A Hierarchical Model for Evaluation and Treatment of Visual Perceptual Dysfunction in Adult Acquired Brain Injury, Part 2

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A framework for evaluation and treatment of visual perceptual dysfunction in adults with acquired brain injury is presented. The framework is based on the concept of a hierarchical structure of perceptual skill levels that interact and subserve one another. Higher level skills in the structure evolve from the integration of lower level skills and are subsequently affected by disruption of the lower level skills. Oculomotor control, the visual fields, and visual acuity form the foundation skills in the framework, followed by visual attention, scanning, pattern recognition, memory, and visual cognition. The order of evaluation and treatment is dictated by the framework. Emphasis is placed on identification and remediation of deficits in the lower level skills that will cause spontaneous improvement of higher level skills. Three treatment principles and five training guidelines are presented that reflect this concept. Specific examples of treatment tasks are provided.

The purpose of evaluation is to guide the clinician in developing treatment strategies that will improve the patient's ability to functionally adapt to the environment and successfully complete daily living skills. The commonly acknowledged principle governing selection of clinical evaluations is to include in a test battery only those evaluations that provide information on how to structure the treatment program to improve functional adaptation. Although this principle is well understood and accepted, it is not standardly implemented in visual perceptual evaluation. In practice, rather than being selective, clinicians tend to create broad-based batteries containing a wide assortment of unrelated perceptual tests. The rationale given for this approach is a desire to be comprehensive, but the real reason may be that clinicians are uncertain as to which perceptual skills will be affected by brain injury, how the skills relate to one another, and how they affect functional performance. Clinicians compensate for their lack of knowledge by evaluating all areas that may affect perception, hoping that this shotgun approach will uncover a significant deficit if one exists. However, the end result of this approach is usually an accumulation of unrelated bits of data that must be sorted out and somehow correlated with each other and with the functional difficulty that the patient is experiencing.

Evaluation tools are often selected on the basis of familiarity. Few clinicians can state why they chose a particular evaluation over another or how they use the information from the evaluation to structure their treatment program. The standard rationale given is that a certain test is used "because we've always used it" or "because so-and-so uses it." The hidden danger in this plan is that much of the testing available to clinicians is designed to reflect what Toglia (1989) referred to as a deficit-specific approach to perceptual evaluation. This approach seeks to relate the observation of a deficiency in task performance to a specific type of perceptual deficit. For example, inability to complete an embedded figures test would indicate a deficit in figure-ground ability. According to Toglia, the limitation of this approach is that "it equates difficulty in performance of a specific task with a deficit [and in doing so]...does not consider the underlying reasons for failure or the conditions that influence performance" (p. 588). Effective treatment planning according to Toglia requires "understanding of the underlying reasons for a difficulty as well as delineation of the conditions that influence performance" (p. 588). This understanding cannot be achieved simply by categorizing the deficit performance.

The advantage of applying a visual hierarchy framework to the evaluation process is that it provides a rationale for the selection of evaluation tools that focuses on the underlying causes of the deficiencies observed in the patient's performance. The framework identifies the critical skills needed for visual perceptual adaptation. Tests can
then be selected that most effectively and efficiently measure these skills. The framework also provides a structure for the evaluation process indicating the order in which the tests should be given, beginning with evaluation of the foundation skills. The following sections describe evaluations that can be used to assess performance of the skill levels in the hierarchy.

**Evaluation**

**Evaluation of the Foundation Skills**

Use of a visual hierarchy framework dictates that evaluation begin by focusing on the integrity of the foundation skills: visual fields, visual acuity, and oculomotor function. The research discussed in Part 1 of this paper has shown that deficits in the foundation skills are common after brain injury and that when they occur, insufficient information regarding the location and features of objects in the environment is sent to the central nervous system. Without an accurate visual representation of the environment, the brain is deprived of critical information needed to formulate decisions and adapt to the environment. Subsequently, the quality of any learning occurring through the visual channel will be severely affected (Sergent, 1984).

**Visual History**

The starting point for evaluation of the visual system is an interview with the patient or family regarding significant visual history. Many patients have premorbid visual conditions that will seriously affect their present visual function. Conditions such as congenital strabismus (which may or may not have been surgically corrected in childhood), amblyopia, ocular trauma, or retinopathy associated with diabetes mellitus and hypertension can compromise visual acuity and oculomotor control. With older adults, special attention must be paid to the disease processes that affect vision. Statistics indicate that 7.8% of all adults past the age of 65 years experience low vision secondary to age-related diseases such as macular degeneration, diabetic retinopathy, glaucoma, and cataracts (Nelson, 1987). In cases of head trauma, the patient may have sustained an injury to the eye or cranial orbit concurrent with the brain trauma. Orbital fractures can result in restricted range of motion of the eyes and diplopia. Direct trauma to the eye can result in optic atrophy, retinal detachment, cataracts, glaucoma, corneal scarring, chorioretinal scarring, and so on. Accurate identification of these conditions is necessary to define the visual limitations the patient will experience and to determine whether treatment interventions will be successful.

