



# *Vision Therapy Post Head Injury*

*Addressing the Root of the Problem*

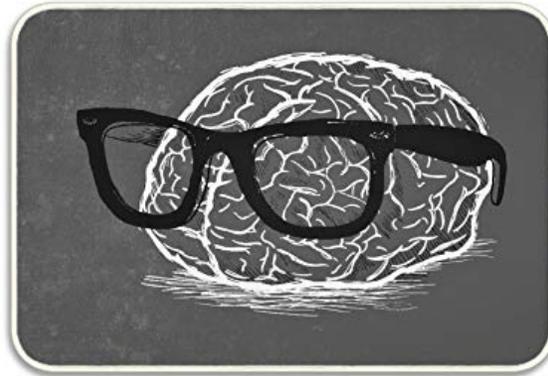
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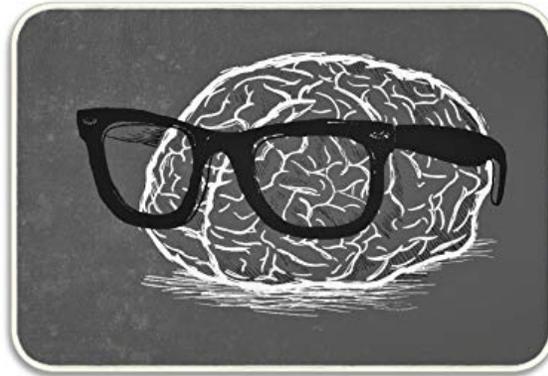
# Objectives

1. Ability to identify patients who would benefit from vision therapy
2. Better Understand how vision is affected following brain injury
3. Understand vision diagnoses post head injury, the functional impacts, and the benefits of remediation based therapy



# Objectives 1 and 2

1. Ability to identify patients who would benefit from vision therapy
2. Better Understand how vision is affected following brain injury



# Brain Injury

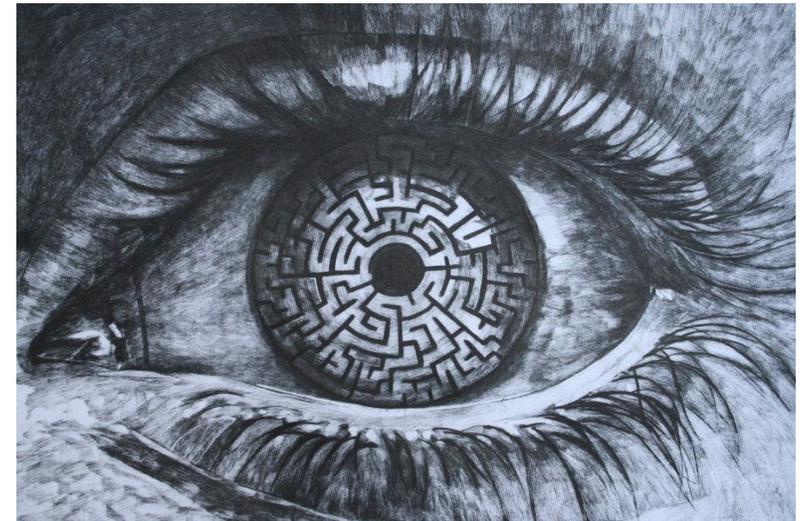
## This is not just another concussion talk

- Can be applied to post-stroke and TBI
- My personal experience is this treatment, when combined with other well-known traditional therapies, can be remarkable and often life-changing



# Brain Injury

- For those of us that went to MSUCOM undoubtedly you remember Dr. Kaufman remarking that “The eye is the window to the brain”
- Although for this we will not be focusing on the physical structure of the eye rather its performance and alteration after injury
- Ongoing research continues to strive to answer many difficult questions surrounding TBI/concussions and there may be more than meets the eye than just clinical symptoms
  - Persistent vestibular/oculomotor changes
  - Persistent fMRI changes





