

# Article ▶ Visual-Spatial Therapeutic Rehabilitation for the Brain Injured Patient

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## ABSTRACT

Therapeutic vision rehabilitation is a significantly underutilized component of the multidisciplinary rehabilitation program for the brain injured patient population. The purpose of this paper is to present the impact of visual dysfunction in brain injury, to demonstrate the benefit of therapeutic vision rehabilitation on the activities of daily life for the brain injured patient, and to give practical activity instructions for the vision therapist. This paper discusses the importance of inclusion of therapeutic vision exercises into the multidisciplinary and visual rehabilitation program with the goal of increasing the potential for reintegration into society and reduction of the social and economic impact of brain injury on society.

**Keywords:** brain injury, vision rehabilitation

## Introduction

Acquired brain injury often results in disability, loss of independence, loss of ability to work, decreased efficiency at work, and an inability to return to independent transportation and driving. It has been reported that 1.5 million people in the United States experience a traumatic brain injury (TBI) every year.<sup>1</sup> Cerebrovascular accident (CVA) or stroke contributes an additional 795,000 brain injuries per year.<sup>2</sup> It has also been reported that 320,000 veterans may have incurred some level of TBI from action in the United States' recent conflicts in Afghanistan and Iraq.<sup>3</sup> At least 5.3 million Americans require long-term assistance for activities of daily living due to TBI,<sup>4</sup> resulting in an estimated \$31.7 billion in national economic loss.<sup>5</sup>

Review of the literature demonstrates a clear and longstanding relationship between acquired brain injury (ABI) and dysfunction of the visual system. Some authors even report that visual dysfunctions are the most common physical sequelae following brain injury.<sup>6</sup> Many visual dysfunctions experienced by brain injured patients result from diffuse axonal injury from stretch and shear forces, which are often not evident on traditional imaging studies like magnetic resonance imaging (MRI) and computerized tomography (CT) scan. The cranial nerves that control eye movements are especially subject to this type of damage. Cranial nerve damage results in oculomotor palsies<sup>7</sup> and strabismus<sup>3,8</sup> with a high prevalence of hyperphoria<sup>7</sup> and diplopia.<sup>3,7</sup> Existing literature also reports other abnormalities of the visual system common in brain injured patients including high rates of disorders of eye movements,<sup>3,9,10</sup> binocular dysfunction<sup>9</sup> (particularly convergence dysfunction<sup>3,6,7,9-11</sup> and reduced ability to maintain binocular fusion<sup>3,10</sup>), accommodation dysfunction,<sup>9,7,11</sup> visual field defects,<sup>3,6,7,12,13</sup> visual neglect (visual spatial inattention),<sup>12,14</sup> visual midline shift,<sup>15,16</sup> decreased contrast sensitivity,<sup>3</sup> color discrimination deficits,<sup>3</sup> fixation instability,<sup>3</sup> gaze-evoked nystagmus,<sup>3</sup> abnormal vestibular ocular reflex,<sup>3</sup>

and a multitude of ocular health injuries,<sup>3</sup> as well as other visually-related deficits like impaired visual processing and short-term memory loss.<sup>3,17</sup> Studies have shown that visual deficits are significantly higher in TBI patients than in control patients without history of TBI.<sup>7</sup> Goodrich et al.<sup>17</sup> found that 74% of independently living mild TBI patients self-reported visual symptoms, and 38% had visual impairment.

Visual dysfunction plays a significant role in impeding the reintegration of brain injury survivors into society. Vision dysfunction can prevent independent living and the efficient return to the work environment, and it raises concerns about safety with returning to driving.<sup>3</sup> Convergence insufficiency has been associated with TBI patients failing to obtain and retain employment.<sup>10</sup> It has also been reported that unattended visual sequelae of ABI can impede general rehabilitation<sup>18</sup> and that visual problems affect military combat deployment duties.<sup>6</sup> There are a number of published articles linking visual dysfunction to success with activities of daily living.<sup>3,6,7</sup> Visual dysfunction has also been linked to comprehension difficulties<sup>7</sup> and reduced reading ability.<sup>3,6,7,17</sup> Visual dysfunction also leads to symptoms of disorientation and confusion and contributes to balance difficulties,<sup>7</sup> which increases the risk of additional injury due to falls. Schuett<sup>19</sup> reports that visual field disorders are a disabling finding in brain injured patients that result in symptoms of deficits in detecting and locating objects and avoiding obstacles and reduced visual-spatial orientation and navigation.