**Visual Field Deficits**

Traditionally, the presence of visual field deficits has been identified clinically by use of a confrontation test. The examiner faces the patient and introduces a visual stimulus in the periphery while the patient fixates on the examiner's face. Detection of stimuli in the four visual quadrants is measured and the parameters of the seeing field are defined on the basis of positive and negative responses from the patient. Trobe, Acosta, Krischer, and Trick (1981) compared the results of a variety of confrontation techniques with those from a Goldman perimetry test to determine the accuracy of confrontation testing in identifying field losses in patients with chiasmal and optic nerve lesions. They found that standard kinetic and static finger confrontation methods were accurate in identifying only 42% of the field deficits in the visual fields. They concluded that finger confrontation is too insensitive a measure to stand alone as the single test for quantifying the visual field and is useful only as a means of alerting the examiner to gross deficits.

The most accurate method for measuring the visual fields is perimetry. Various forms of perimetric testing have been used by vision specialists for years to quantify the visual fields. The earlier manual or semiautomatic forms of testing required considerable examiner skill and patient cooperation to elicit reliable test results. For this reason, only limited perimetric testing has been completed on persons with brain injuries. Computerized automated perimetry, clinically available since the late 1970s, requires less examiner expertise and patient cooperation. The testing equipment, although relatively expensive (the average cost of low-end models is approximately $5,000 to $10,000), can be operated by occupational therapists to measure visual field deficits. Two patterns of visual deficits identified in patients with brain injuries are illustrated in Figures 1 and 2. The evaluations were completed with a Bio-rad Cambridge Perimeter1. The advantage of automated perimetry is that it provides the clinician with an accurate, easily interpreted description of the visual field deficit that can be used to identify potential problems in activities such as driving and reading. The grayscale printout (see Figures 1 and 2) is also an effective tool for educating the patient and family as to the location and size of the deficit.

Despite the numerous advantages in using automated perimetry, there are limitations that affect the type of patient populations on whom the unit can be used. A certain level of concentration and ability to sustain concentration are needed. The test requires approximately 4 to 7 min of sustained concentration during evaluation of a normal field and up to 15 to 20 min of concentration on fields with significant deficits. Although the patient can be given numerous rest periods during the test, he or she must be able to remain alert and to cooperate for that period of time. Patients with fluctuating levels of arousal cannot be accurately evaluated. In addition, the patient

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1Manufactured by Bio-rad, 237 Putnam Avenue, Cambridge, Massachusetts 02139.
must be able to respond to the stimulus within 1 to 3 sec of presentation and must be able to respond by pushing a button with a thumb or finger. Although the more expensive models can increase the length of stimulus presentation and the patient’s response time, in general, patients with motor planning deficits and significantly delayed motor reactions cannot be accurately tested. Automated perimetry is most useful for clinicians who treat persons with mild to moderate brain injuries in either an outpatient clinic or a rehabilitation center.

For clinicians who do not have the financial resources for a perimeter or whose patients would not be appropriate for the test, a combination of confrontation testing and careful observation of the patient in performing daily activities provides useful information regarding field integrity. Changing head position when asked to view objects placed in a certain plane, consistently bumping into objects on one side, or drifting toward one side may indicate a field deficit, particularly if other behavioral signs of visual inattention or neglect are not present. Consistent paralexic reading errors, such as missing or misreading the beginning or ends of words or misreading numbers, may indicate the presence of a central field deficit.

Visual Acuity

Evaluation of visual acuity has already been mentioned in the discussion on contrast sensitivity function testing. Contrast sensitivity function testing is available to the clinician in several forms including both pediatric and adult formats. The test is simple, quick to administer, and does not require verbal responses, thus it is an appropriate tool for persons who have difficulty speaking. The advantage of the test over standard acuity tests, as discussed in Part 1, is that it provides a more comprehensive description of the patient’s visual capability in the environment than do standard acuity tests. Information is obtained about the patient’s ability to perceive objects of low and intermediate contrast, which is more typical of the environment that the patient must negotiate in daily living situations. The test assists the clinician in identifying visual acuity deficiencies in patients who complain of blurry or “not quite right” vision but who present with normal acuity on a standard test. By knowing the acuity limitations of the patient, the clinician can enhance the patient’s performance by increasing the contrast and illumination of critical environmental features.

