Article ▸ # Vision Therapy for the Autistic Patient: A Literature Review and Case Report

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ABSTRACT

Background: The heightened awareness of autism spectrum disorder (ASD) has propelled concern for proper care into a significant public health issue. Vision deficits, including visual processing and integration, may contribute to the anxiety and uneasiness that these individuals frequently experience. Additionally, these deficits often translate into considerable hindrances to classroom success. This paper addresses a sampling of vision-based behaviors in ASD including visual hyper/hyposensitivity, poor facial recognition, lack of eye contact, and visual-motor integration impairments.

Case Summary: A 10-year-old autistic male was referred for diagnosis of convergence insufficiency. There were notable developmental delays and concerns primarily regarding reading comprehension, attention deficits, and spatial organization. He previously received speech and language therapies in conjunction with occupational therapy. Diagnostic testing of the patient's ocular motility yielded tracking inefficiencies and poor accuracy. The Wachs Analysis of Cognitive Structures (WACS) evaluation was performed and revealed weaknesses in a number of visualization tasks as well as in gross and fine motor coordination. An individualized program of vision therapy was recommended to improve his visualization, tracking, and visual motor integration abilities.

Conclusion: This case report illustrates how the distinctive challenges of structuring a successful vision therapy program for the varying presentations of ASD can be met by adapting techniques to the appropriate developmental stage of the child. Vision therapy provides the framework to build skills that are transferrable and valuable in the classroom.

Keywords: autism spectrum disorder, central coherence, Developmental Individual-Differences Relationship-Based (DIR), enhanced perceptual global functioning, floortime, reading comprehension, vision therapy, visual information processing, Wachs Analysis of Cognitive Structures (WACS)

Introduction

Autism spectrum disorder (ASD) occurs in 1 in 50 American children ages 6-17.[1] As its name implies, ASD is characterized by a range of abnormalities in social behavior, repetitive mannerisms, and verbal and nonverbal communication. Continued research into these abnormalities has generated particular interest in discovering the underlying mechanisms responsible for the atypical sensory modulation that many autistic individuals experience. Moreover, these efforts act as foundational tenets of therapies that enable autistic individuals to overcome and manage their difficulties. Studies investigating the prevalence of sensory processing difficulties in autistic children have revealed that a majority of these individuals demonstrate symptoms of avoiding or being unusually interested in specific sensory stimuli (touch, smell, sight, sound, taste, kinesthetic). The resulting distress is frequently disabling as children can become gravely frightened or aggressive when exposed to the abundant sensory inputs in their environments. As with the variable nature of ASD, each autistic individual differs in his or her tolerance towards sensory stimuli.

A study conducted by Leekam et al. discovered that autistic individuals have abnormalities across multiple sensory domains, whereas their typically developing counterparts had no abnormalities, or one, by comparison.[2] These significant differences were found not only in the low functioning autistic population but persisted in high functioning autistic individuals as well. Remarkably, autistic groups contrasted distinctly with neurotypical children in the specific domain of vision.[2] Vision abnormalities include preoccupations with spinning or shiny objects, lights, and inspection of objects from multiple angles for no specific reason.[2] These disruptions are of concern because vision is a predominant sense on which individuals rely for interaction with their environments. Moreover, vision serves as the primary medium for learning in classrooms and guides motor activities.

In addition to these functional peculiarities of vision, organic ocular conditions are often present in autism. In a retrospective study of the prevalence of ophthalmologic disorders in the autistic population, 40% were found to have an identifiable ophthalmic condition including strabismus, amblyopia, or significant refractive error.[3] A large portion of ASD individuals have been found to exhibit reduced convergence, which leads to discomfort and avoidance of near tasks.[4]

