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Visual rehabilitation of hemianoptic head trauma patients emphasizing ambient pathways

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Abstract

When an individual experiences a head injury, trauma shatters the patient's environment as well as affecting her/his body and physiology. Visual neuro-motor functions serve as a major link between self control and the perception of the environment. Information about the visual neurological pathways and their specialized functions serve to guide visual rehabilitative therapy. The visual system proves to be a useful avenue to help the head trauma patient interact with her/his environment and more competently deal with her/his world. An individual's ability to regain stability and improved environmental perception are positively influenced by the development of visual neuro-motor control. Two patients' case summaries illustrate rehabilitation success for patients who manifest field deficit or hemianopsia.

Keywords: Rehabilitation; Head trauma; Visual-motor; Ambient vision; Focal vision; Blind-sight; Hemianopsia; Visualization

1. Introduction

With closed head injury patients, rehabilitation regimens are first centered on sustaining life. This is followed by efforts to promote improved stability and control. Post crises procedures usually are concentrated on extending ranges of movement and body control to increase the quality of life for the traumatic brain injured patient. Using the analogy of Humpty Dumpty, after the fall, everyone is trying to help put him/her together.

Neuro-rehabilitative optometry deals primarily with acquired visual deficits resulting from physical disabilities, traumatic brain injuries, and other neurological insults [1]. In addition to concerns with ocular health, optics, and ocular control limitations, our major thrust in therapy is the utilization of strategies for rehabilitation of ocular neuro-motor control and visual/perceptual disorders. Many of the concepts utilized by rehabilitative optometry are procedures associated with ambient vision, the vision pathway which provides much of ocular motor control and general field awareness. Two case illustrations of trauma patients manifesting field deficits are presented to support and clarify the approach.

After any serious insult, an often overlooked or

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untreated condition is a patient's visual neuromotor control difficulties which are usually seen as visual/perceptual problems. In turn, space, distance, and time relationships all have changed [2]. In the Humpty analogy, Humpty needs help not only in repairing of self but also in repairing his shattered and unstable world.

Following trauma, an early visual experience is the phenomena that the world is displaced and crowding in upon the patient. Because of the displacement, head and eye movements are experienced as if the room, floor and the environment are shifting or unstable. Colors and brightness of color appear different and unusual. Visual cognitive attention and visual apprehension are tunneled and restricted. When attempting to discern detail, things appear doubled or 'crowded in' as if trying to appear in the same place. Thinking, moving, and reaction are all in slow motion and the patient is unable to keep up with the high speed of his world and environment. In all of this, vision is a critical link to understand and relate ones actions to the experienced environment.

Visual neurology is a bimodal process [3]. There are two major pathways of vision, ambient and focal. The ambient pathway provides general information which is necessary for reaction and survival. The focal pathway provides detailed information more related to cultural tasks and is limited to a preselected attention area. Further, the precision and usefulness of focal function requires a stable visual peripheral background, a product of the ambient pathway. In pre-primates, the two pathways are distinct and the ambient track is the major visual pathway [4,5].

The ambient visual processes for the control of movement and the awareness of sensory information is the link to understand the previously described changes. The ambient neurological visual pathway regulates ocular control, rapid wide-breadth scanning, body balance control and changes of movement. The focal pathway functions for local scrutiny and detail within a preselected defined space which requires sustained stability and balance. When the ambient function is compromised, an individual's discrimination of detail (acuity) is reduced [6]. The post trauma patient manifests obvious interference in function of normal ambient pathway processes.

To help understand the neuro-rehab optometric orientation, it is beneficial to think of vision as both a doing and a sensing process. Customary vision care is focused on the sensing aspect of vision, the ability to discriminate detail (visual acuity) straight ahead in a central confined area. In 1977, Hein [7] showed that ocular movements were the critical aspect of kittens learning eye-paw coordination after being raised in a light deprived environment. The doing processes of seeing are most frequently overlooked except when muscle control causes obvious interference with visual sharpness or acuity.