Oculomotor Function

As stated in Part 1 of this paper, the control of eye movements relies on a complex integration of cortical and subcortical commands. A number of factors can therefore disrupt the control of eye movements after brain injury. Much skill and expertise is needed to diagnose the exact cause of the dysfunction observed clinically. Because of the complexity of oculomotor dysfunction, Gianutsos and Matheson (1987) and others (Bouska, Kaufman, & Marcus, 1990; Cohen & Soten, 1981; Cool, 1987; Gianutsos, Perlin, Mazerolle, & Trem, 1989; Gianutsos, Ramsey, & Perlin, 1988; Padula, Shapiro, & Jasins, 1988; Ratcliff, 1987) advocated for a partnership between therapy services, ophthalmology, and optometry in the evaluation and treatment of oculomotor dysfunction in patients with brain injuries. Because the occupational therapist is often the first member of the rehabilitation team to observe the deficit, his or her role is to uncover the problem and obtain appropriate evaluation from a vision specialist. The purpose of an oculomotor screening completed by a therapist is not to diagnose the deficit but to describe its
According to Leigh and Zee (1983) eye movements constitute measurement of eye alignment, binocular fusion, range of motion, fixation, localization, and control. Simple screenings that can be effectively used by clinicians to assess oculomotor control have been described by Bouska et al. (1990) and others (Cohen & Soten, 1981; Gianatsos et al., 1988; Neger, 1989).

Eye alignment can be most easily measured in the clinical setting by observation of the corneal light reflex in the eyes (Neger, 1989). This test, known as the Hirschberg technique, consists of asking the patient to fixate on a pen light and then observing the reflection of the light on the corneas of both eyes. When the eyes are properly aligned, the reflection will appear in same location on each pupil. If one eye is deviated inward (esotropia), the corneal reflection will located towards the lateral side of the pupil in that eye. If the eye is deviated outward (exotropia), the reflection will be located in the medial side of the pupil. Heterotropias can also be detected with a cover test. In this test, the patient is asked to focus on a centrally presented target. A cover is then quickly imposed on one eye while the examiner observes the uncovered eye to determine whether it moves to take up fixation. Movement of the uncovered eye indicates that it was not aligned with the fixation target and the presence of a tropia. No movement indicates that the eye was aligned with the target. The test is then repeated with the other eye (Pavan Langston, 1985).

Measurement of ocular pursuits provides an indication of how well the eyes are able to work together. According to Leigh and Zee (1983) eye movements consist of two basic types: (a) movements that change the line of sight and (b) movements that maintain a steady image on the retina. Eye movements that change the line of sight are known as saccades. The purpose of a saccade is to focus the object under scrutiny on the fovea of the eye (the area used for processing of visual detail). Saccades can be measured clinically when the patient alternates fixating between two objects held approximately 6 in. apart and 16 in. from the bridge of the nose. The patient should be able to smoothly shift gaze between the two objects. Difficulty initiating or executing saccades may indicate extraocular, metabolic, or central neural dysfunction (Leigh & Zee, 1983).

Smooth pursuit eye movements are designed to maintain a steady image on the retina and are measured when the patient attempts to track a moving object. A penlight or target is moved through the nine cardinal gaze positions as the patient fixates on the target. Observations are made regarding speed, coordination, and range of motion of the eyes. As with saccadic eye movements, deficiencies in performance can be due to a number of factors, including neuromotoric strabismus, mechanical restrictions, disruption of central neural control, and ocular injuries (Leigh & Zee, 1983; Neger, 1989). In addition to pursuit movements, the patient's ability to execute vergence movements of the eyes should also be evaluated. Convergence is tested when the patient follows a penlight inward as it approaches the bridge of the nose until it reaches the near point of convergence, which is the distance from the nose where convergence is broken. In persons with normal visual control, the near point of convergence is approximately 3 in. from the bridge of the nose. However, research (Cohen, Gros- wasser, Barchadski, & Appel, 1989; Neger, 1989; Padula, 1991) has shown that persons with head trauma often break convergence at a much greater distance. Convergence insufficiency results in difficulty in achieving and sustaining focus on near vision tasks.

