Visual Dysfunction After Concussion: What Matters, What Changes, What Heals, & What Everyone Keeps Missing…

Jacqueline Theis, OD, FAAO, FNAP

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Financial Disclosures - Dr. Theis

C. Light Technologies - Chief Medical Officer
Vision Science Labs - Advisory Board
Myze – Advisory Board
Horizon Therapeutics - Advisory Panel
Oculus - Speakers Board
MedEvolve - Speakers Board
Tarsus – Speakers Board
PER – Speakers Board
Abbvie – Advisory Panel
Alcon – Speakers Board, Advisory panel
Dompe – Speakers Board
Zeiss – Advisory panel
Roche - Speakers

All risks have been mitigated

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Lecture Objectives

- **Recognize** the most common visual-vestibular-cervical dysfunction patterns after concussion
- **Differentiate** peripheral eye findings from central neurologic visual dysfunction
- **Prioritize testing** instead of over-testing overwhelmed patients
- **Select targeted interventions** (glasses, prism, rehab, referral) based on symptom drivers
- **Explain to patients** *why* their vision symptoms persist even when "everything looks normal"

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Why This Matters

- Patients say: "Something is wrong with my eyes, I can't function."
- Optometrist says: "You're 20/20, your eyes are fine!"
- Patient loses faith in provider, feels unheard, starts to worry that something is actually wrong and no one is seeing it – escalating to ophthalmology and getting unnecessary testing and even less information

"20/20" doesn't mean functional vision

Concussion disrupts integration, neural input and coordination, not structural anatomy we can detect on current diagnostics

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Patient Case

- 38-year-old teacher. Rear-ended in high speed MVA. MRI normal.
- Still dizzy, nauseated, can't read more than 10 minutes, cant tolerate scrolling. Vision is blurry after 5 minutes and "triple" after 10minutes, and has constant headaches and light sensitivity.
- Meds: Trazadone, amitryptiline, ubrelvy,

- Examination
  - Distance Visual Acuity 20/20 OD/OS
  - Refraction:
    - OD: -0.25-0.50x180 20/25
    - OS: +0.25-0.25x170 20/20-
    - Add: +0.50
  - Cover Test: ortho at Distance and Near
  - NPC: 8cm break
  - Slit Lamp Exam: "Normal"
  - Fundus Exam: "Normal" *Fundus imaging taken
  - RNFL OCT: "Normal"
- Plan: Progressive/Occupational Lens

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Patient Case – The Disconnect – the patient isn't Normal

- Examination
  - Distance Visual Acuity 20/20 OD/OS
  - Cover Test: ortho at Distance/Near
  - NPC: 8cm break
  - Slit Lamp Exam: "Normal"
  - Fundus Exam: "Normal" *Fundus imaging taken
  - RNFL OCT: "Normal"

Chief Complaint is at near
- Where is Near VA?

Chief Complaint is blur first then "triple"
- Where is monocular NPA? Facility?
- No NPC recovery noted
- NPC is only done 1x but her complaint is an endurance complaint, should be done 3-5x

Need Mac/GCL OCT for concussion

What are you taking the fundus image of?
- Recommend disc photos if any photos

Patient is on 4 medications that cause dry eye and migraine/sleep dysfunction is highly correlated with dry eye
* Needs vital dye stain

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Pathophysiology

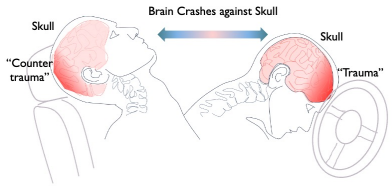

Image courtesy of Jacqueline Theis

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Traumatic Brain Injury - Pathophysiology

