The importance of proprioception and central/peripheral processing in vision rehabilitation.

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Abstract

The visual system is integrated by two systems. The central visual system is primarily concerned with identification or "what" objects are. The peripheral visual system provides visuospatial information on the "where" and "how". This includes spatial working memory, visually guided action and navigation. When a neurological event occurs it can present many visual sequelae including maintaining binocular vision, challenges to the "where" and "how", reading difficulty and dizziness/disequilibrium which can be caused by mismatches in vestibular and motion processing. This poster will discuss how to use proprioception and central/peripheral awareness as tools in vision rehabilitation by reviewing specific examples in patients who have acquired brain injuries.

Background

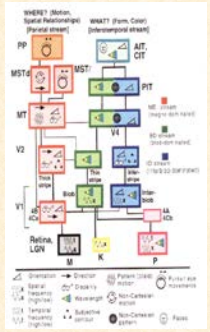
Visual processing includes past experiences that allow single, binocular vision. When the retina receives visual inputs, visual analysis begins. The information goes to two main pathways, the retino-tectal and retino-geniculate pathways[1]. The retino-tectal pathway is primarily motion driven whereas the retinogeniculate pathway form and motion processing[1]. These signals are transmitted in a specific order with specific receptive fields to the primary visual cortex, V1[1]. The primary visual cortex also processes visual information from the magno and parvocellular pathways through 4Ca and 4Cb[1]. The parvocellular pathway exits via the ventral stream and the magocellular layer exits via the dorsal stream (Pic 1).

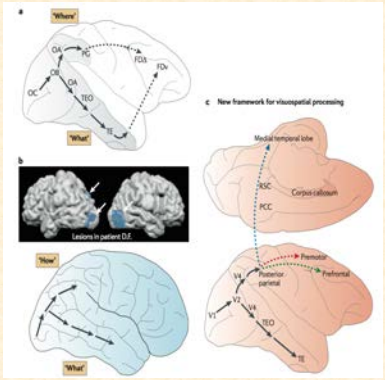
According to Kravitz and et. al, the ventral stream courses through the occipito-temporal cortex to anterior temporal (TE), and dorsal stream travels through occipito-parietal cortex to the posterior half of the inferior parietal lobule (PG) (Pic 2)[2]. Therefore, lesions that occur in the pathways will lead to deficits in object recognition and spatial vision, respectively, identifying to their characterization as "What" and "Where" pathway[2]. An agnosia patient who has a lesion in this area and was diagnosed with impaired perception of objects. These findings combined with the dense interconnections between the posterior parietal and prefrontal premotor areas, led to the proposal that dorsal stream was most appropriately defined as a "How" than as a "Where" pathway[2].

Dorsal stream progenerates to three major pathways:

- Parieto-prefrontal pathway
- Parieto-premotor pathway
- Parieto-medial temporal pathway

Picture 1: A Diagram of the original "what" and "where" pathways





Picture 2: Frameworks of visuopatial processing.
A. The original formulation of the dorsal and ventral streams in the macaque monkey
B. The top panel depicts the location of the lesions in patient D.F. The bottom panel illustrates the "How" pathway.
C. The new neural framework for dorsal stream.
- Parieto-prefrontal pathway (a dashed green arrow)
- Parieto-premotor pathway (a Dashed red arrow)
- Parieto-medial temporal pathway (a Dashed blue arrow)

Visual Rehabilitation

Once an acquired brain injury occurs, often these processes become inefficient in dealing with their respective demands. In order to improve binocular vision, vision rehabilitation for these patients are focused on the areas of central and peripheral awareness, proprioception and the vestibular system.

Peripheral vision helps maintain optimal awareness of the total visual environment. To increase peripheral awareness, you can use larger targets and include motion. To emphasize central processing, smaller targets are generally used and motion is reduced.

Padula has written several publications that have documented what he termed "Post-Trauma Vision Syndrome" (PTVS). PTVS includes symptoms of exotropia, convergence insufficiency, accommodation insufficiency, photophobia, decreased blink rate, spatial disorientation, and balance postural difficulties[3]. Patients not properly treated for PTVS can experience symptoms for many years following a neurological event[3]. Padula suggested that treatment of PTVS include binasal occlusion in conjunction with low amounts of base-in prism and neuro-optometric rehabilitation[3].

Skeffington preferred to describe vision as a dynamic process involving the organism's relationship to gravity and sense of orientation (ANTI-GRAVITY), an understanding of the volume of space within which it finds itself and other beings and objects (CENTERING)[4]. This further supports the notion of central/peripheral processing including motor and vestibular input[4].

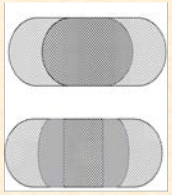
Acquired brain injury patients regularly suffer from motion sensitivity, dizziness, and disequilibrium. The vestibular system and visual systems are unable to provide integration to maintain clear images with head movement. Patients need to relearn how to balance between central fixation and peripheral awareness (lock). This should be dynamic and the patient should be able to alternate depending upon the need of the task. Many patients may be overwhelmed with the periphery and often become overly central (focal) and will locate a target across the room and try to go directly to it and ignore the peripheral motion. These patients generally get better with visual guidance and experience on the use of central and peripheral visual input. Here you can simply help the patient experience with C/P by having them attend to the letter vs. the chart vs. the screen vs. the wall.