When ocular alignment and extraocular control are affected, the primary visual complaint of the adult patient is the presence of diplopia (double vision) or asthenopia. The occurrence of a double sensory image will create stress and confusion as the visual system tries to assimilate the two images. In response, the central nervous system will attempt to reduce the confusion by eliminating one of the images. The patient will frequently adopt a head position that eliminates the second image. For example, a patient with a right lateral rectus palsy may rotate the head toward the left to avoid the action of the lateral rectus; likewise, a patient with paresis of the superior oblique may tilt the head downward to avoid the action of that muscle. Therefore, tilting or turning the head in a certain position may not indicate poor head control in the strabismic patient so much as an adaptive maneuver initiated to avoid visual confusion (Neger, 1989). This possibility means that the clinician must carefully evaluate both neuromotor and visual contributions to head control.

If there is a tendency for deviation of the eyes (heterophoria), the patient may be able to keep the eyes in alignment until fatigued. The heterophoric patient may never complain of diplopia or may complain only when the central fusional control mechanisms are overcome by fatigue of the extraocular muscles, as may occur if the patient is required to do extended periods of reading or other activities requiring sustained focusing. Alcohol and other depressants can also unmask the presence of a phoria. The patient will often resist performing activities that stress the fusional control mechanism and make it more difficult to maintain focus. Complaints of headaches or mental fatigue when the patient is forced to use the
eyes binocularly for extended periods of time are also common. Phorias can be detected clinically with a cross cover, or cover-uncover, test (Pavan Langston, 1985). The patient is asked to fixate on a centrally placed target. A cover is then quickly introduced over one eye for 2 to 3 sec and then over the other eye. Observation is made as to whether the eye under cover moves to take fixation when the cover is removed. No movement of the eye when it is covered and then uncovered indicates that the eye is aligned. Movement of the eye medially when it is uncovered indicates the presence of an exophoria; movement laterally indicates the presence of an esophoria. A small amount of phoria is a common finding in nondysfunctional persons; larger, latent deviations are a symptom of oculomotor dysfunction.

The final areas of assessment should include subjective observation of the patient’s ability to locate and fixate on a target presented in various locations in the visual field. The examiner holds up a target and asks the patient to visually locate the target, fixate on it, and then hold right of midline at near (16 to 20 in.) and middle ranges (21 to 36 in.). Difficulty localizing and fixating on a target can have several causes. Reluctance to initiate eye gaze toward the contralateral field has been associated with parietal lobe lesions (DeRenzi, 1982; Pierrot-Deseilligny, Gray, & Brunet, 1986; Leigh & Zee, 1983). Research (Leigh & Zee, 1983; Mesulam, 1981; Simon, Aminoff, & Greenberg, 1989) has also shown that patients sustaining injury to the frontal eye fields will have difficulty initiating and fixating eye movements toward the contralateral field of vision. Conditions that affect macular acuity, such as macular scarring, optic atrophy, and vitreous hemorrhage may also reduce fixation ability (Leigh & Zee, 1983).

Formal evaluation should be augmented with careful observation of patient behavior during different tasks because certain behaviors can also signal the existence of an oculomotor deficit. Important observations include the patient shutting an eye, squinting, turning away or closing the head on specific tasks; an increase in muscle tone in the jaw, neck, or shoulders on certain tasks; and changes in head positioning during ambulation, sitting, or standing. Other pertinent symptoms include complaints of headache or fatigue or the sudden appearance of agitation or uncooperative behavior when a task is presented, especially if the symptoms appear to vary with the distance at which the task is presented. It is particularly important that the clinician be aware the oculomotor dysfunction can elicit these behaviors, such behaviors commonly are attributed solely to deficits in cognition or emotional control. Overlooked, these correctable oculomotor deficits can exaggerate the actual cognitive or emotional deficits that exist.


Once thorough evaluation of the foundation skills has been completed, the intermediate skills of visual attention and scanning should be addressed. Although separate skills, the two function together so closely that clear distinction between them is difficult to obtain on a clinical test. The two skills are therefore standardly tested together. A number of tests used in research to identify deficits in visual attention and scanning can be successfully adapted for clinical use. Two of these tests, letter cancellation and line bisection, have been shown to be particularly sensitive to the presence of visual attention or scanning deficits. The letter cancellation test consists of single lower or upper case letters arranged in rows on a page. A target letter is identified and the patient is asked to draw a line through each target letter appearing on the page. Research (Weinberg, Pharesky, Diller, & Gordon, 1982, Weinberg et al., 1979; Wilson, Cockburn, & Halligan, 1987) has shown that patients with hemi-inattention will restrict scanning to the side of the page ipsilateral to the lesion (the sound side of space) and subsequently will fail to cancel letters on the side of the page contralateral to the lesion (the involved side of space). An asymmetrical performance on the test is indicative of a deficit in visual attention. In the line bisection test, horizontal lines are placed on a page and the patient is asked to draw a line through the center of each of the horizontal lines. Again research (Schenkenberg, Bradford, & Ajax, 1980; Wilson, et al., 1987) has shown that persons with hemi-inattention will fail to bisect lines in the middle and instead will displace the line toward the side ipsilateral to the lesion (the sound side). The advantages of the tests to the clinician are that they are simple to administer, require minimum time expenditure in presentation and grading, and provide an easily interpreted measurement of the integrity of visual scanning and attention.