ASD exhibits a wide spectrum of motor competencies ranging from severely uncoordinated to on par with neurotypical individuals. A central aspect of motor coordination is the proper collection and perception of sensory input that is employed to make various judgments about the execution of a task. The aforementioned deficits in effective sensory modulation can act to hamper the development of gross and fine motor skills by preventing acquisition or translation of meaningful information from the environment. This is often observable in autistic individuals as unstable balance, heel or toe walking, poor catching or throwing, and poor handwriting. Vision plays an integral role in the motor control process as it establishes what is referred to as a state estimate for an individual. State estimates specify where one is in space relative to objects in the environment, where one's body parts are, an object's size, weight, speed or direction, and other task relevant information.[5] The state estimate is then used in the motor planning process to formulate an adequate action. A growing amount of literature suggests that while low level visual, tactile, and proprioceptive senses are intact in autism, impairments of the motor control process occur at the level of interpretation and integration of these inputs.[5] In the case of generating a state estimate, multi-sensory integration is required. Sensory data must be evaluated appropriately in the context of the task in order to productively use the data. Improper sensory weighting may produce imprecise and sluggish motor control. Autistic individuals may rely more heavily on one source to shore up the deficiencies in other sources, thereby producing a distorted organization of visual space.

It has been reported that autistic children outperform their typical peers in visual search tasks.[6] In these tasks, subjects are asked to find the target that differs from other distracters in one or more characteristics.[7] Local processing (small details in a picture) in ASD individuals appears far superior to global processing (whole picture). Some have gone as far as to propose that the visual deficits seen in autism are linked to their keen interest in details at the cost of their ability for global perception.[7] This preference for local details over global sensitivity has led to the suggestion that ASD individuals have an inability to adapt to expanding visual attention after attending to a more local target. ASD children have shown difficulty in judging sizes of objects when moving from small to large targets.[8] This phenomenon prompted the coining of two terms: weak central coherence and enhanced perceptual functioning. Weak central coherence describes a cognitive style that leans on local rather than global information processing.[9] The enhanced perceptual global functioning theory proposes that autism biases processing towards local details, however it does not imply impaired global perception. This bias is not the product of choice but is a reflection of the underlying differences in brain structure, organization, and connectivity in autism.[10] Thus the theory predicts that when the two levels of processing come into conflict, individuals with ASD will exhibit increased local interference during a global task.

One of the more well-known social characteristics of autism is poor facial analysis. Lack of eye contact is often cited as a recurring observation by parents of autistic children. A wealth of studies has been conducted solely to explore this phenomenon. A study on face gaze and social cognition lead by Spezio, Adolphs, Hurley, and Piven found that autistic adults relied largely on information from the mouth rather than the eyes.[11] They were also better than their control counterparts at facial identity recognition based on the eyes alone or mouth alone, which further supports the idea of enhanced perceptual functioning. Another study found that autistic children had deficiencies in almost all facial processing components except identity matching.[12] Processing emotions, gaze direction, gender, and lip reading proved to be much more difficult tasks as they required a global, configural processing.[13] Autistic children overall demonstrated improved performance when using high spatial frequency features (local facial features) rather than low spatial frequency features (global configuration of faces). These difficulties are born out of the fact that efficient and accurate facial analysis relies heavily on global processing to recognize configuration of faces. Additionally, ASD individuals were found to view non-feature areas of faces significantly more often than core feature areas of the face (eyes, nose, mouth) compared to typical people.[14] These reported observations may stem from a dysfunctional fusiform face area located in the right hemisphere. This region of the brain is responsible for face processing and has been shown to be hypoactive in autism compared to control subjects.[15]

Case Report

A 10-year-old white autistic male presented for evaluation of a suspected diagnosis of convergence insufficiency. His parents' chief complaint consisted of poor reading comprehension in conjunction with attention deficits and poor organization skills. There were also notable delays in fine and gross motor development that had been previously addressed with occupational, speech and language, and physical therapy. His mother expressed concern over the fact that he could not recall stories or answer questions regarding reading passages. He was able to decode words (sound out), however his comprehension of their conveyed ideas was limited.