- Primary traumatic brain damage
  - Mechanical forces → tissue deformation AT the moment of injury
  - Direct damage to blood vessels, axons, neurons, glia, etc
  - Diffuse axonal injury (DAI)/vascular injury (DVI)
  - Focal Injury
    - Vascular (intracerebral, subdural, extradural, subarachnoid injury)
    - Axonal injury
    - Contusion
    - Laceration
- Secondary traumatic brain damage
  - Complication of primary damage
  - Ischemic and hypoxic damage, cerebral swelling, increased intracranial pressure, infection, etc
- Most often: Coup and contrecoup force due to impact of brain within the skull
  - More severe force→ subdural/epidural hemorrhage, subarachnoid hemorrhage, shearing of nerve fibers
- Repeat trauma can lead to chronic traumatic encephalopathy
  - Deposition of tau protein → may lead to neurodegeneration

Diffuse or Focal axonal injury
Neuroinflammation
Autonomic dysregulation
Sensory (dys)integration

Reilly P, Bullock R. Head Injury 2ed: Pathophysiology and Management, CRC Press 2005 Taylor and Francis, Florida

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Concussion Is a Systems Injury

Visual, vestibular, cognitive, and autonomic systems are tightly linked.

Concussion Subtype Classification

- Cognitive
- Oculomotor
- Headache/migraine
- Vestibular
- Anxiety/mood
- Concussion-associated conditions
  - Sleep disturbance
  - Cervical strain

Lumba-Brown A et al. Concussion Guidelines Step 2: Evidence for subtype classification. *Neurosurgery*. 2020;86(1):2-13.

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Why Vision Is Vulnerable After Concussion

- High metabolic demand
- Distributed neural networks
- Eye–head–body coupling through vast overlapping vestibular-cervical-oculomotor networks

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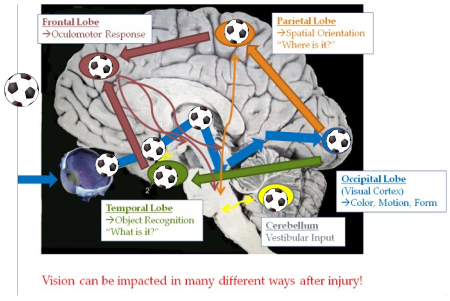
Visual Pathways in the Brain



Vision can be impacted in many different ways after injury!

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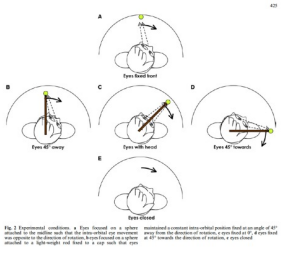
Cervical-Oculomotor Connection



Bexander CS, Hodges PW. Effect of gaze direction on neck muscle activity during cervical rotation. *Exp Brain Research*. 2005. 167:422-432

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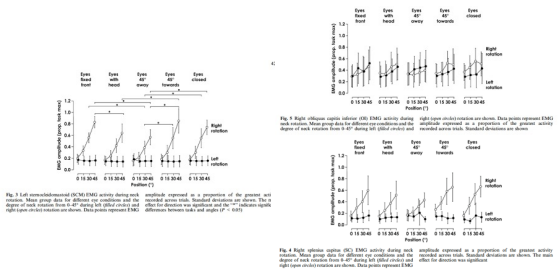
Cervical-Oculomotor Connection



Bexander CS, Hodges PW. Effect of gaze direction on neck muscle activity during cervical rotation. *Exp Brain Research*. 2005. 167:422-432

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Prevalence of Cervical Spine Injury + Concussion

- **In Pediatrics:**
  - 32.5% of those referred to a tertiary care center for concussion or suspected concussion also had cervical spine dysfunction
- **In Pediatrics and Adults:**
  - 9-13% of those presenting to the ED also had a neck injury
  - Neck injury was 2.89 times more prevalent in MVC related concussions
  - Neck injury was more prevalent in females 5 - 49 yo for all types of related concussion

Slide courtesy of Sara Etheredge DPT

Ellis, Michael J., et al. "Cervical Spine Dysfunction Following Pediatric Sports-Related Head Trauma." *Journal of Head Trauma Rehabilitation*, vol. 34, no. 2, 2019, pp. 103–110., https://doi.org/10.1097/htr.0000000000000451.