When an individual has a sudden shift in the relationship of the doing and sensing process of vision, it produces disorientation. After trauma, a patient often transfers his/her self directed eye or head movement, interpreting the recognized change as if it had occurred in the environment. There is an inconsistency in an individual's intent, the proprioception of ones' action, and in sensed stimuli producing a perceptual distortion. Perhaps the following analogy will help to clarify this idea. Assume a blind person was pointing into space and asks to what he is pointing. After being told, consider two alternative circumstances. In the first, he moves his arm and hand to another place and again asks to what he is pointing. In the second, without the man's awareness, the wind has moved his arm and he repeats the question.

In the first example, where the man knew he moved his arm (both intent and feedback), thus he should not be surprised that the second answer (sensed stimuli) was different from the first because he was aware he was pointing to a different place. In the second example, the individual would indeed be surprised that the second answer was different from the first (no intent of moving and no awareness of having moved) and accordingly could only attribute the change to an alteration in the environment. The individual in the first example knew that he had asked two different questions. The individual in the second example asked the same question twice but received two different answers. While both received different answers the first was not surprised, but the second was. The individual in the second situation did not direct the change of his hand and thus wasn't vigilant to potential change. In accordance with his experience, a logical understanding of the difference would be to transfer the observed change. The change must have taken place in the environment.

It is useful to conduct a simple experiment which allows one to experience a similar phenomena. Cover your left eye and direct your attention to an object straight ahead of you. Now change your gaze to another object to the left of the original point of fixation. Notice that when you change fixation, the environment does not appear to shift or move. Again fixate the object straight ahead of you. With your right index finger, gently move your right eye so that it is fixating on the second object. As you move your eye with your finger, you will notice that you perceive a shifting or movement of the environment. In the first situation, there was consistency between the visual motor (doing) and the visual sensory (sensing) operations. In the second there was an inconsistency because you mechanically moved your eye bypassing the visual motor process. In the first situation, you were comparing active/active processes. The second situation demonstrates passive/active processes which have been shown to be ineffective for reliable perception and making appropriate adaptation [8].

In the animal kingdom, ocular movement and visual control relate intimately to the species' movement capabilities and survival needs. An individual's level of motor skills is related to that individual's level of visual skill development and control. The homosapien species is primarily a light directed species which designates that the visual processes have preeminence. As such, the visual/perceptual performance has priority and serves as a framework for our experiential world. The human's visual neurology, using complementary and coordinating pathways, functions both to control movement and to discern information.

The ambient or midbrain visual neurological pathway is frequently overlooked or dealt with as a subservient pathway. It is the dominant pathway both for lower animals and for humans at birth. At birth the cone receptors are not fully developed or the pathway myelination completed. Thus for human beings, the ambient neuro-pathway is dominant both evolutionarily and developmentally.

When either psychological or physical trauma is experienced by humans, the midbrain (ambient) pathway becomes increasingly prevalent in the control of our actions. Along with increased sympathetic neural control, the ambient pathway dominates, allowing the individual to quickly scan wide spatial areas and direct instinctive reactive movements. It permits one to make more appropriate and instantaneous decisions necessary for mobilization to either fight or flee. The ambient visual pathway takes over because it is rudimentary and critical for survival.

2. Implications for visual rehabilitation

The implication of this knowledge serves as a basis to guide visual rehabilitative intervention. When guiding visual regimens for post-trauma patients it is consequential to recognize the important role of ocular motor control and the ambient pathway. Related areas include vision/balance relationships, control of ocular and body movement, as well as guiding ones' body through space. Other aspects are the capacity to see and comprehend space, distance, relationships and dimensionality. In all of this, the integration of an individual's perception of visual motor control related to his perceived visual sensations becomes imperative in both learning from and reacting more effortlessly to the environment.

The neurological model for guiding such intervention has been diagramed by Trevarthen [3], Liebowitze and Post [9] who described the bimodality and related the functional complementary interaction and reciprocal inhibitory cooperation of the pathways. This background is important to appreciate and understand the potency of developing refined visual motor control and the subtle use of lenses, prisms and yoked prisms to achieve such control. Additionally, it helps direct specific therapeutic regimens used by rehabilitative optometrists.

