Optometric therapy for the left brain injured patient

ELIZABETH B. AKSIONOFF, O.D.
NAOMI S. FALK, O.D.

ABSTRACT: This article discusses the role of optometric visual therapy in the rehabilitation of left head trauma patients. It overviews the functions of the left hemisphere and the consequences of traumatic brain injury. A patient who was helped by this perceptual therapy is presented. An overview of the therapy approach used for this patient is discussed.

KEY WORDS: Left hemisphere, traumatic brain injury, developmental optometry, rehabilitative optometry

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Each hemisphere of the human brain has areas of specialized function. The left hemisphere controls motor function of the right side of the body. Fine motor control and related motor adjustments of the right side are processed in the left hemisphere. The right half of the visual field is also processed there.[1]

The left hemisphere is the location of the language function in 85–92 percent of the population. Approximately 95 percent of right-handed people have their speech and language center in the left hemisphere, while 70 percent of left-handed people have their language center there.[2] Of the remaining lefthanders, 50 percent have right hemisphere control of speech while the other 50 percent have speech represented bilaterally.[2] The language function includes the production of speech and language as well as the process of understanding linguistic concepts and verbal memory. It is responsible for processing the language code. The left hemisphere organizes concepts through symbolic formulation and expression.[2]

The left hemisphere has superior analytical skills, of which language is just one manifestation. This portion of the brain provides the analytical process that is required for the analysis of individual components rather than the perception of the whole. Processing is sequential. This is in contrast to the right hemisphere where processing is in a simultaneous, holistic manner.[3] Problem solving in the left hemisphere utilizes its strengths of analytical skill and the language function. One strategy used in problem solving is the use of verbal descriptions.

Trauma to the left hemisphere

Language, verbal and visual memory and sequencing are areas that may be affected by trauma to the left hemisphere.[4] Depending on the location and extent of traumatic injury to the left hemisphere, various types of language disorders may arise. Aphasias result from damage to specialized regions of the brain subserving language. Aphasia is not a physical limitation of language production, but a reduction in the capacity to formulate or interpret meaningful linguistic codes.

Damage to the inferior frontal cortex of the left hemisphere, Broca's area, results in expressive aphasia. This is characterized by good language comprehension but poor spontaneous speech, naming of objects and repetition of verbal sequences.[5] Damage to the temporal-parietal region of the left hemisphere, Wernicke's area, results in receptive aphasia. In receptive aphasia, the patient is able to articulate but exhibits poor speech comprehension. Other linguistic skills, such as reading or writing, may be impaired as well.[5] Damage to this area may also be associated with a superior quadrantopic visual field defect. Widespread damage to the left hemisphere results in global aphasia in which both speech comprehension and production are impaired.

Certain syndromes may arise as a result of injury to either hemisphere, suggesting that the function is mediated by participation of both hemispheres. When one hemisphere is damaged, the other cannot fully compensate. Deficits in visual imagery are found in patients with either left or right hemispheric brain injury.[2] Visualization is a high level cognitive activity. It is not lateralized but involves integration from various levels of the brain via association pathways.

Constructional disturbances also arise from trauma to either hemisphere.[6] These include copying drawings, reproducing geometric patterns or other performance tasks in which there is a disturbance in assembling the parts that cannot be accounted for by sensory or motor deficits alone. Although trauma to either hemisphere can cause a constructional disturbance, the output is often characteristic of the affected hemisphere. A patient with left brain trauma produces a more simplified structure lacking in detail. A right brain injured patient will create a more complex but asymmetrical structure often with distorted orientation.[6]

Visual neglect, the failure to respond to stimuli presented on one side, may also occur with left hemispheric lesions but is more common, severe and lasting in right sided lesions.[6]

Deficits secondary to head trauma may include visual acuity deficits, binocular and accommodative dysfunction, oculomotor motility, visual field deficits, poor perceptual accuracy and other visual perceptual deficits. Poor perceptual accuracy causes improper judgments of distances and rate of movement of objects relative to each other.[7] This leads to poor awareness of self in space leading to frustration in performing daily living tasks. Clumsiness or awkwardness while navigating in a cluttered or unfamiliar environment, in the absence of a visual field defect or visual neglect, may be a result of poor awareness of self in space. Therapy utilizing gross motor movements and yoked prism to create a sensory-motor mismatch has been reported to be effective in reorienting the sensory and motor systems.[8]