His medical history also included anxiety disorder that was managed periodically with medication. His birth history revealed that he was born premature at 7-8 months after complications from toxemia during pregnancy. Consequently, he weighed 2 lbs 4 oz when he was born and was provided oxygen and incubation. His developmental milestones were all late. In school he spends half of the day in a mainstream class with children his age, and the other half of the day is spent in a cluster class with other autistic children.

Table 1: WACS Evaluation Results Summary

Subtest	Not Yet	Emerging	Mastered
1. Identification of Object			
Color Identification, Visual			X
Color Identification, Auditory			X
Shape Identification, Visual			X
Shape Identification, Auditory			X
Hand Identification, Visual		X	
Hand Identification, Auditory		X	
2. Object Design			
Block Stacking			X
Block Construction		X	
Pegboard Figure-Ground		X	
Split Formboard			X
Split Formboard, Half		X	
Split Formboard, Full	X		
3. Graphic Design			
Form Reproduction, Auditory	X		
Form Reproduction, Visual		X	
Graphic Control		X	
Stick Construction, On-pattern			X
Stick Construction, Off-pattern			X
4. General Movement			
Mental Map of Body, Individual			X
Mental Map of Body, Simultaneous			X
Balance			X
Two-Foot Hop			X
Right-Foot Hop			X
Left-Foot Hop			X
Skipping	X		
Catch Ball			X
Line Walk	X		

Upon examination, distance visual acuity was 20/20 OD, OS, OU. Near visual acuity was 20/25 OD, OS, and 20/20 OU. Pupils were round and reactive to light without afferent pupillary defect. Extraocular motility movements were full with no restrictions or overactions. Confrontation fields were full to finger counting. Cover test did not elicit any significant exophoria, but rather a slight esophoria at near. Near point of convergence was normal. Refraction yielded mild hyperopia OU, and vergence ability was adequate. NSUCO saccades revealed good accuracy (5+) and ability (5+) with only minimal head (4+) and body movement (4+). On NSUCO pursuits, the patient was able to complete the task (ability 5+) but had excessive head (1+) and body movement (1+) and was slightly behind the moving target (accuracy 3+).

Anterior segment ocular health examination was unremarkable. Posterior segment health was evaluated with dilated fundus exam and was also unremarkable.

Figure 1: *Drawing of a person*

A diagnosis of mild oculomotor dysfunction was made, however additional testing using the Wachs Analysis of Cognitive Structures (WACS) exam was recommended to fully elicit underlying deficits in visual processing.

WACS: Wachs Analysis of Cognitive Structures

The WACS test was originally designed to evaluate children ages 3-6 years with considerations applied for non-verbal individuals. Four areas of assessment are evaluated: identification of objects, object design, graphic design, and general movement. The test consists of 15 tasks that require a variety of manipulative, visual, sensory, and body movement. Instructions for the task are presented by separating auditory and visual inputs to isolate and identify processing deficits in either modality. Results of the WACS evaluation are summarized in Table 1. Though the norms provided for the WACS are dated (the test has not been normed for over 30 years), the WACS is useful in creating a criterion-based profile of the patient's visual spatial abilities compared to those typically in place by age six years.

The results revealed difficulty in the visualization of abstract ideas or objects as well as gross motor and visuo-spatial inefficiencies. Although the patient has the ability to decode words, he struggles with reading comprehension – specifically with the ability to create a mental image of the abstract information that is gathered by reading (visualization). Without visualization, words fail to impart meaning to the idea being conveyed. In this simple example: "The boy walked his dog in the park," the reader is able to extract meaning from the sentence by drawing on past experiences to build a mental image. One may picture a young boy wearing a cap, holding a blue leash, the end of which is snugly fit around a scruffy dog with drooping ears walking through an area with trees and benches. This difficulty becomes evident in the patient's struggle to identify concealed shapes within a box by touch alone (hand identification activity in the WACS). One must be able to generate a mental construct of the sides and corners that are felt.