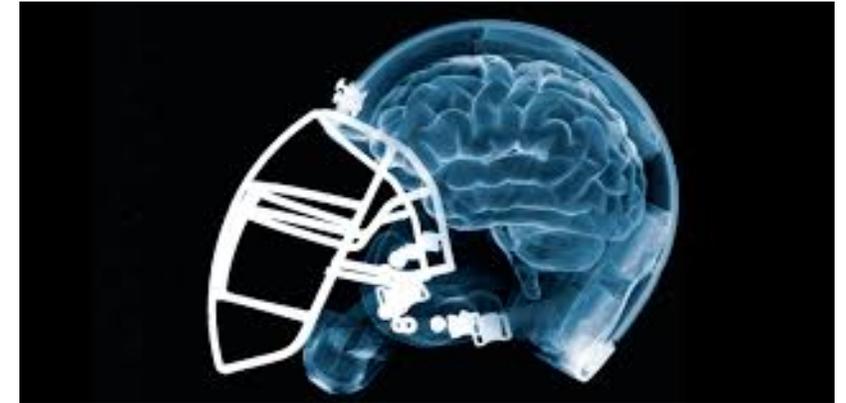
# Brain Injury

- According to CDC:
  - “A disruption in the normal function of the brain that can be caused by a bump, blow, or jolt to the head or penetrating head injury”
- Mild TBI ≠ Concussion
- This is vague and under-represents what a concussion can be
  - Has no validated criteria for this
    - Concussion should not be classified as mild, moderate, or severe
  - Is it apart of the TBI spectrum but associated with lesser degrees of diffuse structural change
  - It is an injury that results from reversible physiological changes



# Brain Injury

- **Berlin Guidelines for sport related concussions**
  - Sport related concussion is a traumatic brain injury induced by biomechanical forces
  - May be caused by a direct blow or impulsive forces
  - Induction of rapid onset short-lived impairment of neurological function that resolves spontaneously. In some cases symptoms can evolve over minutes to hours
  - May result in neuropathological changes but the acute clinical signs and symptoms largely reflect a functional disturbance rather than structural injury. As such no abnormality is seen on imaging
  - Results in a range of clinical signs and symptoms that may or may not involve loss of consciousness
  - Resolution of the clinical and cognitive features typically follows a sequential course but in some cases can be prolonged
    - *Post Concussion Syndrome*



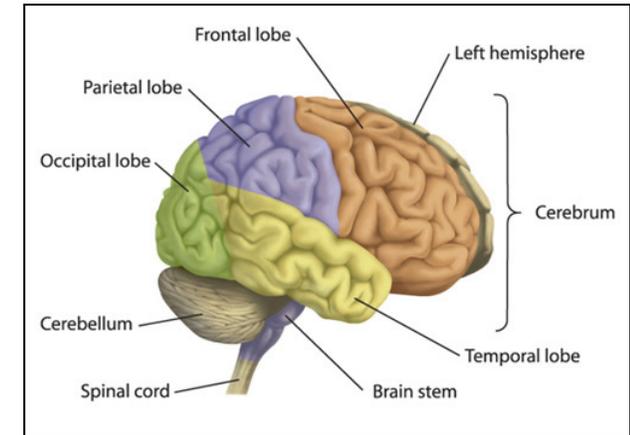
# Vision As A Role

- Approximately half of the brain's circuits are involved in vision and control of eye movements
- We are understanding the importance of the visual pathways and their interactions with the brain as evident in the injury evaluations
  - King-Devick
  - Mobile Universal Lexicon Evaluation System (MULES)
  - Smooth Pursuit
  - Near Point Convergence
  - Video-oculography
    - Saccades
    - Pupil Size



# Vision and the Brain

- Occipital Lobe
  - Primary visual cortex
  - Visual association cortex (analyzed for orientation, position, and movement)
  - Initiation of smooth pursuit eye movements
  - Visual field loss
- Brain Stem/Cerebellum
  - Dizziness
- Parietal Lobe
  - Locating Objects
  - Eye Movements
  - Drawing or Construction of Objects
  - Amnesia for routes and location
  - Difficulty moving through space
  - Neglect
- Frontal Lobe
  - Saccades
  - Attention
- Temporal Lobe
  - Combines sensory information associated with the recognition and identification of objects such as people, places, and things
  - Processes visual information leading to visual recognition and language
  - Hallucinations
  - Object identification



