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**VISION**

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**VESTIBULO-  
OCULAR REFLEX**

Coordinates eye and head movement. A dysfunction can indicate a problem with the inner ear.

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# The Connection between Vision and Balance

By Dr. Nathan Davis, OD

For most of us, vision is a term used to describe how clear things are. In reality, the impact of vision on our lives is much more profound than just the clarity of the images being perceived. To maintain balance and navigate space in our physical world, we must organize and integrate information from the **visual** (eyes), **proprioceptive** (information perceived through our muscles and joints to tell us where we are in space) and **vestibular** (inner ears sensing motion, equilibrium and spatial awareness) systems. A deficiency in any of these three vitals systems can have a dramatic impact on the person's ability to exist in their world.

The intimate relationship between the vestibular (inner ear) and visual systems begins at birth, as the vestibular system is the only fully myelinated (a protective sheath around the nerve allowing the nerve impulse to move more quickly) and functioning system that we are born with (Tecklin). It is this system that guides our movement, which in turn guides the development of our visual system during our first years. When we are young, movement guides vision. However, as soon as we develop the necessary visual skills, vision begins to guide movement.

## VISION & THE BRAIN

It is generally thought that between half and two-thirds of the brain is used for visual processing. When our eyes are open, two-thirds of the electrical activity of the brain is devoted to vision (Fixot). Our vision is such a powerful sense that it can override information from the other senses, which is sometimes beneficial and other times detrimental. When the visual system is not working properly, providing incorrect information to other somatosensory systems, it can dramatically interfere with our quality of life. Fortunately, the human brain is able to continuously create new pathways and neurological connections (synapses) throughout our lives, referred to as neuroplasticity. This concept of neuroplasticity is what allows us to develop the necessary control over different sensory systems, so that we may be able to enhance our ability to interact with the physical world, and thus our overall quality of life.

## VESTIBULO-OCULAR REFLEX (VOR)

Dizziness and disequilibrium are often the result of a vestibulo-ocular reflex (VOR) dysfunction (a reflex which coordinates eye and head movement) and an unstable binocular (how well the eyes work together) system (Cohen). A disruption of balance, or just generally feeling off



in our movements, is very common after an acquired brain injury. This is due to a disruption in the integration of the vestibular and visual systems. This sensory incoherence is similar to the situation where the sound and the picture on the TV are out of sync. Both the sound and the picture work, and when isolated may even be pleasant to attend to. However, when those systems are used together, with the timing off, there is a dramatically negative response. Fortunately, using the concept of neuroplasticity, the systems can be synced back together! The proper source of this mismatch must be identified first in order to receive proper treatment. Through proper evaluation and skilled vision therapy, we can improve visual deficiencies.

## VISION SPECIALISTS

One must take particular care in choosing an Optometrist that specializes in therapeutic vision treatment. Some common titles that we use to describe our specialties can include Developmental Optometrist, Vision Therapist or Neuro-Rehabilitative Specialist. I would recommend finding out if the Optometric Physician is a member of the College of Optometrists in Vision Development (COVD), or the Neuro-Optometric Rehabilitation Association (NORA). These are two of the leading communities with respect to the field of visual therapy.

## FUNCTIONAL VISION EXAM

A functional vision exam from a Neuro-Rehabilitative, or Developmental, Optometrist is far different than routine eye exams. Beyond ensuring that the health of the eye itself is adequate, and that sight is sharp, a functional vision exam measures a patient's oculomotor skills, tracking not only their ability to follow a moving target but also their ability to quickly and accurately jump from one target to another. A thorough exam also assesses the patient's ability to focus on a target, and to use both of their eyes together to maximize their sense of depth. Additionally, we note the ocular alignment at different positions of gaze, including distance and near, as well as under different stressful situations such as cognitive loading. Flexibility is another key component of our vision assessment, as patients should be able to efficiently move their fixation from one target to another (such as a near to far target, and back). After we have established a thorough understanding of how a patient's visual system is working, we then incorporate movement and cognitive loading into the diagnostic testing. It is important to note how the visual system performs



as the vestibular system is activated, as this may give the provider a clue where the disconnect in the sensory integration lies. It is also important to note whether the cognitive processing and visual system can both function at a high level at the same time. Because vision guides most of our activities, including movement, these motor functions must be an essential part of any thorough exam.