Sutton, Mitchell, et al. "Neck Injury Comorbidity in Concussion-Related Emergency Department Visits: A Population-Based Study of Sex Differences across the Life Span." *Journal of Women's Health*, vol. 28, no. 4, 2019, pp. 473–482., https://doi.org/10.1089/jwh.2018.7282

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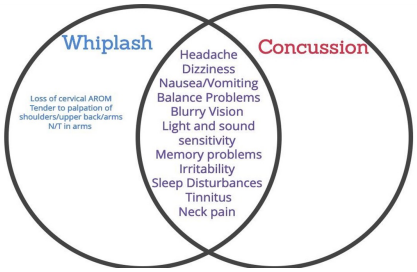
Symptomatology of Whiplash & Concussion



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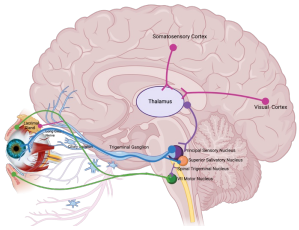
Direct Activation of Trigeminal Afferent Pathway (V1)



- 1st order Trigeminal afferents innervate the conjunctiva, cornea, eyelid → sends signal to **cell body** in Trigeminal nucleus → axons project to the trigeminal brainstem nuclei
  - Spinal trigeminal nucleus
    - Thermoceptive and nociceptive fibers
  - Principal sensory nucleus
    - Fine touch and pressure fibers
- 2nd order neuron: → thalamus
  - Join the contralateral spinothalmic pathway
- 3rd order → Somatosensory cortex
  - Supraspinal centers include somatosensory cortex

Image courtesy of Jacqueline Theis created in BioRender

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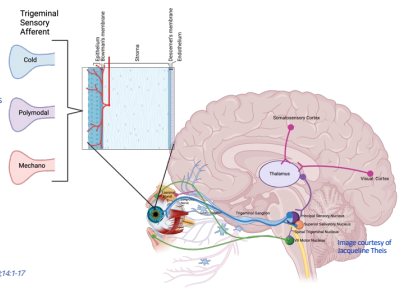
Corneal Blink Reflex – Light Sensitivity + Dry Eye

1) Reflexive Blink
   - Bilateral Symmetric Contraction of Orbicularis Oculi
2) Tear
   - Lacrimal Gland
   - Meibomian Glands



Guerrero-Moreno et al. Front. Cell. Neurosci. 2020;14:1-17
Muller et al. Exp Eye Res. 2003;76:521-542
Yang AY et al. Yale J Bio Med. 2018;91:13-21

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Common Visual Symptoms in Concussion

Physical	Mental	Emotional
• Loss of Consciousness <30 seconds	• Confusion	• Irritable
• Post-traumatic amnesia <24 hours	• Memory problems	• Easy to anger or upset
• Dizziness	• Disorientation	• Nervous
• Headache	• Inability to concentrate	• Anxious
• Disorientation	• Inability to think clearly	• Sadness
• Balance problems	• Mental fogginess	• Depression
• Nausea	• Inattention	• Crying more than normal
• Vomiting	• Loss of focus	• Lack of interest in usual activities
• Sensitivity to noise		
• Sensitivity to light		
• Blurred Vision		
• Double Vision		
• Tingling		
• Fatigue/Drowsiness		

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Convergence Insufficiency Symptom Survey (CISS)

		None	Just very rarely (Rarely)	Sometimes	Fairly often	Always
1.	Do your eyes feel tired when reading or doing close work?					
2.	Do your eyes feel uncomfortable when reading or doing close work?					
3.	Do you have headaches when reading or doing close work?					
4.	Do you feel sleepy when reading or doing close work?					
5.	Do you lose concentration when reading or doing close work?					
6.	Do you have trouble remembering what you have read?					
7.	Do you have double vision when reading or doing close work?					
8.	Do you see the words move, jump, swim or appear to float on the page when reading or doing close work?					
9.	Do you feel like you read slowly?					
10.	Do your eyes ever hurt when reading or doing close work?					
11.	Do your eyes ever feel sore when reading or doing close work?					
12.	Do you feel a "pulling" feeling around your eyes when reading or doing close work?					
13.	Do you notice the words blurring or coming in and out of focus when reading or doing close work?					
14.	Do you lose your place while reading or doing close work?					
15.	Do you have to re-read the same line of words when reading?					
		__ x 0	__ x 1	__ x 2	__ x 3	__ x 4

Total Score: _____

Figure 1.12 Symptom Survey
Clinician instructions: Read the following subject instructions and then each item exactly as worded. Circle subject responds with "yes" (please qualify with frequency choices. Do not give examples.
Subject instructions: Please answer the following questions about how your eyes feel when reading or doing close work.