Despite some debate about the presence and extent of spontaneous recovery of some visual deficits,<sup>19,20</sup> studies have shown vision dysfunction to be longstanding if left untreated.<sup>10,20</sup> In addition, most ABI visual dysfunction is not correctible by traditional refractive or medical treatments. It is important that rehabilitative vision treatment addresses the overall function of the visual system and is not limited to ocular function and ocular health,<sup>3,7</sup> as 85% of the TBI patients that were found to have vision deficits presented with

20/20 or better visual acuity.<sup>3</sup> Multiple techniques have been described in the literature to address functional deficits related to visual dysfunction including various optical devices<sup>12,16,20-22</sup> and therapeutic intervention techniques.<sup>20,23-26</sup> Studies have shown success at reducing visual symptoms in brain injured patients with therapeutic intervention,<sup>2</sup> as well as resolution of homonymous hemianopia with various rehabilitation techniques.<sup>20</sup> Schuett<sup>19</sup> reports that “compensatory therapies have been developed, which allow brain injured patients to regain sufficient reading and visual exploration performance through oculomotor training.” Jose et al.<sup>7</sup> suggests that TBI patients should be involved in the rehabilitative process similar to those patients diagnosed with convergence insufficiency who have not suffered a brain injury.

Neuroscience-based concepts of plasticity have emerged that provide a neuro-physiological basis for the success of therapeutic rehabilitation. Huang<sup>2</sup> suggests that vision therapy techniques strengthen synaptic connections and induce cortical reorganization. Newer imaging techniques like Positron Emission Tomography (PET scan) and Functional Magnetic Resonance Imaging (fMRI) studies<sup>27,28</sup> provide evidence of the structural and physiological changes produced in the brain through the therapeutic rehabilitative process.

Established vision therapy techniques for treating the specific oculomotor and visual perceptual dysfunctions are useful in the therapeutic vision rehabilitative process for brain injured patients. Traditional vision therapy techniques can be used with minor adjustments in protocol or special accommodations specific for the brain injured population. However, there are unique visual deficits that arise in the brain injured population (including visual field deficits, visual neglect, and visual midline shift syndrome), in which less well known vision therapy techniques involving visual-spatial training and techniques to improve body awareness and visual-spatial perception are particularly useful. Body awareness is the ability to recognize different parts of one’s own body and effectively and accurately to position and move the body in space. Body awareness is dependent on being able to perceive and integrate information coming from many senses, including vision. Body awareness provides a foundation for the development/rehabilitation of visual-spatial awareness. Visual-spatial awareness is the ability accurately and effectively to analyze and orient in space using visual representations and their spatial relationships.<sup>29</sup>

Body awareness and visual-spatial awareness are evaluated as part of a neuro-optometric evaluation including ocular motility evaluation, binocular coordination evaluation, visual midline shift test, yoked prism neutralization of midline shift, visual field evaluation, visual neglect evaluation, posture and gait screening, vestibular-ocular reflex evaluation, visual motor evaluation, and consultation from other rehabilitation professionals including physical therapists and occupational therapists. Specific diagnostic tests of visual-spatial perception, like the Hess-Lancaster test and the VTE spatial localization



**Figure 1:** Set up of the Body/Posture Rock procedure.

board, can also be useful. A sample of visual-spatial therapeutic techniques is described below. The following techniques are often most beneficial when used in conjunction with other non-therapeutic visual interventions including spectacle and contact lens treatments, medical treatments, adaptive techniques, and visual rehabilitative devices such as yoked prism, peripheral awareness prism systems, compensatory prism, Fresnel prism, occlusion techniques, filters, tints, and anti-reflective coatings as part of a multidisciplinary rehabilitation program.