The research of Weintraub and Mesulam (1988) suggests that visual scanning and attention should also be measured with an unstructured visual array to determine whether the person is able to employ the higher level strategy of imposing structure on an unstructured array. Scanning tests that present an unstructured array include the slash the line test of Albert (1973), the computerized test, REACT, developed by Gianutsos and Matheson (1987) and the scanboard test by Warren (1990). All three tests are simple to administer and provide useful observational data on the strategy the patient uses to scan a visual array. Use of the unstructured tests in conjunction with those that present stimuli in a structured array will clearly indicate the severity and nature of the patient’s deficits in visual attention and scanning.

For clinicians who require a standardized test, Wilson et al. (1987) combined a variety of functional tasks requiring visual scanning and attention with conventional visual scanning tests into a structured battery called the Behavioral Inattention Test (BIT). By combining functional tasks with conventional tests, the BIT provides a comprehensive description of the patient’s deficits and their...
possible effect on performance of daily living activities. Validity of the BIT as a sensitive measurement of visual inattention was established in research comparing post-cerebrovascular accident patients with matched controls (Wilson et al., 1987).

Evaluation of the High Level Skills: Pattern Recognition, Visual Memory, and Visual Cognition

The final area of evaluation involves the high level skills of pattern recognition, visual memory, and visual cognition. Although these skills, especially those of visual cognition, traditionally have been the focus of evaluation, application of a hierarchical framework would suggest that such evaluation may not be needed. Research has shown that the integrity of higher level skills in the visual hierarchy is dependent on integration of the lower level skills. Thus, a deficit in a lower level skill will produce corollary deficits in higher level skills. Deficiencies in higher level skills are the end products of deficits in the skills subserving them, just as the inability to tie a necktie can be viewed as the end product of upper extremity paralysis. It may not be necessary to spend evaluation time analyzing the existence of deficits in these higher level skills because evaluation of the lower level skills will explain the deficits observed and provide more direct and useful information for treatment planning.

There may be occasions when evaluation of higher level cognitive skills is relevant and will provide useful information to the clinician, especially with higher functioning patients. But when evaluation of visual cognition is undertaken, clinicians must be aware that they cannot accurately interpret information gained from these tests without first completing thorough evaluation of the foundation skills to determine the influence these skills will have on the patient's visual cognition. Exclusive evaluation of the visual cognitive skills without testing of foundation skills, as has been traditionally emphasized, will place the clinician in the position of blindly interpreting the patient's behaviors and will provide little useful information for treatment planning.

Gianutsos and Matheson (1987) raised this issue in a review of 94 articles published on testing procedures for measuring visual perceptual deficits after brain injury. The most popular tests reviewed were variations of matching and copying tests. Gianutsos and Matheson found several limitations in the testing procedures chosen, the most problematic of which was "that the most widely used tasks are poorly understood, either in terms of underlying cognitive processes or in terms of applicability to the demands of daily living" (p. 211). Most of the traditional tests chosen are, according to Gianutsos and Matheson, "often complex...themselves [and] require explanation. All too often they are used for clinical assessment and then offered as explanations [for behavior]" (p. 213). Abreu and Toglia (1987) also addressed this issue, stating that standardized cognitive perceptual evaluations emphasize normative comparisons between persons with brain injuries and their noninjured counterparts. The performance scores derived from these test "are useful in determining the presence and severity of dysfunction but...reveal little about the patient's functioning" (p. 442).

Clinicians must remember why they perform evaluations. The patient comes to the clinician with a diagnosis of brain injury already confirmed by sophisticated medical procedures such as a computerized tomography scan or magnetic resonance imaging. Further documentation that the patient performed poorly in a certain skill area compared with his or her peers as a result of the brain injury is not necessary. What is necessary is to determine where the patient's strengths and weaknesses lie in the visual system and how the weaknesses can be minimized and the strengths exploited to enable the person to best adapt to the environment. Therefore, the purpose of a clinical evaluation is, as Abreu and Toglia state, to provide a picture of the patient's residual abilities. Testing that primarily provides a vehicle for careful observation of the patient's skills and procedures that allow maximum flexibility in manipulating test materials to bring out the patient's best performance will be the most useful to the clinician for designing treatment intervention. Little emphasis should be placed on scores and normative comparisons; great emphasis should be placed on how the patient approaches the presented tasks and which type of cues provide the greatest benefit to performance. The danger of using standardized cognitive testing in this area is that the test can sometimes take on a life of its own and the giving of the test can become more important than the quality of information it provides.