Head trauma can result in an inability to process more than a minimum of perceptual elements at one time.[6] Moviegenics or Motor Planning is the ability to organize and sequence thoughts and actions. Planning requires the ability to contend with a variety of simultaneously presented ideas or events. For accurate motor planning to occur, good impulse control, memory and attention skills are necessary. Head trauma patients frequently suffer from impaired sequencing, poor intersensory integration, impulsivity, and attention and memory dysfunctions.[9] For a patient having these characteristics, Motor Planning is an extremely difficult task.

In the optometric evaluation of a head trauma patient it is necessary to evaluate all aspects of a patient's visual function. A thorough ocular examination should include refractive analysis, binocular and accommodative testing, visual perceptual testing, visual field screening, dilated fundus evaluation, biomicroscopy, pupil evaluation and applanation tonometry. Routine refractive, accommodative and binocular testing will often reveal deficits that hinder a patient's performance and recovery. These deficits can be remediated using conventional treatment with lenses, prisms, low vision devices and/or vision therapy.

Physical therapists, speech pathologists and occupational therapists are highly skilled at their specialties. With the aid of these professionals a trauma patient may be able to achieve the physical activities of daily life on a task-by-task basis but the spontaneous, integrated sequencing of these acts may be difficult. The focus of this article is the optometrist's role in the rehabilitation of head trauma patients after a careful evaluation and remediation of visual and binocular skills, and ocular health has been completed. If visual perceptual deficits remain then it is the optometrist's role to emphasize a cognitive approach to problem solving and planning. The approach is similar to perceptual therapy used in optometric vision therapy. Often traumatic-brain-injured patients have experienced a disruption in the pathways where vision is integrated with kinesthetic, proprioceptive and vestibular processes. These patients retain the engrams established through life experience but cannot access them. For these patients, the role of rehabilitative vision therapy is to integrate cognitive activities with self-generated motor activities using constant feedback. Movement alone, without the opportunity for error recognition, does not produce adaptation. Research shows that this must be self-generated movement.[10] Sensory feedback plays a vital role in adaptation. It helps develop motor coordination, to maintain it and helps us cope with altered sensory inputs.[10] It appears that it is the premotor cortex that plays a role in Motor Planning and the visual guidance of movement.[11]

Case report

The following is a case in which optometric vision therapy was used with a patient at the Northport Department of Veterans Affairs Medical Center.

A 70-year-old white male suffered a left hemispheric cerebrovascular accident in May 1989. Complaints included difficulty with word retrieval skills (a mild expressive aphasia) and short-term memory loss. He also noted a tendency to bump into objects as he walked through a room. The deficit that seemed most bothersome was an inability to dial the telephone. He was able to mechanically push the buttons but he would lose his place after the third number and not be able to recover. This is an example of how mild perceptual deficits in short-term memory and sequencing have caused a significant functional problem for the patient. While undergoing head trauma therapy at the Northport Department of Veterans Affairs Medical Center Eye Clinic, he was also undergoing therapy with a speech pathologist for his mild expressive aphasia.

A primary care evaluation was fairly unremarkable. His refraction and visual acuities were OD: +0.75−0.75×90, 20/20 and OS: plano, 20/20. On cover test he showed orthophoria at distance and a low exophoria at near. Convergence near point was 3″/5″/OS out/diplopia elicited. With a red lens before the right eye the convergence near point was 4″/6″/OS out/ diplopia elicited. Motilities were full, with no limitations but with some slight jerkiness. With a +2.25 add, determined by fused cross cylinder testing, nearpoint visual acuities were 20/20 for OD and OS. Nearpoint testing through the add showed a 6 prism diopter exophoria. Base in ranges were x/12/8 and base out ranges were x/20/14. Pupils were equal, round, responsive to light. No afferent pupillary defect was present. Intraocular pressures were 17 mmHg in each eye by applanation tonometry. A dilated fundus examination and slit lamp examination revealed no ocular pathology. Visual fields both on confrontation and with Goldmann perimetry revealed full fields OD and OS.