### **Body Awareness**

Body awareness training can be used for patients with visual midline shift syndrome and visual neglect. Visual midline shift syndrome can occur with injuries resulting in body hemiparesis.<sup>16</sup> In body hemiparesis, the sensory receptors from one side of the body are out of balance with the other side. A portion of the visual system (the ambient system) is modulated and matched with other sensory motor systems through the midbrain. It is theorized that the ambient visual system tries to balance the inequality of the body using the pre-injury process and results in dysfunction of visual-spatial perception.<sup>16</sup> Defective body awareness can also occur in patients with visual neglect. It is important to address body awareness in visual neglect to establish a visual motor map to provide the foundation for a visual representation of space or visual-spatial awareness. Sensory based stimulation has been shown to enhance representation of neglected space.<sup>16</sup> When supported with therapeutic devices like yoked prisms, these types of activities can be an effective and long-lasting treatment strategy.<sup>16</sup> The following exercise works to support the visual, motor, and vestibular systems using stretch receptors in the proprioceptive system to aid realignment of the visual-motor midline. These types of exercises are often carried out by physical and occupational therapists to address other sensory and motor deficits. Interaction and communication with other health care professionals within a vision rehabilitation program can be very useful in the patient’s overall recovery.



**Figure 2:** Example of a Hart chart as used in the Body/Posture Rock procedure.



**Figure 3:** Example of use of harness and balance board.

## Body/Posture Rock

### Procedure:

#### Level 1:

1. Have the patient sit in a chair with both feet flat on the floor. Stack books on each side of the chair, so that when the patient leans to one side, she/he can touch the top of the books with a flat palm. Have the books at the same height on each side of the chair (Figure 1).
2. The patient should rock as far to the left as possible, then rock to the right as far as possible. Noticing the weight shift from the left to the right, have the patient touch the books with the palm of the hand on the corresponding side.
3. After three rocks to each side, have the patient sit straight with their weight centered, equal weight on each side. To help the patient see if they are centered have him/her sit in front of a mirror with a piece of tape on their chest running vertically from their chin to their navel. Place a corresponding piece of tape on the mirror. Have the patient visually confirm that the tape on the chest lines up with the tape on the mirror. Point out visual misalignments and encourage the patient to adjust body posture if needed.
4. Emphasize visualization and proprioceptive feel of body position.
5. To increase difficulty, time to a metronome or add visual cognitive loading like reading a Hart chart (Figure 2) or verbal cognitive loading like reciting the alphabet or answering math problems.
6. Have to patient close his/her eyes and align his/her body using only visualization and proprioceptive clues. Have the patient open their eyes to check alignment and to adjust body position if incorrect.

#### Level 2:

Repeat the above activity using an unbalanced surface, like a large exercise ball.

#### Level 3:

Repeat the above activity while standing. A walker, harness, or other support device can be used as needed to ensure stability and prevent fall.

#### Level 4:

Repeat the above activity while standing on an unbalanced surface like a balance board or two weight scales, one under each foot while standing (ensure the patient is stable and that the fall risk is very low). A walker, harness, or other support device can be used as needed to ensure stability and prevent fall (Figure 3).

## Visual Scanning

Visual scanning techniques are essential for patients suffering from hemianopic and other visual field defects. Visual scanning techniques can also be beneficial for patients with visual neglect to reinforce and aid rehabilitation of the visual-spatial framework. Although spontaneous recovery may show some improvement of visual field in the early stages following brain injury,<sup>20</sup> these patients tend to develop disorganized scan paths with multiple fixations in the absence of structured rehabilitation.<sup>30</sup> Margolis<sup>20</sup> states that multiple studies show functionally significant restoration of visual field through scanning training. There is evidence indicating effectivity of training both large saccades<sup>20</sup> into the blind field and border zone stimulation.<sup>31</sup> Literature documentation<sup>31</sup> and clinical experience suggest a process/hierarchy of therapeutic exercises/activities to employ. The following exercise is an example of



**Figure 4:** Initial set up of the Saccade Scanning procedure.



**Figure 5:** Example of a tachistoscope.

a task specific scanning exercise that requires both horizontal and vertical scanning.

### Procedure 1: (Saccade Scanning)

1. Have the patient sit in a chair with both feet flat on the floor. Spread a group of simple three dimensional shapes (i.e. colored cubes or shape blocks) on a table in front of the patient within their physical reach. Place more targets in the missing or neglected visual field, but make sure there are at least a few targets in all fields (Figure 4).
2. Depending on the patient's ability level, either verbally call out the color or the shape and have the patient touch the called out target, or show the patient a picture (in primary or slight downgaze) of the target and have them touch the target. It is very important to encourage reaching and touching of the target in order to provide the motor stimulation that aids in the development of the visual-motor map of space, especially in patients with visual neglect.
3. Give the patient clues verbally and/or physically by waving your hand in the general location of the target if the patient is unable to locate the target. The movement of your hand will help increase awareness of the neglected space.
4. Encourage the patient to visualize the full visual field.
5. Encourage the patient to verbalize.
6. To make the exercise more challenging, add a cognitive demand. While the patient is searching for the targets, have him/her do math problems or spell words.
7. Perform the exercise timed and encourage increased speed.
8. Decrease the motor component of reaching and touching as target localization improves.