Table 2: VT Activities for OMD, Body Awareness, and Bilateral Integration

Activity	Description
Angels in the snow	Start lying on the ground. Tap a limb and patient moves indicated limb. Progress to homolateral and then contralateral movements. Brushing limbs against the floor allows the patient to feel their different body parts.
Walking rail	Begin with tape on the ground. Walk along the line and observe posture and approach. Progress to rail and look for patient's awareness of the midline. Eventually walk heel to toe forward before backward. Can also attempt crossover of feet and using flashlights to point at feet.
Chalkboard circles	Chalk in each hand. The patient draws circles moving in the same direction then opposite direction.
Balance board	Balance on top of the board with support before allowing patient to attempt by himself. Touch specified parts of the board to the floor (left, right, front, or back). Track a moving target without falling off.
Robot directionality	Patient directs therapist towards a location or the performance of a task.
Body map	Draw a life-size representation of the patient. Add in as many body parts as possible. Patient identifies different body parts on himself and then on the drawing. Ask about the function of those body parts. Identify body parts on therapist who is standing next to patient and then across from patient. Identify body parts on people in magazines.
Pursuits	**Description**
Marsden ball	Start with lying on the floor and have the patient track the ball swinging side-to-side or in a circular motion. Eventually incorporate motor and spatial aspects of catching and bunting.
Flashlight tag	One flashlight is for the therapist, one for the patient. Follow the therapist's light. Can include making loops, figure 8s, or letters.
Rolling ball	Lower level activity. From a seated position, roll a ball towards the patient and have them track across the distance. Maintain a slow enough speed to allow for a pursuit. Cross the midline with the rolls and ask the patient to catch and roll the ball back.
Saccades	**Description**
Multi-matrix	Colored blocks with numbers/letters on them. Patient arranges them in order or according to a pattern. Introduce loose prism to promote vergence training as well.
Sorting cards	Sort playing cards by suit or number.
Space fixator	Change patient's fixation from one target on the fixator to another. Have the patient point to the indicated targets. Incorporate bilateral coordination with different hands used and simultaneous movements with feet.

As a part of the evaluation, spatial organization and body awareness are assessed. The patient is asked to draw a picture of a person and to include as many body parts and details as possible. Figure 1 represents the patient's drawing.

The patient explained that the eyes of the person were at the top of the forehead and his hands were directly next to his face. His legs also appeared to be disjointed from the rest of the body. This distortion of body awareness is consistent with the patient's reduced bilateral coordination and poor motor planning, and it may contribute to his self-stimulating actions. Hand flapping and finger flicking characterize common self-stimulating actions in autism. It is thought that they may provide the individual with proprioceptive information about the body – where their body parts are currently located in space.

With the results of the WACS, an additional diagnosis of overall visual spatial deficits and vision-integration deficits was made. An individualized program of vision therapy (VT) was recommended to address the patient's visualization difficulties, with emphasis on improving reading comprehension and tracking while establishing body awareness and gross/fine motor proficiency.

Discussion

Vision therapy has been shown to improve control of eye movements during reading.[16-19] Recent studies have provided additional evidence for the treatment of other visual dysfunctions such as convergence insufficiency and accommodative dysfunctions with VT.[20-25]

To date, however, there are very few reports on the efficacy of vision therapy in the special needs populations. Nine patients in Duckman's study on the efficacy of VT in cerebral palsy patients showed improvement in their accommodative, oculomotor, and visual perceptual skills.[26] A case study performed by Dudley and Vasche explored the effectiveness of VT in a developmentally delayed male child who improved both objectively and subjectively in his visual attention, tracking, and visual perception.[27] Kaplan and his colleagues noted remarkably improved posture, body orientation, and visual motor task performance in autistic children when employing yoked prism in a series of studies.[28-30] The question of whether or not VT actually improves a patient's quality of life has also been addressed in studies done by Cook in 1995[31] and Harris and Gormley in 2007.[32] Both studies espoused the tremendous progress and impact that VT can have on the quality of life in patients suffering from various visual conditions.