Treatment

Although the research devoted to identifying the existence and nature of visual deficits after brain injury is extensive, that exploring the effectiveness of treatment is sparse. The research that does exist suggests that treatment must consist of a combination of remediation and compensation or what Neistadt (1990) referred to as remedial and adaptive. A remedial approach focuses on the deficit identified and attempts to diminish it through direct intervention to improve performance in that area. An adaptive or compensatory approach concentrates on the person's residual abilities and attempts to exploit them to minimize the influence of the deficit area. Both approaches are valid treatment options, as some aspects of visual dysfunction appear to be amenable to direct treatment intervention and others require a level of central nervous system processing so refined that remediation is not possible when serious injury has occurred. The best intervention strategy incorporates both approaches.
Treatment Principles

A review of the available research suggests three general principles for effective treatment intervention. The first principle is to remediate or minimize the sensory deficit. Treatment in this area is directed toward deficits occurring in the foundation skills of visual field, acuity and oculomotor control. Maximization of these skills is critical because visual awareness must be present for higher level visual processing to occur. Research has shown that some remediation of foundation skill is possible. Zihl (1980, 1981) and Zihl and Von Cramon (1979, 1982, 1985, 1986) have demonstrated that deficits in the visual fields can be decreased with intensive stimulation of the blind hemifield and Pommerekenke and Markowitsch (1989) showed that compensation for visual field deficits can be increased with training. Ron (1981) and Kommerell, Oliver, and Theopold (1976) have shown that some aspects of oculomotor control can be improved through training exercises. When remediation is not possible, assistive devices can be used to minimize the deficit. Visual acuity can be maximized with refractive lenses. Rossi, Solomon, and Reding (1990) have demonstrated that compensation for spatial neglect and field deficits can be increased with the application of Fresnel press-on prisms. Padula (1988, 1991) has shown that, postural adaption, visual orientation, and attention can be improved with the application of prisms and selective occlusion. Manipulations of the environment, such as increased contrast of critical features needed for orientation or the improvement of lighting conditions to enhance visual acuity, will also help minimize the effect of the visual deficit.

The second treatment principle involves education of the patient to increase awareness of the deficit. According to Levine (1990), persons with sudden sensory loss do not experience immediate awareness of their deficit. Awareness is gained instead through a gradual process of self-observation and inference as the person discovers the limitations imposed by the loss. Levine reported that lack of awareness after the sudden onset of hemianopsia is a common occurrence even in persons with no intellectual dysfunction. Several cognitive mechanisms operate to automatically compensate for the insensitive fields and create the false illusion of vision. These mechanisms enable a person with hemianopsia to experience a complete form even when part of the form falls in the unseen fields (Sergent, 1988). Although a person may be unaware of a visual limitation, his or her actions will indicate that it is present. Thus the person may run into walls, fail to find food on a plate, commit reading errors, and so on. The person will often attribute these errors to other causes, such as poor lighting or a faulty wheelchair. Evaluation tools that provide graphic illustrations of the effect of the deficit can facilitate education of the patient and family. Data such as the grayscale printout provided by an automated perimeter that depicts the deficit area in the visual fields, or an asymmetrical performance on the letter cancellation test, furnish simple straightforward evidence to the patient and family of the existence of a deficit.

Gianutsos and Matheson (1987) contended that for compensation to occur, patients must be made aware that the deficit exists and experience that their senses are no longer reliable. Awareness of the deficit enables the person to develop what Gianutsos and Matheson described as "intellectual override" in planning for situations, such as driving or reading, where compensation for the deficit is needed. Weinberg et al. (1979) and Diller et al. (1974) demonstrated that, once aware of the deficit, persons with visual neglect are able to learn effective strategies to compensate for hemifield inattention in academic activities and self-care.

