.[3]

Although some consider vision primarily as a passive process, both subconscious and conscious aspects of the visual process are essential to guide action. It is important to remember that the more passive aspects of the visual process may yield 20/20 eyesight, even for a child who may be struggling with math, reading, and writing. However, excellent eyesight alone fails to inform us whether the patient's two eyes team, focus, and move accurately enough to read across a page, line up numbers for a math problem, or guide fine-motor control for handwriting and copying. When the visual process fails to guide action effectively, the addition of a perceptual deficit on top of this can be overwhelming. If a child has not had appropriate development of the visual process, as can often be the case with SID, habilitating the integration of the senses along with the fine motor movements through vision therapy can make a world of difference.

Case History

Anna, a nine-year-old white female, presented for her first comprehensive vision examination. Anna had no complaints concerning visual clarity; however, her mother stated that she had trouble with math, reading, and writing. Specifically, she wondered whether Anna had trouble tracking, as she often used her fingers to follow along and frequently moved her head while reading. Additionally, her mother stated that Anna read slowly, skipped lines, often lost her place while reading, and responded better to oral instructions rather than written instructions. At the time of her examination, she was in the 3rd grade and had an IEP at school after being held back one year. She had been diagnosed with sensory integration dysfunction as well as ADHD. She was not taking any medication for either condition.

Anna was adopted at birth, and little is known about her biological family aside from the fact that her mother used drugs and alcohol during pregnancy. While there is no way to know for sure whether causation existed, the mother's substance abuse, especially during pregnancy, is a known risk factor for developmental delays including SID.

Although Anna started crawling at 9.5 months and walking at 13 months, her occupational therapy evaluation indicated below-average bilateral coordination and strength, problems with motor planning, and issues with oral and tactile sensitivity. She also scored low in fine motor integration and had difficulty with fine motor precision, such as folding paper. The occupational therapist recommended clinical therapy, but Anna and her mother decided that they wanted to focus on these areas on their own at home. They planned to place an emphasis on strength and stretching by initiating yoga as well as swimming lessons.

Table 1: Examination Data

VAsc:	Distance: OD 20/20, OS 20/20, OU 20/20 Near: OD 20/20, OS 20/20, OU 20/20
CTsc:	Distance: Ortho Nearr: Ortho
EOMs:	Full/Unrestricted OD, OS
PUPILS:	3mm dim, 4mm bright OU Reactive pupils, No APD OU
NPC:	18cm break / 25cm recovery
COLOR VISION:	Normal with Ishihara
FCC:	+0.25 (net)
NRA:	+3.25/+2.75 (net)
PRA:	-3.75/-3.00 (net)
MRx:	OD plano-0.25x180, OS plano-0.25x165
SLE and DFE:	WNL

Optometric Findings

The data in Table 1 was obtained at Anna's initial comprehensive examination. Her unaided visual acuities were found to be adequate, and her refractive status was non-contributory.

While an MEM was not performed, the intern conducting the examination added additional chart notes to clarify that there was an attempt made to put +1.00 lenses in front of the patient to see if she would accept plus. However, with the +1.00 in place, she was unable to see anything below the 20/40 line.

Aside from a greatly reduced near point of convergence, most of Anna's basic visual components were normal, and she was then referred to the Vision Therapy Clinic at Pacific University. The parental predictive symptom checklist suggested frequent problems with mistaking words with similar beginnings and endings, poor spelling skills even after studying, poor letter-to-sound matching, having to learn new words over and over, trouble finishing written assignments, difficulty keeping attention on reading, and poor coordination and balance.

Anna sat through a developmental evaluation where her stereo acuity and accommodative and vergence facilities were measured. She also completed multiple tests assessing her eye movements, laterality and directionality, and perceptual skills. The results are listed in Table 2.

Table 2: Developmental Education – 3/14/15

DEM:	Vertical – 59th percentile Horizontal – 3rd percentile
Piaget:	Category A only Age equivalency <5 years old
Gardner:	Execution: 25th percentile Recognition: 11th percentile
Beery VMI:	8th percentile
Accommodative Facility with +/-2.00:	4 cycles per minute (average of 2 min testing period)
TVPS-3 (Test of Visual Perceptual Skills):	*Discrimination*: 16th percentile *Memory*: 25th percentile *Spatial Relations*: 37th percentile *Form Constancy*: 2nd percentile *Sequential Memory*: 25th percentile *Figure Ground*: 25th percentile *Visual Closure*: 9th percentile
Vergence Facility with 6 prism diopter BI/BO:	5 cycles per minute (average of 2 min testing period)
Test of Auditory Analysis Skills:	1st grade ability
Super Stereo:	*Side 1*: 50" *Side 2*: 30" *Side 3*: 70"

As shown, Anna had consistently below-age-norm scores across the board. Anna's saccades and pursuit eye movements were evaluated utilizing the NSUCO Oculomotor Test, Visagraph, and the Developmental Eye Movement Test, in that order. Anna's results from the NSUCO Oculomotor Test can be found in Table 3.