Developmental Individual-Differences Relationship-Based Model

The Developmental Individual-Differences Relationship-Based (DIR®) "Floortime model" was conceived to provide a clinical framework for developmentally delayed children, including children with autism, to organize their sensorimotor function, and thinking to be attentive, interactive, and relate with others.[33,34] The *developmental* element of the model is founded on the basic abilities that typical children master by age 5. This encompasses the ability to self-regulate and be composed enough to attend to their environment, to maintain social back-and-forth communication, to connect ideas in a logical manner, and to communicate their requests.[35]

The *individual differences* component focuses on the unique biology of each child. This biology acts as a basis for how they gather, control, respond, and interpret their senses. A child may exhibit hyper- or hyposensitivity to any number of stimuli, all of which must be accounted for when considering their learning style and personality. The underlying premise is that every individual has a distinctive method of processing information taken in by the senses, which is a critical consideration in the design of treatment programs.[35]

Lastly, the *relationship-based* aspect refers to the context of the relationships that the child has with caretakers, therapists, and their peers. This involves an increased awareness of the child's emotions with the intent of introducing them to the concept of a shared world.[35] This creates possibilities for challenging the child to master higher levels of relating, communicating, and thinking as one interacts with them.

Vision Therapy for Autism Spectrum Disorder

Treating ocular motility disorder in autistic children may require providing supports deficiencies in gross motor ability in conjunction with modified techniques that reflect their developmental level. A stabilized body provides the framework for accurate visual-motor learning.[36] As body awareness improves and stability is solidified, the patient discovers that there is a center to his body. From that center, the eyes visually project out into space as he begins to understand and localize himself in the environment. The visual system can then begin guiding body movements. Without a firm basis on centering the body, the transition from the more primitive relationship of motor leading vision (seen at times as excessive head and body movement) is difficult. As is typified by autism, gross motor deficits can run the gamut of possibilities. The patient displayed marked difficulty in skipping and crossover line walking – tasks that involve good coordination and bilateral integration. To address these issues, a list of activities provided in Table 2 describes techniques that encourage oculomotor development, bilateral integration, and body awareness.

Yoked prisms can be incorporated to train visual motor integration. Prism actively engages the attention of a patient by presenting a mismatch between the visual pathway and vestibular-proprioceptive pathways. The patient must attend to these different sensory inputs and make adjustments to accomplish the activities. The initial response to yoked prisms is often remarkable as the child explores the changed visual world. There may even be improvements in posture depending on the direction in which the prism is applied. Starting with large amounts of prism (20 prism diopters or more), perform an activity without the prism and then with the prism, noting changes in their attention and coordination. The prism can then be changed to different base directions.

Another goal of the therapy was to improve visualization. This was accomplished primarily through various manipulations and modifications of parquetry block activities. The following sequence was employed:

1. Build on top of template
2. Build next to template
3. Copy therapist's pattern – including offset shapes, gaps in the patterns, corners touching sides (a simple variation is to have the patient develop a pattern that the therapist must copy)
4. Parquetry memory – rebuild therapist's pattern after being shown the pattern for a set amount of time
5. Identifying single shapes by feel inside concealed bag
6. Identifying a pattern of shapes by feel – matching them visually then building them
7. Describing patterns for therapist to build – alternatively switch places
8. Building on a template with outside borders only
9. Building patterns as if they were rotated or flipped
10. Building patterns from different perspectives in the room

Activities should be modified to correspond to the developmental level of the child. Many of these parquetry techniques can also be modified to where the patient and therapist switch roles. This is principally effective in cultivating communication (expressing their thought process and motor planning) and language skills in addition to exercising their adaptability and creativity. The back and forth interaction generated is a much desired result. The goal of these activities is to promote the formation of the mental imagery that reading comprehension requires. This can be incorporated into the activities by not allowing the patient to manipulate the parquetry block after he has placed it on the table. He must first deliberate on how the shape should be oriented and its location before placing it on the table.