- Mitchell G, Scheiman M, Borsting E, et al. Evaluation of a symptom survey for convergence insufficiency patients. *Optom Vis Sci* 2001;12:37
- Borsting EJ, Rouse MW, Mitchell GL, et al. Validity and reliability of the revised convergence insufficiency symptom survey in children aged 9-18 years. *Optom Vis Sci* 2003;80:832–8.
- CITT. The convergence insufficiency treatment trial: design, methods and baseline data. *Ophthalmic Epidemiol*. 2008;15(1):24-36

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Brain Injury Vision Symptom Survey (BIVSS) Questionnaire

SYMPTOM CHECKLIST *Circle a number below:*

Please rate each behavior. How often does each behavior occur? (circle a number)	Never	Seldom	Occasionally	Frequently	Always
EYESIGHT CLARITY					
Distance vision blurred and not clear – even with lenses	0	1	2	3	4
Near vision blurred and not clear – even with lenses	0	1	2	3	4
Clarity of vision changes or fluctuates during the day	0	1	2	3	4
Poor night vision / can't see well to drive at night	0	1	2	3	4
VISUAL COMFORT					
Eye discomfort / sore eyes / eyestrain	0	1	2	3	4
Headaches or dizziness after using eyes	0	1	2	3	4
Eye fatigue / very tired after using eyes all day	0	1	2	3	4
Feel "pulling" around the eyes	0	1	2	3	4
DOUBLING					
Double vision – especially when tired	0	1	2	3	4
Have to close or cover one eye to see clearly	0	1	2	3	4
Print moves in and out of focus when reading	0	1	2	3	4
LIGHT SENSITIVITY					
Normal indoor lighting is uncomfortable – too much glare	0	1	2	3	4
Outdoor light too bright – have to use sunglasses	0	1	2	3	4
Indoors fluorescent lighting is bothersome or annoying	0	1	2	3	4
DRY EYES					
Eyes feel "dry" and sting	0	1	2	3	4
"Stare" into space without blinking	0	1	2	3	4
Have to rub the eyes a lot	0	1	2	3	4
DEPTH PERCEPTION					
Clumsiness / misjudge where objects really are	0	1	2	3	4
Lack of confidence walking / missing steps / stumbling	0	1	2	3	4
Poor handwriting (spacing, size, legibility)	0	1	2	3	4
PERIPHERAL VISION					
Side vision distorted / objects move or change position	0	1	2	3	4
What looks straight ahead--isn't always straight ahead	0	1	2	3	4
Avoid crowds / can't tolerate "visually-busy" places	0	1	2	3	4
READING					
Short attention span / easily distracted when reading	0	1	2	3	4
Difficulty / slowness with reading and writing	0	1	2	3	4
Poor reading comprehension / can't remember what was read	0	1	2	3	4
Confusion of words / skip words during reading	0	1	2	3	4
Lose place / have to use finger not to lose place when reading	0	1	2	3	4

Laukkanen H, Scheiman M, Hayes JR. Brain Injury Vision Symptom Survey (BIVSS) Questionnaire. *Optom Vis Sci.* 2016;94(1):43-50.