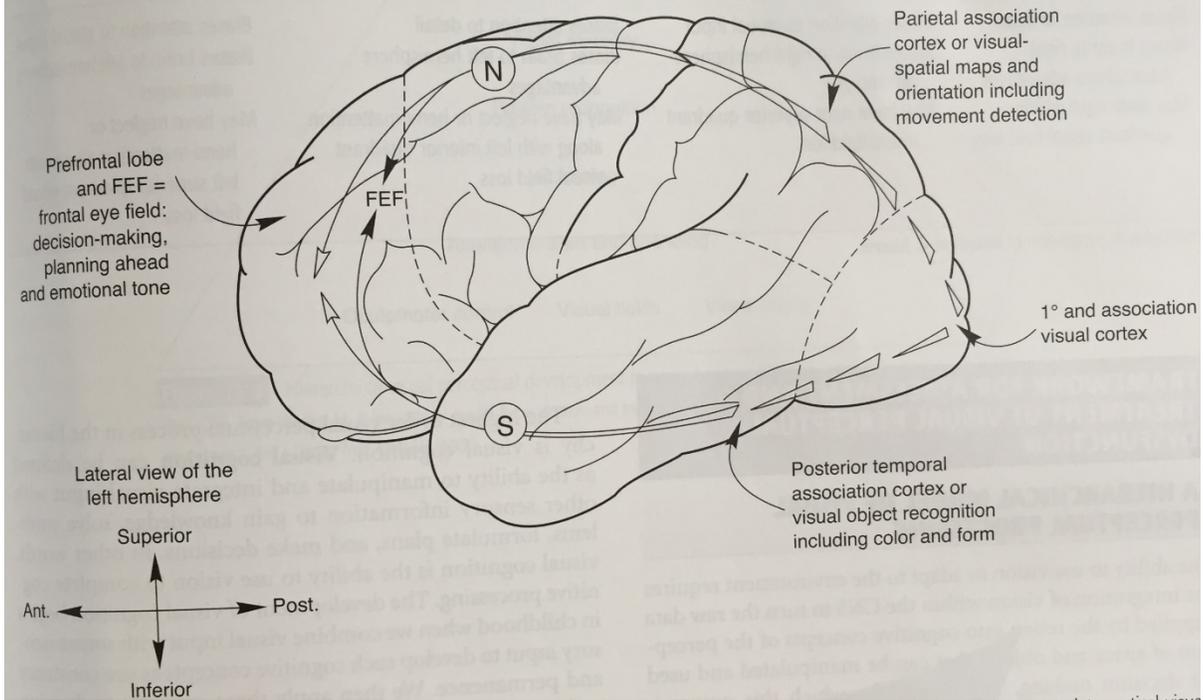
# Visual Loop

## PARALLEL-DISTRIBUTED PROCESSING OF THE VISUAL SYSTEM

Two parallel routes carry visual information from the occipital lobe to the prefrontal lobe and frontal eye field (FEF). Fibers from these two routes distribute to many areas along each route (not illustrated) before terminating in the prefrontal cortex and FEF as illustrated.

**N** = "Northern" or superior route via parietal and frontal lobes.

**S** = "Southern" or inferior route via temporal and frontal lobes.



# Visual Abnormalities

- Visual abnormalities are known to occur frequently
  - Accommodation
  - Convergence
  - Saccadic/Smooth Pursuit
  - Photophobia
  - Stereopsis (depth perception)
- At least one visual problem was noted in the following cohorts:
  - 69% of 11-17 year olds with concussion in the outpatient setting
  - 60% hospitalized adults
  - 65% of military personal suffering as a result of blast-induced injury

**Convergence Insufficiency**  
can make text look double  
when trying to read

**Some people with**  
**Convergence Insufficiency**  
experience a "halo effect"  
instead of double vision



# TBI/Concussion

- Patient is in your office
  - Give SCAT 5 symptom questionnaire
    - Only complete full SCAT 5 if injury less than 3 days
  - Evaluate per your current standards
    - King-Devick
    - VOMS
- Identify needs/Recommendations
  - Tailor therapies to their struggles
  - Patient will explain like their eyes are disconnected from their body
    - Blair Witch Project
  - More to come



# Near Point Convergence (NPC)

- Double vision greater than or equal to 6cm
- Abnormalities were found in 49% of concussed patients
- Abnormalities are found in the general population but at a much lower rate, 2-8%
- Needed for near vision work such as reading
- Children's Hospital of Philadelphia
  - Persistent symptoms beyond 8 weeks
  - Following formal physical therapy including vestibular and balance therapy
    - Brock string
    - Pencil push-ups



# Vestibular/Ocular-Motor Screening

- Vestibular/Ocular-Motor Screening (VOMS)
  - Abnormal findings
    - Blurred/double vision
    - Nystagmus
  - Symptom provocation
    - Headache
    - Dizziness
    - Nausea
    - Fogginess
  - Coordination failure
    - Inability to keep pace
    - Inability to perform