A perceptual evaluation was performed yielding the following results. Ocular motility was accurate with voluntary pursuits and saccades. However, on the NYSOA King-Devick test performance was very slow, with difficulty in recalling numbers out of sequence. The Wold Digit Symbol Test was performed accurately but very slowly. The Gardner Test of Visual Perceptual Skills showed a wide variation in performance: Visual Figure Ground Subtest 14/16 correct, Visual Memory subtest 8/16 correct and the Visual Sequential Subtest 0/16 correct. On tachistoscopic testing where both the number of digits and speed of presentation were manipulated, maximum performance was elicited at 2 digits/ msec. With tachistoscopic testing he showed difficulty with sequencing and number recognition. He was very easily distracted. The Beery Test of Visual Motor Integration was done with good form perception and adequate spatial organization. On pegboard testing, the direct reproduction of all five shapes was excellent. On the indirect pegboard test in which the same five patterns are presented but the task is to produce the mirror image (reversed left to right), he had difficulty with the complex patterns. The Piaget Test of Left-Right Awareness showed that while he had an adequate sense of laterality, he had a difficult time when trying to project this into space. For further information regarding a perceptual battery for head trauma patients see Aksionoff and Falk in this issue.[12]

As a result of the perceptual testing it was determined that the patient's main difficulties were in visual sequential memory, visual memory, poor attention span and generalized poor body schema.

The focus of therapy was to institute a structured program consisting of a repetitive sequence of visually guided motor activities to develop planned motor movements. These movements were to be self-generated. Feedback was provided with all the activities.

Procedures

I. Gross motor movements

Gross motor therapy is the starting point to develop association pathways through motor movement. As in optometric vision therapy, motor therapy proceeds through various stages in the brain-injured patient. These include awareness of body schema, motoric self lateralization, cognitive self lateralization and development of left-right concepts. The purpose of working with gross motor movements is to establish Motor Planning, which is a movement that is first carefully planned and then executed. Success at this level leads to integrated motor activities.

Trauma patients often experience difficulty with the inhibition of movement. Self-generated movements require active inhibition of the limbs not being moved. For example, the sequence progresses from movement of an entire arm, to forearm, wrist and finally fingers. With each progressive step a more precise motor movement is required as well as more inhibition. As success with each level is reached, a new component can be added to the procedure. Adding intersensory stimuli such as a metronome to a task can be very challenging to a trauma patient who has difficulty attending to more than one piece of information at a time. Another component to add is a time-out, which requires the patient to actively inhibit a behavior. For example, if a movement is to be made to each beat of a metronome, a time-out would require that the patient not make that movement to every third beat. As success continues, a visual code that the patient must follow when performing the motor movements can be incorporated. At each level Motor Planning is emphasized. Before the physical movement occurs, the patient is to visualize the movement and then match it. If an incorrect response is made, verbal feedback is employed. The patient is to repeat the process until a correct response is obtained.

II. Attentional techniques

Various tachistoscopic or visual memory techniques can be used to develop the speed and span of recognition and attentional level. Letters, arrows, numbers or shapes all can be used for these tachistoscopic activities. Visual search activities and Michigan tracking worksheets are useful for attentional skills. Various computer orthoptic and rehabilitative programs are available for use with the head trauma patient as well.[13]

III. Chalkboard work

Chalkboard work involves graphomotor and fine motor control. Windshield wipers, templates, rhythmic writing and coding exercises[14] are used. Activities of this type relate to attentional demands over time. Intersensory integration is added to increase the demand for sequential control of the fine motor activity.