When an individual is dark adapted, the ambient pathway becomes dominant for vision functioning. Mackworth [10] demonstrated that when individuals were dark adapted and experienced a visual task overload, they lost acuity and showed both constricted and tunneled fields. In Mackworth's experiments, college students mimicked the visual response evident with post trauma patients. They too acted as if there was a 'crowding effect' [11], which arises from the lack of fixation stability, while using a global texture detection system. The effect is as if space collapsed in on itself with a compromise and interference in focal visual processing (acuity).

When deciding on a regimen of care for a head trauma patient with a lateral field deficit, it is helpful to proceed systematically. The first consideration is to evaluate the patient's level of insight of his/her field cut. When an individual manifests a field loss, he/she does not see the loss. It is most helpful to have the patient gain an awareness of the area covered by the loss as well as an ability to localize the involved area and relate it to what is viewed in the sighted field. Often the subjective feeling is that the eye on the side of the deficit 'is not seeing right'. The patient does not see the missing part of his/her field. The area is perceptually 'filled in', much like the normal physiological blind spot. Helping the patient appreciate the nature of the deficit helps to understand why one bumps into things or, when reading, does not go to either the beginning of the line (left field deficits) or the end of the line (right field deficits).

In general, the first goal is to guide the patient to develop skills to cope with his or her problem. The use of compensatory vision aids is often best delayed until after the patient has demonstrated that functional improvement is unlikely. In my experience, the first critical assessment is to evaluate the quality of ocular movement control and the extent of ocular motor fields. When the visual motor quality is good, one can anticipate a potential to develop an improved level of perceptual awareness in the deficit field. Frequently, the initial gain is the patient's ability to learn and trust the phenomena called 'blindsight' [12,13,14]. When blind-sight can be appreciated, it can lead to field expansion, complete recovery of motion and possible improved sensory fields. (I have chosen to hyphenate 'blind-sight' because it used both to describe a phenomena as well as a neural process).

To assure communication, the behavior which has been labeled as blind-sight should be clarified. Blind-sight refers to a phenomena related to individuals who manifest a complete hemianopsia but simultaneously have an awareness of near-by objects in their blind field, especially as an object approaches. Often such patients recognize object orientation with relative accuracy. Accuracy levels from eighty to ninety percent have been reported. In spite of the level of success, such patients always say they 'are guessing'. Research has demonstrated that there are measurable neurological responses in the complementary sighted field [15].

The blind-sight phenomena is not sight as we know it for such patients continue to manifest hemianopsia fields when tested. One patient I worked with, who was able to appreciate blind-sight, described his awareness as, 'While I may not have regained sight, I do have insight.'

3. Treatment strategies

In assessing treatment areas in order to guide visual rehabilitation for head injury patients, it is necessary to determine whether or not the patient is experiencing a visual crowding phenomena, a phenomena similar to that of contour interaction observed with amblyopia. Evidence of the crowding phenomena are patient symptoms (often stated as trouble seeing), fixation instability, accommodative dysfunction, and non-refractive acuity reduction at both distance and at near [6]. When questioned, patients may report seeing double and/or the awareness of environmental shifts or movements. Often significant gains can be made by using relatively low powered optical lenses, small amounts of base-in prism, or bi-nasal occluders. (See Padula, Argyris this journal).

Another area of concern is the patient's perceived visual midline [16,17]. Frequently head trauma patients manifest a shift in visual midline particularly when there is a field deficit, either a hemianopsia or one of neglect. Significant functional gains can be made with most such patients when steps are taken to align the visual midline with the body midline.

4. Rehabilitative strategies

When prescribing a therapy program, the patient's ability to comprehend and understand instructions is important. One needs to question the level of a patients support system to help oversee therapy procedures. When the patient and/or support personnel are capable of following instructions, it is useful to prescribe a fixation procedure to develop the ability to accurately fixate a pen light directed towards the patient's eyes.

The recommended fixation procedure requires two lights, one directed towards the patient's right eye, the other towards the left eye. The lights, held in the assistant's right and left hands, are alternately turned on. The sequence is to first turn on the light in the sighted field followed by the light on the side of the field deficit. The patient is advised to shift fixation as soon as he or she recognizes that a light has been turned on. It is important that the patient generates ocular movements to accurately fixate the light. Fortunately, the light can be recognized even when turned on in the non-sighted field because the glow is visible in the sighted field. Start with the assistant in front of the patient. The assistant holds the lights in different locations within the fields. As the patient gains skill, it is recommended that the assistant stand behind the patient holding the lights in both the right and left fields. Ludlam [18] has also reported success with this relatively simple procedure.