# Vestibular/Ocular-Motor Screening

- Smooth pursuit:
  - Ability to follow a slowly moving target
    - Horizontal and vertical
  - Fingertip at distance of 3 feet and moves smoothly in each direction to 1.5 feet from midline in each direction
  - It should take 2 seconds to move from the far left to the far right
  - 2 complete cycles are done
- Saccades
  - Ability of the eyes to move quickly between targets
    - Horizontal and vertical
  - At a distance of 3 feet hold examiner's fingers 1.5 feet from midline, achieving a patient gaze of 30 degrees in each direction
  - Metronome pace of 120 beats per min
  - 10 complete cycles are performed

# Vestibular/Ocular-Motor Screening

- Convergence
  - Focus on small target (14 font, Letter R)
  - Start object 3 feet away and slowly bring towards nose
  - Note location of double vision or outward movement of one eye
  - Blurred vision does not count
  - Abnormal is anything at or beyond 6cm
- Vestibular-Ocular Reflex (VOR)
  - Ability to stabilize vision as the head moves
    - Horizontal and vertical
  - Focuses on object at distance of 3 feet
  - Head moves in 20 degrees from midline
  - Completing 10 repetitions (1 full cycle of either right to left or up and down)
  - Use Metronome at a rate of 180

# Vestibular/Ocular-Motor Screening

- Visual Motion Sensitivity (VMS)
  - Tests visual motion sensitivity and the ability to inhibit vestibular-induced eye movements
    - Horizontal and vertical
  - Patient holds arm out and focuses on their thumb
  - Focusing on their thumb they rotate 80 degrees away from midline
  - This is completed in the horizontal and vertical planes
  - Metronome again is used to ensure pace
  - Rate of 50 bpm with one beat in each direction



# Treatment

- Identify needs/Recommendations
  - Sub-symptom threshold activity
    - 30 minutes daily
  - Physical therapy with vestibular
  - Occupational therapy
    - Fine motor
    - Vision therapy
  - Speech therapy
  - Psychological/Counseling
  - **Refer to Neuro-Optometry**
  - Osteopathic manipulative medicine
  - Alternative treatments
    - Biofeedback
    - Diet
    - Brain Yoga



# Special Considerations

- **Driving**
  - Must be addressed with the patient
  - Use in office testing to support your recommendation
  - In difficult cases may have to involve the State
  - Consider driver's rehab!
  - Involve other specialists



# Treatment

- When to refer
  - Typically will give patient about 4 weeks
  - Can be years later though
  - Must be individualized and personalized
    - Listen to the patient and their struggles
    - Understand vision can be their culprit even without true vision changes
    - May not have blurred/double vision instead headache/fatigue after reading



# Objective 3

Understand vision diagnoses post head injury, the functional impacts, and the benefits of remediation based therapy



# Vision Therapy

- Vision therapy is a rehabilitative program, prescribed to treat developmental and/or neurologically induced dysfunctions of the visual system. The **American Optometric Association** defines vision therapy as a sequence of neurosensory and neuromuscular activities individually prescribed and monitored by a doctor to develop, rehabilitate, and enhance visual skills and processing.
- “The ultimate goal of optometric vision therapy is not simply to impact positively on various aspects of the oculomotor system *per se*, in isolation, but to attain clear and comfortable binocular vision at all times”. Ciuffreda, 2002.
- The history of strabismus orthoptics dates back to 7<sup>th</sup> century
- AM Skeffington
  - Recognized as the Father of behavioral optometry
  - Coined the idea of the behavioral concept of vision
    - Emphasizes the influence of the environment and experience on visual function
    - Recognize the plasticity of the visual system
    - The relationship of vision with other organismic function
    - Recognized the role of vision as a modality for gathering and processing information



# Visual Hierarchy

Warren 1992, 1993

- Impact of vision at each skill level of this hierarchy influences the overall integration of the visual environment.
- The foundation includes oculomotor control, visual fields, and visual acuity. These are the basic visual skills required to take in information accurately from our visual world.
- Unilateral inattention is represented in this second level, and this deficit would complicate our ability to properly scan and attend to incoming visual information.
- Decreased visual scanning would present difficulties in pattern recognition, which includes (1) form constancy, (2) figure ground perception, (3) visual closure, (4) visual organization, and (5) spatial orientation. Moreover, the optimal functioning of pattern recognition skills are necessary for our ability to retain visual information, also known as visual memory.
- The highest skill level of this hierarchy is visuocognition, in which we are able to integrate visual perceptual information with other sensory input in order to complete executive functioning tasks, such as planning, problem solving, and decision making.
- Determining the cause of a deficit requires an understanding of how brain injury affects the integration of vision at each skill level and how the skill levels interact to produce visual perception.