Picture 3: Central/peripheral awareness during exam

Proprioceptive feedback provides the patient with a more stable localization of the target and increased peripheral awareness.

Picture 4: Unstable letters

Picture 5: Proprioception helps stabilize



Picture 6: Binasal Occlusion

Binasals reduce confusion in the central field and emphasize peripheral localization. This provides the patient with a more stable central visual field and less symptoms of motion and disequilibrium. Generally narrower the better.

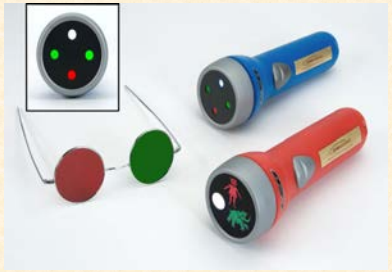
Testing Considerations

Example 1 – Worth 4 dot testing at near

A-If diplopia or suppression is found, add proprioceptive feedback by having the patient touch or hold it.

B-This may help maintain binocularity because the target is now larger (hand and worth 4 dot together), but this also increases peripheral awareness as the motion may stimulate fusion as you bring the hand in from the side.

C-You may also place your hands out to the side and ask the patient to be aware of them while looking at the Worth 4 dot.



Example 2 – Diplopia reported during visual acuity testing

A-At near it is easy to add proprioceptive localization. Often you cannot include proprioceptive feedback at distance because the chart is too far away. Here you can add peripheral awareness by asking the patient to look from letter to full chart to screen to the four corners of the exam lane. Is diplopia present under one or more conditions? This often helps the patient to begin to understand the nature of central/peripheral vision and how both are helpful to maintain single vision.

B-The larger target of regard may also help the patient use periphery to decrease the symptoms of dizziness/disequilibrium under a static condition such as sitting. If so, you should also check the patient during mobility activities.

Mobility Considerations

Example 1 – Observations while turning a corner

A-Patients who have complaints of dizziness/disequilibrium should be evaluated first under static conditions such as sitting, and then during the dynamic activity of walking.

B-Observe the patient while walking around a corner. Look at where the patient is looking, if they are blinking/staring and if they are fixating on any objects during the turn.

C-If you observe primarily a stare the patient is likely to have difficulty with the motion that ensues with head movement. Direct the patient to blink and/or briefly fixate on several objects while making the turns. This fixation should anchor them from the motion and decrease symptoms. This is similar to a person who may touch a wall to ground them self proprioceptively while walking. The use of visual or proprioceptive anchoring can decrease symptoms of motion and dizziness.

Picture 7: Without blinking or fixating, patient may experience motion and thus disequilibrium

Picture 8: Patient should blink and/or fixate while turning

Visual Rehabilitation Considerations

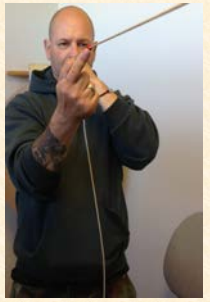
Example 1 - Beads and String

A-If a patient reports two beads (diplopia), ask he to touch the bead. This provides both proprioceptive localization as well as enlarging the target (bead and the hand).

B-One can try to remove the hand from the bead and keep the hand to the side to provide more peripheral feedback without directly touching the bead.

C-If diplopia occurs outside of arms length, one may also add a wood dowel which is considered a "tool". Tools are beneficial as they provide a proprioceptive lengthening of space. One could also attach a beads and string to a television across the room.

Picture 9: Patient reports diplopia



Picture 10: Touching the bead. Patient no longer sees double.

Example 2 – Fusional Ranges with Peripheral Awareness

A-If a patient cannot fuse the targets, ask the patients to bring his hands up and to the sides. This allows the patient to increase peripheral awareness and increase ranges.

B-You can have the patient move their hands to add motion and peripheral awareness. This also helps to increase the fusional ranges.

Picture 11: Motion and peripheral awareness

Recommendations to OT/PT/Speech

A critical component of the rehabilitation team is to share treatment considerations so that the patient may recover to their highest potential. The following are important concepts to share with the rehab team.

1- Increasing awareness of central/peripheral vision and the use of proprioceptive localization can help to reestablish binocular vision.

2- Proprioceptive localization and central/peripheral vision are also critical components when evaluating patients with dizziness and/or disequilibrium.

3- It is important to share these components of visual rehabilitation with the other members of the rehabilitation team as it should allow the patient to more quickly regain comfort and skill in their activities of daily living.

References

1- Helvie R. "Neural Substrates of Vision." In Vision Rehabilitation Multidisciplinary Care of the Patient Following Brain Injury. 2011 p. 65-66.

2- Kravitz D, Saleem K. "A New Neural Framework For Visuospatial Processing." Nature Reviews Neuroscience 2011;12:217-227.

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