5. Complementary procedure

A complementary therapy procedure, often used in conjunction with the light fixation, is a procedure, designed to foster the development of a patient's ability to visualize the unseen space 'within' the area of the field deficit. The employment of motor scanning within the area of deficit is important. After scanning the area, the patient is directed to fixate an object straight ahead, followed by trying to 'internally picture' or visualize where the field is and what is seen in the field.

6. Compensation strategies

When a patient demonstrates that functional improvement is unlikely, compensatory procedures should be considered. Compensatory procedures consist of the use of ocular devices which are designed to make it easier to function with a field loss. Considered alternatives are the use of higher powered yoked prisms or the Rekindle [19] system of field expansion, which uses either one or two prism buttons in the effected side of the field incorporated into the patient's lens prescription. The Rekindle system provides an opportunity for the patient to get a quick glance into the lost field. The function of such a device can be compared to the use of a rear view mirror in a car. It is always there when needed, but not attended to unless there is a need.

Comprehension of the neuro optometric approach may be augmented by the following two case studies which demonstrate the effectiveness of a visual-motor rehabilitation approach. Both patients were diagnosed as having homonymous hemianopsia, a loss of ipsolateral fields.

The two case summaries illustrate the functional results of visual rehabilitation which are possible for patients with field cuts. The first patient, (JM) persists in manifesting no sight ability in his blind field after therapy. However, he demonstrates impressive improvement in function utilizing blind-sight. The second patient, (AP) now manifests relatively normal bilateral motion detection field, although she continues to be aware of low level detail discrimination differences when comparing her sighted field with her field which was blind.

6.1. Case study No. 1

JM, a 68-year-old male, presented on 07-26-93 after suffering a cerebrovascular accident. In addition to his field cut, he manifested word aphasia. Following his stroke, he was aware of diplopia, a condition which had been less bothersome over time. He complained of continued 'difficulty in seeing'. When questioned, he was aware of a crowding effect, letters and words wanting to encroach upon each other.

JM was a retired employee of the state, and lived on a farm. In addition to his active participation in farming, he had pursued a hobby of furniture building in a mechanized shop. He wanted to improve and expand his activities in both of these areas.

Compared to his previous lens prescription, JM's refractive findings were relatively unchanged. He manifested a bilateral right homonymous hemianopsia. Further, he showed a visual midline shift to his right. Diplopia was evident throughout the examination sequence.

His first lens prescription was prescribed to relieve the crowding and help eliminate diplopia. Such a prescription often is a modest amount of either base-in prisms, plus lenses, or bi-nasal occluders to help stabilize visual attention. A previous study of post-trauma children demonstrated the potent effect of small powered prescriptions to produce significant changes in ocular control [20].

During the next 5 months, he continued to be aware that things were 'not quite right'. This observation was true when he used his contact lenses or bifocal glasses. His lens prescription was changed to incorporate a small amount of base-right yoked prism to reposition his visual midline. Two forms of therapy were prescribed: (1) pen light stimulation, and (2) visualization techniques to heighten his awareness of his right visual field.

I last saw JM during June of 1994. At that time he was driving the farm tractor and was back in his wood shop building furniture. He continued to be aware that 'something was still not quite right' but said he knew when to look to his right. He reported that he no longer miss-reached or bumped into things. He also reported that he had experienced no accidents or near accidents in his shop. Although he continues to have word aphasia, he has started scanning the newspaper and 'reading' material relating to his furniture making hobby. JM continues to manifest a hemianopsia, but is using his awareness of blind-sight to accomplish some sophisticated eye hand tasks. (JM was in for a follow-up examination when this was being edited. He reported that he ran the combine this fall to harvest both corn and soy beans).