### Procedure 2: (Card Scanning)

1. Have the patient sit or stand about 10 feet in front of a large uncluttered wall. Spread a group of targets (can be memory game card pictures, playing cards, word flash cards, math problems, etc. based on the patient's performance and cognitive level) on the wall in front of the patient. Place more targets in the missing or neglected visual field, but make sure there are at least a few targets in all fields.
2. Have the patient hold a matching set of targets (memory card matches, corresponding suits of playing cards, or answers to math problems) in their hands.
3. Have to patient turn up a card in their hand and then visually locate its match on the wall.
4. Give the patient clues verbally and/or physically by waving your hand in the general location of the target if the patient is unable to locate the target.
5. Encourage the patient to visualize the full visual field.
6. Encourage the patient to verbalize.
7. To make the exercise more challenging, add a cognitive demand. While the patient is searching for the targets, have him/her do math problems or spell words. Make sure the cognitive demand does not deter significantly from visual scanning performance.
8. Perform the exercise timed and encourage increased speed.
9. Add forward and backward walking and/or add a balance board or beam.

### Visual Perceptual Speed

It is important for brain injured patients, especially those with a hemianopic visual field defect, to have good visual perceptual speed. Even after scanning training, these patients will require more saccades to view their full field than a person with a full visual field. Therefore, a hemianopic patient must spend additional time and energy scanning their environment and must have good visual perceptual speed and visual-spatial

awareness to process this information. A good therapeutic rehabilitation program will address and train both ventral stream processing (“what is it” analysis) for stationary flashed targets and dorsal stream processing (“where is it” analysis) for moving targets. The following therapeutic activity is an example of ventral stream processing using flashed stationary targets.

### Tachistoscope:

A tachistoscope is a device that displays an image for a specific amount of time. Many tachistoscope machines or computer based programs display the image for a very brief period of time: a short flash, often 1/10 to 1/100 of one second (Figure 5). For patients functioning at a lower level, or if a tachistoscope instrument or program is not available, manual flash cards can be used.

1. The tachistoscope flash technique can be performed at either a near working distance or a far working distance. Have the patient sit in a chair with both feet flat on the floor or stand in a comfortable position.
2. Flash an image or series of images, numbers, letters, words, etc. based on the patient’s current ability level.
3. Encourage the patient to visualize the image as a whole picture, not individual parts, and to rely on the visual image to verbally repeat the targets flashed. If the patient has a visual field defect or visual neglect and misses targets, verbally encourage the patient to scan visually.
4. As the patient’s success improves, decrease the flash time, add more images, and increase the cognitive load.
5. Add forward and backward walking and/or add a balance board or beam.
6. Have the patient write or draw the image seen instead of verbally repeating it.
7. Have the patient repeat or write the image in reverse; this encourages visualization of the image.
8. Add a visual-spatial demand by placing an “x” on a grid and have the patient describe where the “x” was placed. Add multiple grids.

### Conclusion

By employing the above visual spatial exercises within a full scope vision rehabilitation program as part of a multidisciplinary rehabilitation program, optometrists, vision therapists, and other members of the rehabilitation team can improve the quality of life and the ability to perform activities of daily living for brain injured patients. By maximizing the recovery for these patients, we can improve the likelihood of successful return to active participation in society with return to the workplace and independent transportation, thereby reducing the economic and social burden of ABI on society.

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# VISIONBUILDER

## A windows based vision therapy program

In addition to all the functionality of ReadFast (a guided reading program that displays text/stories to be read in a moving window), VisionBuilder offers many additional features including some binocular activities using red/blue glasses and an ocular motor drill with a directionality component. Includes a metronome and the following activities: Comprehension Test, Moving Window, Recognition, Track Letters, Reaction Time, Binocular Reading, Visual Memory, Randot Duction, See Three Pictures and Jump Duction. Available in 2 versions, the Office Version is licensed for use on multiple computers within one optometric office and can track the progress of each patient. The Home Version is licensed for use on one computer. Includes instructions and pair of red/blue glasses.



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