# Remediation Approach

- The remedial or developmental approach is typically initiated based on the premise that the brain can acquire or reacquire function through environmental stimulation.
- Reacquisition of skills should follow the original path of development.
  - In Piaget's model of cognitive development, and in Warren's visual hierarchy model, the lower level performance components are acquired prior to more advanced visual and cognitive skills.
  - Treatment activities should place initial emphasis on foundational skills, regardless of the individual's level of functioning, in order to ensure that the foundation is solid prior to advancing to higher level skills.
- Choosing activities that have multiple levels of difficulty, the ability to alter speed requirements, and offer the opportunity to adjust levels of attention complexity are important to consider for grading activities up or down to foster meeting the client's goals while considering his or her just right challenge.



# Compensatory Approach

- Compensation is a treatment approach that aims to maximize existing visual function by providing strategies to enhance the patient's ability to assimilate visual information efficiently.
- A compensatory approach should also place emphasis on understanding underlying difficulties in visual perception in order to learn when to initiate the use of strategies to overcome limitations.
- Rather than focusing on one task specific skill, the client should gain the ability to use the learned strategies in various situations.
- Warren supports the use of practicing strategies for visual perceptual deficits within context to ensure carryover of application to ADLs.

# Oculomotor

- Range of Motion
- Pursuits
- Saccades
  
- Function
  - Reading
  - Sports (tracking ball)
  - Giving attitude
  - Grocery shopping
  - Driving
  - Packing medications

When you read, your eyes do not smoothly travel over the print. Instead, they make short jumping movements called saccades.

These eye movements must be made quickly, sequentially, and accurately so that the words come to the brain in the proper order.

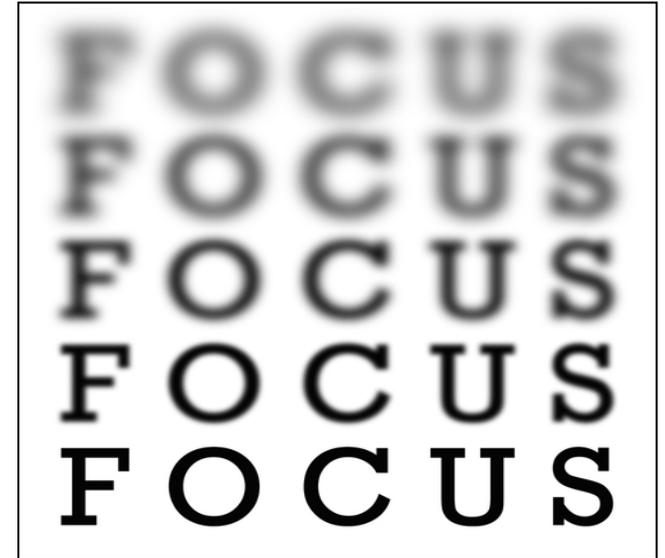


Words "floating" on a page can be a symptom of Oculomotor Dysfunction.



# Accommodation

- The automatic adjustment of the eye for seeing at different distances
- Three Components
  - **Amplitude**- Getting it clear
    - Parasympathetic system
    - Can be a problem for many farsighted individuals who usually pass the far Snellen chart.
  - **Sustenance**- Keeping it clear
    - Print comes into and out of focus, especially with fatigue.
    - Sympathetic system
  - **Facility**- Changing focus from one distance to another.
- Function
  - Ability to take notes in school shifting focus from white board to notebook
  - Shifting visual focus from the speedometer in the car to traffic signs
  - Ability to read directions on a recipe and then set the timer/oven temperature