6.2. Case study No. 2

AP, a 55-year-old female, was examined in a rehabilitative hospital setting during July, 1993. Prior to her cerebrovascular accident she had worked as a computer programmer. AP presented with a left homonymous hemianopsia and left hemiparesis. She reported that she could not get to the beginning of a line when reading, had difficulty locating food on the left side of her plate, and had difficulty finding her utensils, especially those to her left side.

Relatively little change was found in her lens powers for either distance or near seeing demands. She manifested full ocular motor fields in that she could track a target accurately in all fields with either eye. However, tracking lacked ease and fluidity of movement. Visual localization, the ability to locate a second target in her field of view while maintaining fixation of a target, was accomplished by gross field scanning when the second target was positioned in her left field. Along with the bilateral left field loss, AP showed a pronounced visual midline shift which required three diopters of base-right prism [18]. This was found by having AP identify when a wand, which she was looking at, was directly in front of her. The wand was alternately moved from both her right and left sides in the lateral plane. She consistently identified the wand to be in front of her nose when it was in front of her right eye.

Lenses were prescribed incorporating yoked prisms to assist her in defining her visual midline. Additionally, a visualization procedure was prescribed for AP to develop an awareness of 'where' the left field would be in her visual world. An 'L' shaped bookmark was recommended for use when reading as a complementary adjunct to the visualization procedure. The upper arm of the 'L' was to serve as a guide to allow her to recognize when she had moved her eyes adequately to arrive at the beginning of the line of print.

When AP was seen for her 4-month follow-up examination, her progress was notable. In her previously unsighted field, she was aware of movement (25° with her right eye and 35° with her left eye). Visualization activities were increased in the following way: She was to first look and locate an object in her left affected field. Then she was to fixate on an object. After doing this, she was to re-fixate to an object straight ahead of her. While maintaining fixation straight ahead, she was asked to visualize both the field and the previously seen object in her left field and to do this as 'clearly' as possible. While maintaining fixation straight ahead she was to reach for the visualized object. After reaching and before removing her hand, she was to again look in her left field and note the accuracy/inaccuracy level of her reach.

Additionally, AP was prescribed the previously described penlight stimulation procedure along with an extension of the visualization process appertaining to other functional challenges. The goal was to assist in her efforts of gaining arm and hand mobility. She was instructed to visualize the view of her left arm and hand. Further, she was asked to fixate and focus upon a place she wanted to move her hand. While maintaining fixation, she was encouraged to project what it would look like getting her hand to that place. She was instructed to then attempt to perform the action while keeping her focus on the goal.

When AP was again seen during March, 1994, she reported improved reading with no need to use an aid to see the beginning of the line. After 8 months she was able to detect motion to her left to 180°, even when not expecting a test stimulus. She was aware of a low-level discrimination difference in her left field as compared to her right field. Since regaining the ability to detect motion to full 180° fields, she had gained increased movement ranges and control of her left arm, leg, and body movement. She was anticipating returning to part time employment at her previous job.

A recommendation was made to therapeutically use alternate pairs of equal-powered yoked prisms to shift direction and selectively expand/contract the viewed fields. Such a regimen is often valuable to develop weight shifts, body posture changes, and changes in bilateral limb movements.

Yoked prisms transform light in such a way that viewed objects appear shifted towards the apex of the prisms. Further, they change right/left field distances with the lateral prism placement and forward/back distances with vertical prism placement. These distance shifts are more pronounced when prisms are curved surface lenses. The view through the prism bases is magnified, generating an expansion of spatial distance. Through the apexes of the prisms, the view is minified and accordingly contracted or shortened in distance. This spatial change, the expansion of the base-side and contraction of the apex-side, has a pronounced effect on movement. When the prism base is in the lateral position, the change is in bilateral balance and movement. When the prism base is in the vertical position, the movement change is in backward/forward balance. The effects of the prism changed stimulus, utilizing ambient pathway processing, automatically and unconsciously serve as a trigger to shift balance and movement within the observed environment.

7. Conclusions

It should be noted that case studies have limitations. An essential value of case studies is to document overlooked or unexpected results. Care should be taken not to make emphatic generalizations. The two case reports illustrate the value of utilizing procedures to develop visualization and to elevate the level of awareness and control in visual-motor skills. When both motor control and awareness improved, gains were made in usable field expansion along with improved stability of the observed environment. Therapy resulted in improvements which correlate with the enhancement of the patients' perceived reality. This in turn allowed improved predictability and more effective interaction within their environment.