IV. Yoked prism

Yoked prisms are prisms worn before each eye with the bases pointing in the same direction. A sensory-motor mismatch is produced when yoked prisms are used in conjunction with a physical activity such as Marsden Ball Bunting; creating a problem-solving situation for the patient incorporating physical feedback. As the motor system readjusts to the image displacement of the prism, a signal is sent to the brain causing an adjustment in the sensory system as well. This problem-solving technique uses self-generated motor activities to cause a reorientation of both the motor and sensory organization in the cortex.

V. Parquetry series

A parquetry block series can be used to emphasize form perception, visual memory or visualization. This technique was used as a visual memory and visualization technique. A design was composed of colored squares, triangles or diamonds. The design was then covered from view and the patient instructed to recreate the design. Short term memory deficits will cause this to be a difficult task. As in all techniques, feedback is crucial. If a design was incorrect, the patient was given another opportunity to view the design and correct his own error. This constant opportunity for feedback allowed a structured problem solving approach to be developed. As performance improved, more shapes were added to the design, and a longer interval between exposure and duplication was possible.

VI. Military turns/room relations

In this procedure the patient is situated in the center of the room. A reference point is established for each wall in the room. A task requiring sequencing, visualization, laterality and directional skills is presented. For example, the patient is asked to visualize which reference point he would be facing if he made a turn in a specific direction, to the right for example. After reporting a verbal solution to the task, the patient must self-determine the appropriateness of the response by physically following the initial given sequence. Via physical feedback, these techniques help develop a relationship between the patient and objects in space (also known as directionality).

VII. Visualization techniques

Visualization is the substitution of lower level processing (motor) by vision. Visualization techniques are the last phase of the therapy. High level visualization techniques can be incorporated into a parquetry series or a tachistoscopic series.

At the end of therapy, which lasted for 1 year of weekly 45 minute in-office sessions, the patient exhibited improved awareness of himself in space. He no longer complained of bumping into objects. Scores on the TVPS Visual Memory (14/16) and Visual Sequential Memory (12/16) tests improved. Importantly, he felt that he was functioning better in his activities at home. He showed more confidence in his capabilities. A significant improvement was seen in his ability to successfully dial the phone again. This had always been a very frustrating task for him. Although his primary care examination did not reveal significant visual problems, the perceptual evaluation did highlight certain areas of difficulty. It is within the realm of an optometrist trained in vision therapy to manage cases such as this.

Discussion

In the rehabilitation process, a trauma patient comes into contact with numerous professionals from neurologists to speech pathologists to occupational and physical therapists. All of these professionals have a vital role in the rehabilitative process. However, none are as qualified as optometrists to assess and rehabilitate the visual and visual-perceptual system. Depending on an evaluation of the patient, the degree of optometric intervention possible must be determined. In some cases, the trauma may be so severe that visual rehabilitation is futile. An ideal time to work with these patients is while they are receiving concurrent speech or occupational therapy. Improved visual skills often will make the progress in other rehabilitative areas proceed more rapidly.

After refractive, accommodative and binocular deficits are addressed, visual perceptual deficits can be addressed. All of the training procedures require complex information processing. They require planning, initiation and sequencing in addition to the visual and motor components. The training procedures were organized in a sequence ascending the Visualization Pyramid. The base of the pyramid, and the foundation from which all visual skills develop is gross motor movements. Gross motor movements begin as unrelated movements, then become more organized as both sides of the body are brought together at the midline. This leads to dynamic related gross motor movements where movement through space is added. These techniques provide the basis for body schema and laterality. Fine motor development is the next step up the pyramid. After that comes oculomotor development and directionality, which is an expansion of laterality. This leads to figure-ground analysis and spatial coordination. The pyramid peaks with visualization.

This case was an illustration of how an optometrist trained in visual therapy can have a significant impact on the head trauma patient. Left brain trauma usually does not cause the visual symptoms, such as binocular dysfunction, more easily amenable to visual therapy. However, brain trauma does disrupt the cortical pathways that affect behavior. It is optometric visual therapy in conjunction with occupational therapy, speech pathology and physical therapy that can influence the rehabilitation of the left brain trauma patient. ■

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Optometry Service (123)
Northport VA Medical Center
Northport, NY 11768

SUNY State College of Optometry
100 East 24th Street
New York, NY 10010