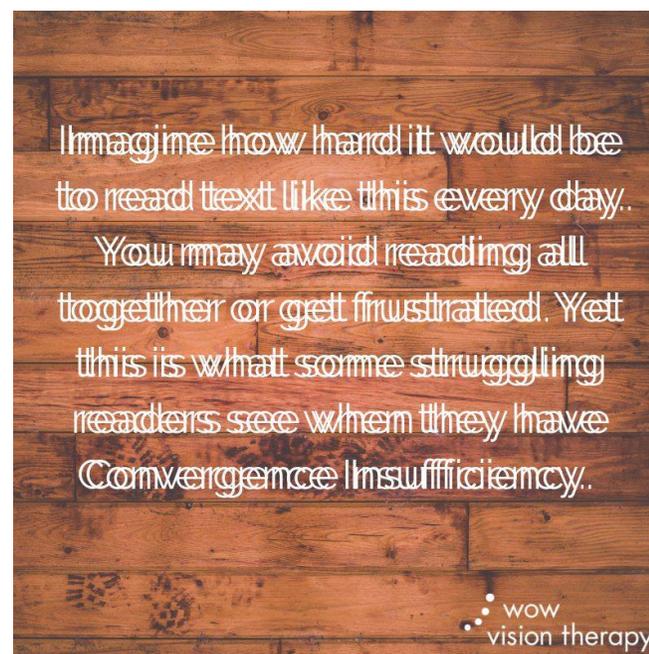


# Vergence Skills

- Convergence
  - Coordinated movement of the two eyes so that the image of a single point is formed on corresponding retinal areas.
  - Common to have difficulty with both accommodation and convergence
- Function
  - Sewing
  - Reading pill bottles
  - Dialing a phone
  - Texting

**Convergence Insufficiency**  
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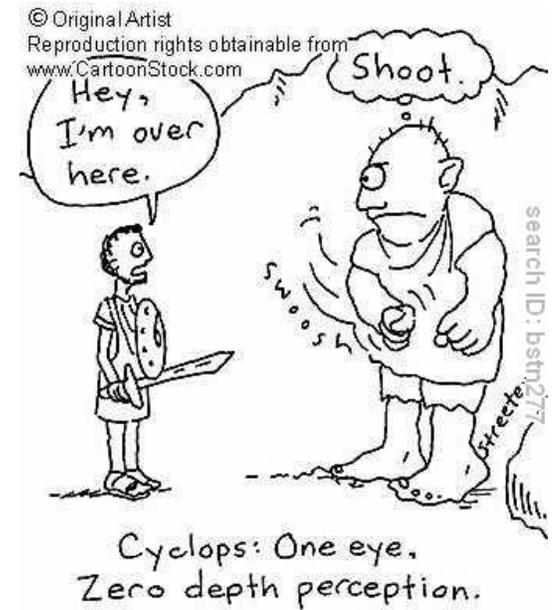
# Vergence Skills

- Divergence
  - More strenuous/harder
- Vergence facility
  - Changing alignment at change in distance
  - Affects how quickly we can change our viewing distance
- Function
  - Playing board games
  - Packing medication box
  - Measuring ingredients
  - Reading labels in the grocery store
  - Driving



# Depth Perception

- Binocular
  - Stereopsis, or 3rd degree fusion
  - Requires 2 eyes working together
  - Brain uses retinal disparity to compare information from two differing points of view
  - Lack of stereopsis leads to difficulty with coordination
- Monocular cues
  - Shadowing
  - Line of parallax
  - Superimposition
- Function
  - Driving
  - Stairs/curbs
  - Getting into the bathtub
  - Pouring liquids



# Post Trauma Vision Syndrome

- Characteristics: exotropia, diminished stereopsis, accommodative dysfunction, oculomotor dysfunction, convergence insufficiency, and spatial disorientation
- Signs/Symptoms: diplopia, dizziness, headaches, light sensitivity, diminished visual scanning, blurred vision, poor visual anchoring, poor visual memory, decreased depth perception, poor concentration and attention, and decreased balance/coordination/posture
- William Padula, O.D.
  - Hypothesizes that the root cause of Post Trauma Vision Syndrome is resulting from a shearing injury to the midbrain. As a result, there is disorganized visual spatial information negatively impacting the focal and ambient visual system.



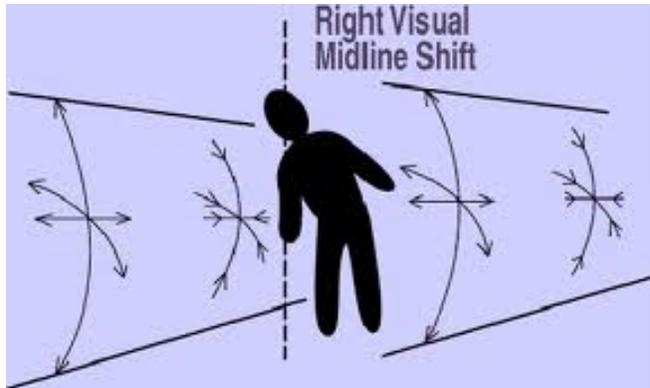
# Bimodal Visual System

- Focal Vision: The “what”
- Detail oriented, attention/concentration, identification
- Conscious, oriented to present, reactive
  