According to Toglia (1991), patients with brain injury do not spontaneously recognize their limitations and the need to compensate. Their concept of their capabilities is based on premorbid experiences and may cause these patients to overestimate their abilities after injury. Without a true understanding of their limitations, patients may be unwilling to employ compensatory strategies. To increase insight, Abreu and Toglia (1987) advocated teaching a patient how to monitor and control performance by learning to recognize and correct errors in performance. Giving the patient immediate feedback about his or her performance and pointing out deficiencies facilitates this process, as does teaching the patient to use self-monitoring techniques such as activity prediction, in which the patient predicts how successfully he or she will perform an activity and identifies the aspects of the activity where errors are likely to occur. The patient then compares his or her actual performance with the predicted performance. Use of this technique helps the patient develop anticipatory skills and increased awareness of how the deficit will affect his or her functional capabilities. Pacing and stimulus reduction are other self-monitoring strategies recommended by Abreu and Toglia. Pacing involves teaching the patient to slow down when performing an activity so that the central nervous system can completely process the information being presented. Stimulus reduction involves decreasing the amount of visual stimulus that must be processed; for example, removing the clutter on a desktop, increasing the font size and spacing of text on a page of written material, or restricting driving to quiet residential streets.

The third treatment principle is to institute consistent systematic training to develop compensation strategies for the deficit. The one characteristic shared by the studies that achieved a measure of success in treatment was implementation of a regular systematic treatment protocol (Diller et al., 1974; Diller & Weinberg, 1977; Gordon et al., 1985; Rao & Bieliauskas, 1983; Weinberg et al., 1979; Weinberg et al., 1982; Gordon et al. (1985)) found that the more complex the perceptual and organizations aspects of a task, the more the task must be
practiced to develop adequate skill consolidation. Visual skills, especially the higher level skills of attention, scanning, memory, and cognition, must be overlearned to ensure consistency in execution. Use of an interdisciplinary approach to treatment is one of the most effective ways to increase consistency. Each discipline working with the patient will encounter different functional limitations imposed by the deficit, and therefore an opportunity to practice adaptive and remedial strategies. To be successful, however, there must be consensus between the disciplines on the approach to be taken toward treatment, so that the patient does not receive conflicting instruction in compensatory strategies.

**Training Guidelines**

From these general treatment principles, specific training guidelines can be derived to direct the design of the treatment protocol and selection of therapeutic activities. In reviewing the pattern of visual deficits observed after brain injury, one can see that the majority of deficits will occur in the foundation skills and those just above them in the hierarchy: the skills of visual attention and scanning. Unfortunately, the limited scope of this paper does not permit discussion of the extensive training techniques applicable to remediation of the foundation skills. Only the areas of visual attention and scanning will be addressed. In treatment of deficiencies at these skill levels, four training guidelines can be used to direct the selection of treatment activities. The guidelines are not skill specific, but are directed toward establishment of strategies that promote reorganization of attention and scanning.

The first training guideline is from research by Weinberg et al. (1979). They studied the effect of training on improving visual scanning in patients with left visual neglect. Fifty-seven subjects with acquired right brain injury and mild to severe visual neglect were divided randomly into experimental and control groups. The experimental group received 20 hours of a specific training regimen focusing on increasing visual scanning to the left. The control group received standard rehabilitation including daily occupational therapy treatment. The training regimen provided to the experimental group included use of anchoring techniques (see Figure 3) to reorganize the strategy used to scan a confined space and use of a scanning device specially designed for the study. An organized left-to-right scanning pattern starting in the impaired space was emphasized and reinforced in all activities. Each subject was taught to consciously begin scanning on the involved side to compensate for the neglect and reorganize the scanning pattern. On completing the training period, both groups were reevaluated on the test battery given before implementation of treatment. In the experimental group, 65% of the subjects with severe neglect and 55% of those with mild neglect improved on 3 out of 4 of the tests on the battery. In contrast, only 11% of the subjects with severe neglect and 17% of the subjects with mild neglect in the control group showed similar improvement on the test battery. Weinberg et al. attributed this success to their ability to make the experimental subjects aware of their visual deficit and then give them a systematic method to overcome it. The training guideline derived from this study trains the patients to reorganize their scanning strategy by beginning the scanpath in the impaired space.

The second training guideline functions as an adjunct to the first. Weinberg et al. were able to successfully reorganize the strategy used to scan a confined space and in so doing improved their subjects’ performance on academic tasks. However, they did not observe a carryover of this strategy when subjects were scanning a broad visual space, as is needed for extrapersonal orientation to the environment. This finding is not surprising, given what is known about the limited generalization skills of persons with brain injuries (Toglia, 1991). Because many of the life skills occupational therapists work on with their patients require orientation to a broad visual space, the second training guideline is to broaden the visual field that the patient scans as much as possible. The working field should be large enough to require the patient to either turn the head or change body positions to accomplish the task. An activity incorporating these first two training guidelines is illustrated in Figure 4.