The Visagraph indicated that when Anna read 2nd grade level text, her reading rate was 57 words per minute (138 words per minute expected) with 90 percent comprehension. Based on Visagraph findings, the overall reading eye movement efficiency was estimated at a 1st grade level equivalency. Lastly, the Developmental Eye Movement test was performed. Anna scored in the 3rd percentile for horizontal eye movements, indicating a marked oculomotor dysfunction, especially given her above-average performance on the vertical subtest.

Testing also revealed that Anna's laterality, directionality, and perceptual skills were all below normal, indicating multiple perceptual deficits.

Vision Therapy

Once testing had been completed, Anna entered into a vision therapy program

specifically to address her oculomotor dysfunction, laterality and directionality confusion, and significant perceptual delays. She and her mother worked diligently throughout the summer both in attending therapy sessions and completing their assigned home activities. Anna's sensory integration dysfunction proved difficult to overcome during therapy. Many of the activities did not come naturally, nor did they seem to improve from week to week as would be expected in a child with basic eye movement problems without concurrent SID.

The initial focus with Anna's therapy was to improve her accommodative and vergence skills. She was being treated using traditional activities including saccadic work with a Hart chart, Kirschner arrows, loose lens rock, and variable tranaglyphs, all with minimal improvement. However, after attending lectures presented by Certified Optometric Vision Therapist Linda Sanet and her husband Dr. Robert Sanet, I had more confidence in placing more emphasis on Anna's perceptual deficits as well. Linda Sanet suggested that when a patient has difficulty with visualization, which is involved with many perceptual skills, it is better to start at a more elementary level through the sense of touch: tactile, kinesthetic, and proprioceptive.[4] It was in my favor that even though Anna's occupational therapist noted tactile sensitivity, Anna experienced no discomfort with this sense in office, and so began our work with parquetry blocks (Figure 1).

Figure 1: *Parquetry block procedure*

Figure 2: *Parquetry blocks used with a "feel box"*

Starting at the most basic level, we used parquetry blocks and a "feel box" (Figure 2). In this way, Anna was able to use touch to identify the shape, to start to visualize what that block might look like, and then to describe it to help solidify the image in her mind. In *Thinking Goes to School: Piaget's Theory in Practice*,[5] Drs. Hans Furth and Harry Wachs note that "the hand is a source of input information not readily available to the eye or ear. The child feels texture, then matches it with vision," and in this way, all types of information input are used. This was certainly true with Anna. After only one week with parquetry blocks, both objective and subjective improvement emerged.

The next activity was to recreate a three-block pattern built in front of her. Upon completion, she was to analyze the two and determine whether or not they were in fact exactly the same. It was not as important that the two patterns matched perfectly, but that Anna was able to successfully evaluate and understand the similarities and differences. In a study conducted by Kavale, it was found that visual memory along with visual discrimination showed a larger association with reading ability than any other perceptual skills.[6] This was again confirmed in a recent study by Woodrome and Johnson,[7] showing a specific relationship between visual discrimination and letter identification abilities. In light of this research, it seems clear that the inclusion of visual discrimination activities is of great value.

Anna's progress continued quickly, with her creating her own pattern behind a box

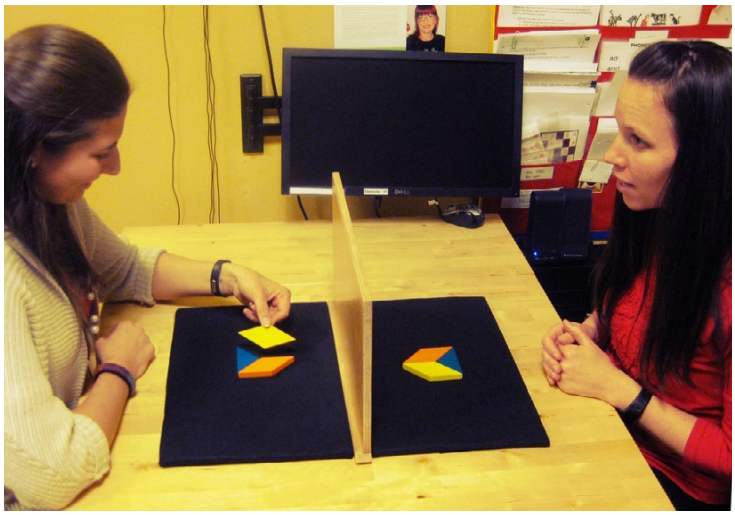

Figure 3: *Parquetry block description*

that she had to describe in enough detail that someone else could recreate it (Figure 3). Next, we added a memory component by exposing two shapes, one of which was altered by the turn of a single block. She was to memorize the difference and recreate the change once the second shape was hidden from view. Upon mastery of this task, she began to "build in another place," where she was asked to visualize and hold the shape in her mind as she walked to another room to recreate it.