- Ambient Vision: The “where”
- Spatial orientation, posture/balance, movement
- Preconscious, anticipates change, proactive
  
- Two pathways of vision to the brain need to work simultaneously to process these different types of visual information
  
- If acting in isolation, confidence in balance and posture is compromised
  
- WOW Vision Therapy – supplemental materials to learn more



# Visual Midline Shift Syndrome

- A neurological event that often corresponds with hemiplegia and hemiparesis.
- The ambient visual process attempts to create a balance by expanding a concept of space on the unaffected side and compressing the concept of space on the other side.
- You may observe an individual leaning or tilting their head away from the neurologically affected side.
- Yoked Prisms can move the image to midline



# Research

- **Vision Diagnoses are common after concussion in adolescents**
  - Master, C. L., MD, CAQSM et al 2015
- Cross sectional study reviewed records from 7/1/2013 to 2/28/2014
- Patients age 11-17 years with concussion diagnosis.
  - Total of 100 adolescents, mean age 14.5 years
- 69% with vision diagnoses
  - 51% accommodative disorders
  - 49% convergence insufficiency
  - 29% saccadic dysfunction
  - 46% manifesting in more than one vision diagnosis
- General population
  - 2% - 8% convergence insufficiency
  - 5% accommodative dysfunction
- Convergence Insufficiency Symptom Survey (CISS)
  - Screening tool – validated 15 point questionnaire to monitor changes
- ImPACT
  - Computerized neurocognitive testing for acute concussions
  - Correlation between poorer composite scores of visual motor speed and visual disturbances –to be expected...
- Academic accommodation considerations



# Research

- **Occurrence of oculomotor dysfunctions in acquired brain injury: a retrospective study**
  - Ciuffreda, K. J., O.D., Ph.D. et al 2007
- Reviewed records of 220 ambulatory individuals with acquired brain injury (n=160 TBI, n=60 CVA) with vision symptoms
- Records from 2000-2003, searching for oculomotor dysfunctions including accommodation, versional oculomotility, vergence, strabismus, and cranial nerve palsy
- Results:
  - 90% of TBI manifested in oculomotor dysfunction
    - Accommodation
    - Vergence
    - Versional oculomotility
  - 86.7% of CVA manifested in oculomotor dysfunction
    - Strabismus
    - Cranial nerve palsy
    - Versional oculomotility
- Non-ABI cohort with near work symptoms
  - Convergence Insufficiency in 4% of cases
  - Accommodative insufficiency in 9% of cases



# Research

- **Vision Therapy for oculomotor dysfunctions in acquired brain injury: A retrospective analysis**
  - Ciuffreda, K. J., O.D., Ph.D. et al 2008
- Computer based query retrospective analysis for ABI patients between the years of 2000-2003
- Reviewed records of 220 ambulatory individuals with acquired brain injury (n=160 TBI, n=60 CVA) with vision symptoms
  - Only those with vision therapy prescribed and completed the vision therapy program for remediation of oculomotor dysfunctions were selected
    - N=33 TBI, n=7 CVA
    - Treatment success = marked/total improvement in at least 1 primary symptom and 1 primary sign
  - Oculomotor dysfunctions considered: vergence, versional oculomotility, and accommodative deficits
- 90% TBI treatment success
- 100% CVA treatment success
- Improvements remained stable 2-3 months later
- Findings suggest considerable visual system plasticity in response to targeted vision therapy



# Research

- **The scientific basis for and efficacy of optometric vision therapy in nonstrabismic accommodative and vergence disorders**
  - Ciuffreda, K. J., O.D, Ph.D. 2002
- Vision therapy for non-strabismic accommodative and vergence disorders
  - Highly specific, sequential, sensory-motor-perceptual stimulation paradigms and regimens
  - Purposeful, controlled, evidence based manipulations of target blur, disparity, and proximity to normalize
- Using bio-engineering models of the oculomotor system as a conceptual framework, a detailed quantitative overview of various static and dynamic models of accommodation and/or vergence optometrist vision therapy was completed
- Selected research studies that provide objective support for the scientific basis for and efficacy of optometrist vision therapy were reviewed
- Accommodative vision therapy: the objective findings support modifiability and normalization of accommodative responsivity following vision therapy
- Fusional Vergence vision therapy: the objective findings support modifiability and normalization of accommodative responsivity following vision therapy

Convergence Insufficiency makes the words "move"  
and look double at times..