We also must ensure that the patient has balance between their central and peripheral visual systems. Similar to the vestibular system, the visual system can be broken down into a central processing system and a peripheral processing system. The central system is used mainly for clarity in order to identify details of an object. The peripheral system is used to initiate spatial localization and to process movement. Many acquired brain injuries can create an imbalance between the two systems, and visual therapy can be used to rebalance the system.

Extensive trial framing is also a part of a thorough exam, as we need to determine the effects that different prisms and filters have on a patient's performance. Prisms are special lenses that we use to not only bend light, but to alter a patient's perception of space (Suter). Patients who have had a traumatic brain injury may organize the space around them in a very inefficient and inaccurate way, or they may lose awareness of it altogether. This can cause patients to bump into things regularly, or feel uneasy as they move around. Using prisms at the appropriate time, and with the appropriate instructions, during therapy allows these patients to become aware of their surroundings again, and to reorient their spatial organization. Filters allow us to determine whether adding or subtracting different wavelengths of



light will have a positive or negative affect. Some patients can experience a calming effect when exposed to certain wavelengths of light, while other patients may use colored filters for transient activities such as reading on the computer.

## TREATMENT

Assuming the necessary anatomical structures are adequate within each system, many deficient skills can be enhanced through the efforts of the hard-working patient, with guidance from a skilled therapist. If the patient was determined to have a vestibular-visual dysfunction, a multidisciplinary approach to treatment usually works best, consisting of skilled vision and vestibular therapists. From a visual therapy perspective, therapists look to maximize visual skills while slowly loading the tasks with different sensory-driven concepts.

Neuro-Rehabilitative Optometrists' therapy protocols generally deal with isolating the specific visual skills first, and enhancing them to the best of the patient's abilities. The concept of therapy is built around the idea of neuroplasticity. We start with a specific visual skill in mind, and we present the patient with a particular task. As the patient has to figure out how to perform this particular task, they are indirectly enhancing the specific skills necessary to succeed in that task, while broadening their own sense of body awareness. Learning in the neurological sense, or creating new neural pathways, only happens when the patient is presented with an engaging new task they have to adapt to. As the patient's mastery of a specific visual skill increases, we continue to load the task so the patient is constantly being pushed to new levels of achievement.

Visual therapists have many distinct exercises. The skill is knowing when to incorporate the exercises and how to load them. Because much of the success of the patient lies in developing a better understanding of how to control their visual system, great care must be taken to guide them along the appropriate path so the right neurological patterns are formed. An example of this could be having a patient perform specific motor functions with different types of prisms on, which is an incredible way for a patient to reorganize their spatial localization. Depending on the nature of the diagnosis, we may use prisms to emphasize different aspects of a patient's spatial and body awareness, or we may use prisms to load a task as their current grasp of the concept grows. Different powers of lenses can be used in the same

way, in that they have the ability to stimulate a person's sensory awareness, while loading a task to increase the skill level required for success. In fact, therapeutic lenses such as prisms and specific-powered lenses are used by Rehabilitative Optometrists to affect the neurological pathways, changing neural wiring (this is much more powerful than just making the image clearer!). This can be reliably measured in research labs with the aid of Visual Evoked Potentials (VEPs), Electroencephalographys (EEGs) and functional Magnetic Resonance Imaging (fMRIs), which are specific instruments used to scan the brain.

Once the patients have developed sufficient visual skills, we can then incorporate head and body movement with many of the exercises. This allows the patient to continue to get feedback on the visual performance, while slowly integrating the vestibular system until they are neurologically linked together again. In a way, this is very similar to the process of childhood neurological development, having one system guide another system to a higher level of performance.

As we continue to broaden our understanding of how the brain works, our ability to affect a positive change increases as well. For patients who may be suffering from balance issues, knowing that there is a strong, influential visual component may be the key to getting the help they need.

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