Unfortunately, in an academic setting, interns rotate through clinical sites every three months. As we reached the "flipped and rotated" task to address form constancy, my time with Anna came to an end.

Table 3: NSUCO Oculomotor Test Data

3/14/14	*Saccades*	*Pursuits*
Ability	3	3
Accuracy	1	2
Head Movement	1	1
Body Movement	2	2

Post Therapy

In a three-month span of vision therapy, Anna made more than a year's worth of improvement. As shown in Table 4, her visual closure skills had improved from the 9th percentile to the 63rd, and her DEM scores for her horizontal eye movements had improved from the 3rd percentile to the 78th. Her laterality and directionality had improved to age norms, aside from the letter "y," which was her only error on the Gardner recognition subtest. Both accommodative and vergence facility values improved to above average, and her stereo acuity improved to 20 arc seconds on all 3 sides of the Super Stereo test. As mentioned, we had only just begun to touch upon form constancy when my clinical rotation through the school ended, so this percentile, along with her Beery VMI, remained unchanged. Tables 4 and 5 compare the pre-therapy data and the examination performed after three months, at which point my time with Anna was completed.

Table 4: Pre-Therapy vs. 3-Month Progress Report Data

	Developmental Evaluation – 3/14/14	*3 Month Progress Report – 7/24/14*
Accommodative Facility with +/-2.00:	4 cpm (average of 2 min testing period)	10 cpm (average of 2 min testing period)
Vergence Facility with 6 prism diopter BI/BO:	5 cpm (average of 2 min testing period)	11 cpm (average of 2 min testing period)
DEM:	Vertical – 59th percentile Horizontal – 3rd percentile	Vertical – 93rd percentile Horizontal – 78th percentile
Visagraph:	57 words per minute 1st grade equivalency	120 words per minute 4th grade equivalency
Gardner:	Execution: 25th percentile Recognition: 11th percentile	Execution: 68th percentile (no errors) Recognition: 54th percentile
Super Stereo:	*Side 1*: 50" *Side 2*: 30" *Side 3*: 70"	*Side 1*: 20" *Side 2*: 20" *Side 3*: 20"
TVPS-3 (Test of Visual Perceptual Skills):	*Form Constancy*: 2nd percentile *Visual Closure*: 9th percentile	*Form Constancy*: 2nd percentile *Visual Closure*: 63rd percentile
Beery VMI:	8th percentile	8th percentile

Table 5: Pre-Therapy vs. 3-Month Progress Report NSUCO Data

	Saccades Pre	*Saccades 3 Months*	*Pursuits Pre*	*Pursuits 3 Months*
Ability	3	5	3	5
Accuracy	1	4	2	3
Head Movement	1	5	1	4
Body Movement	2	5	2	5

Today Anna is receiving one-on-one reading assistance for half an hour two times per week in her 4th grade classroom. She is currently at a 3.5 grade level in reading. She is also receiving half an hour of math tutoring three times per week. Looking back, it is my belief that the tactile component of utilizing the parquetry blocks may have been the key difference that was needed to accelerate Anna's progress.

Conclusion

To be most effective in vision therapy, the therapist must be able to evaluate the current level of ability of their patient and make

modifications as appropriate. As a student clinician, I would argue that in the case of a patient with sensory integration dysfunction, an approach working solely on basic visual efficiency skills may not be sufficient to address the wide constellation of deficits and developmental delays by which they may be affected. In light of this, it is important to be aware and to have the resources or referral information to provide these patients with a more complex therapy program so as to give them every chance at success.

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- Deadline: April 1
- Grant Selection: May 15
- Final Reports Due: May 15 of following year
- http://betasigmakappa.net/grants.htm
- Eligibility: All optometry students, irrespective of membership in BSK, are eligible.

BSK-AOF Grant

- One or two fellowships up to $4,000, Fellowship requests may exceed $4,000; however, anything in excess of $4,000 will be at the discretion of the BSK Central World Council.
- Deadline: Early August
- Grant Selection: September
- http://www.aaopt.org/aof/Programs/Faculty/BSK
- Eligibility: All optometric faculty, including adjunct faculty, within 3 years of faculty appointment, optometric residents at any school or college of optometry, irrespective of membership in BSK or AOA, are eligible.

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- Grant Selection: September
- http://www.covd.org/?page=BSK_Research_Grant
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- Grant Selection: September