When it is mild, it looks a little blur..

When it is moderate to severe, and our eyes do not turn  
in enough, i see double, and it gives me a headache



# Research

- **A randomized clinical trial of vision therapy/orthoptics versus pencil pushups for the treatment of convergence insufficiency in young adults**
  - Scheiman, M, O.D., et al 2005
- Randomized, multicenter clinical trial.
- 46 adults, 19 to 30 years of age, with symptomatic convergence insufficiency were randomly assigned to receive 12 weeks of treatment
  - Office-based vision therapy/orthoptics
  - Office-based placebo vision therapy/orthoptics
  - Home-based pencil pushups
- Primary outcome measure: Convergence Insufficiency Symptom Survey (CISS)
- Secondary outcome measures: Near Point Convergence (NPC) and positive fusional vergence at near
- Only patients in the vision therapy/orthoptics group demonstrated statistically and clinically significant changes in the near point of convergence (12.8 cm to 5.3 cm,  $p = 0.002$ ) and positive fusional vergence at near ( $11.3\Delta$  to  $29.7\Delta$ ,  $p = 0.001$ ).
- Patients in all three treatment arms demonstrated statistically significant improvement in symptoms with 42% in office-based vision therapy/orthoptics, 31% in office-based placebo vision therapy/orthoptics, and 20% in home-based pencil pushups



# Research

- **Post-therapy functional magnetic resonance imaging in adults with symptomatic convergence insufficiency**
  - Widmer, D. E., OD, MS et al, 2018
- Purpose to investigate changes in brain activation following office-based vergence-accommodative therapy versus placebo therapy for CI
- Adults age 18-30 years (n=7) with symptomatic CI randomized to 12-week treatment groups
  - Vergence-accommodative therapy n=4
  - Placebo n=3
- Baseline fMRI scan with viewing a red/blue randot stereogram, increasing convergence demands
  - Activation observed in occipital lobe and areas of the brain devoted to attention
- After vergence-accommodative therapy
  - Decreased in occipital lobe spatial extent, increased in level of posterior, inferior portion.
  - New activation in lingual gyrus (not seen in placebo group)
  - Significant decrease in areas devoted to attention
- After placebo therapy
  - Continued activation in areas devoted to attention
  - No activation in lingual gyrus
- Suggests that when experiencing CI symptoms, convergence requires conscious effort. Decreased attention activation was associated with improvements in clinical signs (fusional vergence)



# OT/PT Role

- Vision Screen
  - Completed as a part of the initial OT/PT evaluation
    - Acuity
    - Diplopia
    - Suppression
    - Visual fields
    - Convergence
    - Accommodation
    - Saccades
    - Pursuit
  - Starts the referral process if red flags are present
- Provides Vision Therapy which is directed by the Neurovisual optometrist (OTA as well)
- Developmental approach **based on function**
- Tools and activities
- Discharge per Neurovisual Optometrist recommendations



# Before and After Therapy



# Neurovisual Optometrist

- Functional evaluation with OT/PT present
  - Eye posture
  - Stereo depth perception
  - Suppression
  - Diplopia
  - Acuity
  - Prisms
- Goal is to determine if the visual system is effectively processing information for functional skills
- Prescribes vision therapy
- Standardized visual fields test
- Visual Evoked Potential
- Important to medical clearance for driving



# Medical Provider

- Evaluates medical status and determines if reported visual issues are due to other medical conditions or require more evaluation
- Visual screening
- Responsible for writing a script for Neurovisual Optometry and Visual Remediation/Occupational Therapy
- Provides a medication list for first appointment



# Discharge Planning

- Re-evaluations occur at optometrists' discretion to determine progress and treatment plan updates, including prism adaptations.
- Neurovisual optometrist in coordination with therapist determine discharge.
- Complete progress updates and discharge plan to physiatrist.
- Client's to follow up with previously established eye health doctor, or continue with neurovisual optometrist for prism maintenance.
- Home exercise programs are needed and provided by therapist per optometrist discretion.
- Neurovisual optometrist should note and communicate with client the ability in regards to return to driving and work.



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*Thank you!*

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