The tactile integrative activities afford a more concrete task since they present the patient with a physical object that can be manipulated. As the patient touches the corners and sides, he must mentally map out the figure. Once single shapes are mastered, the parquetry blocks can be glued together to increase the difficulty of the task. Figure 2 provides some examples.

As progress is made, activities become less concrete and more abstract. When first introduced to a new task, it is

Table 3: Re-evaluation Results

Subtest	April 20, 2013 Re-evaluation after 9 months therapy	July 2012 Initial evaluation
1. Identification of Object		
Hand Identification, Visual	Mastered	Emerging
Hand Identification, Auditory	Mastered	Emerging
2. Object Design		
Block Construction	Mastered	Emerging
Pegboard Figure-Ground	Emerging	Emerging
Split Formboard, Half	Mastered	Emerging
Split Formboard, Full	Mastered	Not present
3. Graphic Design		
Form Reproduction, Auditory	Emerging	Not present
Form Reproduction, Visual	Emerging	Emerging
Graphic Control	Emerging	Emerging

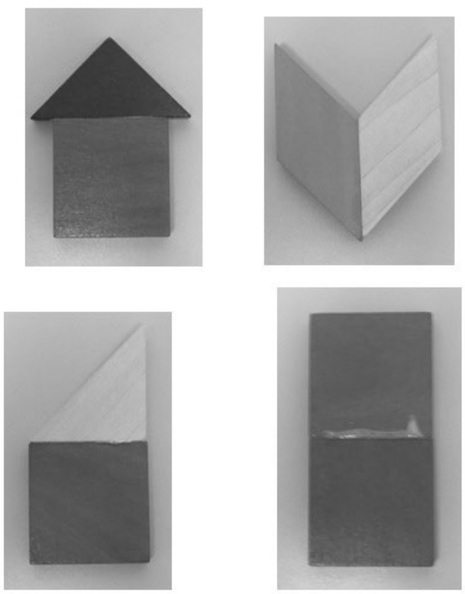

Figure 2: *Parquetry patterns*

necessary to interject concrete adjustments to help the child learn the concept of the activity.

At the end of 26 sessions, a re-evaluation was performed utilizing the WACS protocol. Table 3 shows his re-evaluation results.

He improved in six out of nine categories that were re-tested. His mother reported improved attention when reading and more significantly, improved reading comprehension grades. The patient excitedly relayed his 95% on his latest reading comprehension test. Figure 3 shows his new drawing of a person.

His new drawing properly places his hands at his sides, his feet connected to a body and his eyes in the appropriate place on his head. This implies a much improved body awareness and mental map of himself.

Recommendations were made for occupational therapy to evaluate his fine motor skills. It was observed that during his re-evaluation, the patient could reproduce shapes by drawing them in the air, but his drawings became distorted when using pencil and paper.

Figure 3: *Drawing of a person re-evaluation*

Conclusion

The patient presented with difficulties in reading comprehension that were linked to his visual perceptual insufficiencies. Although autism can present numerous challenges that require co-managing and concurrent therapies over a range of specialties, traditional VT techniques can be modified to meet the patient's needs where they are developmentally weak. Utilizing the DIR "floortime" model facilitates opportunities for communication to occur in a more natural and logical manner. The combination of these techniques allowed the patient to develop the proper visual perceptual skills that have in turn supported improvement his comprehension ability.

The well-established literature and reports describing the visual processing difficulties in autistic patients greatly outnumber reports of interventions used to treat patients with these problems. As such, the complexity and variability of this population, combined with limited knowledge, has yielded enormous need for appropriate care. Though these patients may never reach age equivalent levels of proficiency, improvement is possible and may contribute greatly to their quality of life and daily activities.

Autistic individuals truly require individualized care that can often be complicated to grasp. Optometrists are in a strategic position to address their issues through a VT program that integrates motor-based approaches to encourage visual skill development. Unfortunately, there is little literature providing evidence for the success of VT for these patients. However, the advent of awareness of autism may push for research in the future. Nevertheless, autistic patients should be considered as candidates for VT as it may improve their quality of life.

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