The third training guideline is to reinforce the visual experience with a sensorimotor experience. Research on sensory coding has shown that integration of visual information with somatosensory information is crucial for effective coding of the visual information (Ayres, 1972). More simply stated, a stronger, longer lasting visual image is formed within the central nervous system if what is seen is verified by tactual exploration. According to Ayres, it is through the process of tactile verification of visual
Figure 4. An activity requiring use of an organized scanning strategy. The patient must locate the beginning of each row of numbers by finding the anchoring line on the left side and then reading the numbers across. Pointing to each number as it is read helps to pace the activity and ensure that the patient scans efficiently.

Gianutsos and Matheson (1987) reported that they were able to improve reading accuracy in patients with left visual neglect by teaching them to slow down and carefully study each word. The key to success, they contend, is to make sure that the patient actually sees the word or object being viewed. Toglia (1989), similarly advocated teaching patients to double check their interpretation of a visual scene to make sure that critical details are not missed. Matching tasks can be effectively used in training patients to inspect scenes for detail (see Figure 6).

The final training guideline is to practice the skill within context to ensure carryover of application to daily living activities. The activities illustrated in the figures provide a starting place for the therapist to begin reorganizing the strategies needed for successful visual integration. However, research has shown that patients with brain injuries generally do not spontaneously transfer skills from one learning situation to the next (Toglia, 1991). Toglia suggested that transfer of learning can be
facilitated when the patient applies the strategy in different contexts of daily living. For example, the patient can be required to use the strategy of initiating the scanning pattern in the impaired space when selecting clothes from a closet, searching for items in a refrigerator or on a shelf, shopping for groceries, reading, and driving. The more repetition of the strategy the patient experiences under varied circumstances, the more he or she is able to generalize the skill and transfer it to new situations. There is no substitution in therapy for the practice of real-life situations in assisting the patient to develop insight into abilities and compensate for limitations.

As in all treatment, the therapeutic activities selected must be graded in terms of difficulty to ensure that the patient is challenged but not overwhelmed by the demands of the task. Careful task analysis will indicate the potential difficulties. The patient should be made aware of where the challenges lie so he or she can prepare for them. This awareness will not only increase the patient’s chance of success on the task but will also increase awareness of limitations. Close attention should be paid to the materials used in terms of the density, structure, and speed at which stimuli are presented, and these parameters should be manipulated to facilitate performance. At least a portion of treatment should center on how to make the patient’s environment and daily demands more user-friendly to enable easier compensation for deficits. It is paramount that the therapist remember that the goal of treatment is successful adaption to the environment, whether that be accomplished by remediation of the deficit or by compensation for it.

Although the treatment and training principles described are directed primarily toward the lower level skills in the hierarchy, application of the hierarchical framework would indicate that this is sufficient. Reorganization and enhancement of these skills provides a firm basis for employment of the higher level skills of visual cognition and memory needed to effectively adapt to and manipulate the environment. Although discrete lesions primarily affecting integration of the highest order visual skills may be possible, the vast body of current research in visual perceptual dysfunction indicates that lesions affecting organization of attention, scanning, oculomotor control, acuity, and visual fields are much more common. By directing evaluation and treatment toward remediation of these lower level skills, the therapist should be able to address the cause of the visual perceptual dysfunction and obtain a more satisfactory outcome in the patient’s adaptation to the environment in work and play.

However, the truth of the preceding statement has not yet been confirmed by research. Whether or not shifting from an emphasis on the final product, visual cognition, to the foundation skills of oculomotor control, visual fields, and acuity will actually improve the patient’s adaptation to the environment remains to be objectively established. No major body of research has been applied to this area as yet. There are several reasons for the paucity of research on the efficacy of treatment. One of the most powerful may be the lack of a logical framework for understanding the organization of visual perceptual skill. Such a framework is a necessary prerequisite to the establishment of treatment protocols and a methodology for conducting research. This article proposes the framework; now the framework must be tested in the clinic to determine whether it is valid. Only the first step has been taken.

Summary

The application of a developmental hierarchy as a framework for evaluation and treatment of visual perceptual dysfunction after adult brain injury has been presented. Review of the research confirms that brain injury affects lower level skills that form the foundation for visual perception. Disruption of these skills interferes with successful execution of the skills above them in the visual hierarchy. Thus deficits in higher level skills such as visual cognition and memory may be manifestations of dysfunction at a lower level and may disappear once the deficits in lower level skills are remediated. Application of such a framework requires a fundamental change in the methods used to evaluate and treat visual perceptual dysfunction. The traditional and currently used tests of visual perception that emphasize visual cognitive skill may need to be abandoned in favor of tests such as automated...
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References


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