The focus of treatment for both the cited cases was to develop ocular motor control for facility and accuracy of fixation and visual localization. Once the relevance of the ambient vision process is recognized, the significance and value of both eye movement quality and fixation control is apparent. The ambient visual pathway has been shown to be responsible for recognizing changes in the visual field, localizing areas of interest, seeing distances and relationships, and providing support for selected sustained attention. Treatment procedures can capitalize upon this knowledge. Efforts to develop the awareness and control of ocular movements coupled with the correlation of focal vision processes can be used to maximize success. It is apparently crucial to stimulate a more synergetic function of the ambient and the focal pathways.

When vision is driven by the ambient pathway, focally specific performance is lowered or suppressed. This can often lead to the selection of care regimens specifically directed to treat the obvious symptom, reduction of acuity. Results of such an approach can be discouraging especially when focal demands are made with post head trauma patients. As stated earlier, the visual function of head trauma patients is dominated by ambient visual processing. Attempts to use glasses primarily to enhance acuity and accentuate focused vision are likely to precipitate a visual overload. The clinical and research evidence indicates that head trauma patients exhibit behavior to that of visual overload. When visual overload occurs, an individual is slower in vision performance, requires more fixations for a given task, and manifests faulty ocular control reflected by ataxic like ocular movements and fixations drifts [21].

A key instruction used for both patients was to first look, try to see what needed to be done, and then to let 'seeing' command the doing. The word seeing is used in a literal sense: 'to come to know by the eye, to perceive, to form a mental picture of'. When one experiences vision overload, the ambient and the focal vision processes act to inhibit one or the other pathway. The goal is to achieve consistent complementary interaction between vision-motor control and the sensed aspects of seeing. The ability to coordinate sight, hindsight and foresight depend upon an individual's ability to coordinately and effortlessly react to information from both the ambient and the focal vision pathways.

A critical aspect of the prescribed treatment was the recognition of the important role played by the ambient neuro-visual pathway, a finding which was observed earlier with a syndrome of juvenile patients suffering from physical or physiological trauma. Progress was achieved by guiding the development and utilization of improved cognizance and control of visual motor functions. These gains were coupled with techniques to stimulate the integration of visual motor processes and visual awareness. Perception was enhanced when the patients gained consistency between what was sensed within the external environment related to what he/she was aware of doing.

While both patients continue to manifest functional interferences, the quality of their lives has significantly improved. Their lives are now brighter because they have been able to gain awareness and enhanced rapport with the available information from a lighted world. Along with the described gains, both patients developed standard acuity. Acuity levels, which are temporarily lowered when a patient has difficulty with fixation control and stability, can be regained after achieving fixation stability.

Throughout therapy, patients were instructed to visually focus on goals and outcomes. This helps a patient to react more spontaneously to that which one sees. One can project a model as to why vision-motor control and stability are fruitful areas for rehabilitation. To be visually efficient, good fixation ability is required to maximize the potential synergistic relationship of the visual bimodal processes. When the bimodal processes complement each other, vision becomes more effortless and automatic. To be efficient, visual motor functions need to spontaneously react, freeing vision to operate in an automatic mode. When not automatic, vision performance is time delayed and out of step, a frequently observed behavioral pattern associated with head trauma. Functionally delayed vision performance results in unsteady ocular and related body movement control. When focal vision processing is demanded of a patient who lacks adequate motor control for visual ground stability, it slows general processing, an interference prone to cause visual overload accompanied with reduction of central (high frequency) visual discrimination.

The principal change in making decisions and designing the described treatment was a shift of intent. Focus was shifted to the doing processes of seeing rather than upon the sensing processes. The orientation was to help the patient internalize the spatial characteristics of potential visual fields. This was followed by guiding them to develop the necessary ocular motor control patterns necessary to effectively operate within the potential fields. The two case reports demonstrate that the development the motor skills can sometimes lead to improved guidance of movement and orientation, whether using either blind-sight or expanding field awareness.

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