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Vision Quality of Life with Time Survey (VisQuaL-T)

Activities Important to You	0 – 15 min	15 – 30 min	30 – 45 min	60+ min	N/A
Read for pleasure?	0	1	2	3	N/A
Study for a test / examination?	0	1	2	3	N/A
Complete homework?	0	1	2	3	N/A
Complete work in an office setting? (i.e. reading / writing / typing reports)	0	1	2	3	N/A
Be in crowded locations? (i.e. malls, train station, airports, meetings, busy walkways, etc.)	0	1	2	3	N/A
Tolerate habitual lighting in a classroom or workplace?	0	1	2	3	N/A
Use a smartphone / tablet?	0	1	2	3	N/A
Play a computer / console video game?	0	1	2	3	N/A
Use a computer or laptop for general purposes? (i.e. email, Facebook, etc.)	0	1	2	3	N/A
Watch a show / movie on a screen larger than 9"? (iPad Pro or larger)	0	1	2	3	N/A
Additional Activity 1: _____	0	1	2	3	N/A
Additional Activity 2: _____	0	1	2	3	N/A
Additional Activity 3: _____	0	1	2	3	N/A
	__ x 0	__ x 1	__ x 2	__ x 3	N/A

Total: _____

Y-Score (Total / number of questions answered): _____

Dungan ME, Scheiman M, Yaramothu C. Vision Quality of Life with Time Survey: Normative Data and Repeatability. Clin Optom (Auckl). 2023 Sep 12;15:205-212. doi: 10.2147/OPTO.S406407. PMID: 37719026; PMCID: PMC10505015.

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Combined Prevalence of Visual Dysfunctions in TBI

- All TBI
  - Accommodative dysfunction 42.8% (31-54.7%)
  - Convergence Insufficiency 36.3% (28.2-44.9%)
  - Visual field Loss 18.2% (10.6-27.1%)
    - Moderate to severe TBI 39.8% (29.8-50.3%)
  - Visual Acuity Loss(20/200 or worse) – 0% (0.-1.1%)
    - Moderate to severe TBI 3.2% (0.3-9.3%)
- Mild TBI
  - Accommodative Dysfunction 43.2% (29.2-57.7%)
  - Convergence Insufficiency 37.2% (24.3-51.1%)
  - Visual field loss 6.6% (0-19.5%)
  - Visual acuity loss of 20/200 or worse – 0%

- *Possible association of LOC with severity of visual symptoms*

Merezhinskaya N, Mallia RK, Park D, Bryden DW, Mathur K, Barker FM 2nd. Visual Deficits and Dysfunctions Associated with Traumatic Brain Injury: A Systematic Review and Meta-analysis. Optom Vis Sci. 2019 Aug;96(8):542-555.

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Reduced Convergence in Concussion is Common

- 24% - 89% of patients have convergence insufficiency post-concussion
  - ~50% self-recover within 4.5 weeks
  - ~40% recover with vision therapy in 11 weeks post-injury
  - ~10% recover with vision therapy 23 weeks post-injury

Storey EP, Master SR, Lockyer JE, et al. Near point of convergence after concussion in children. Optom Vis Sci. 94(1):96-100

Goodrich GL, Flyg HM, Kirby J, Chang CY, Martinsen GL. Mechanisms of TBI and Visual Consequences in Military and Veteran Populations. Optom Vis Sci 2013: 90:105-12

Pearce KL, Sufrinko A, Lau BC, et al. Near point of convergence after a sport-related concussion: measurement reliability and relationship to neurocognitive impairment and symptoms. Amer J Sports Med. 2015. XX(X)

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Symptom Pattern Recognition

- Stop memorizing diagnoses.
- Start recognizing symptom clusters.

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Reduced NPC alone is not necessarily "Convergence Insufficiency"

- N=83, patients <21 years old, >28 days postconcussion with chronic concussion-related symptoms
- 89% (74) had reduced NPC
  - 95% had oculomotor disorders
  - 41% had accommodative disorders only
  - 28% had accommodative AND convergence insufficiency
  - 8% had convergence insufficiency (as defined by CITT)
  - 5% had nonspecific vergence dysfunction
  - 3% had convergence excess only
  - 1% had both convergence excess AND accommodative disorders
- Receded NPC present in majority of post-concussion patients
- Receded NPC is NOT synonymous with diagnosis of convergence insufficiency

Raghuram A, Cotter SA, Gowrisankaran S, Kanji J, Howell DR, Meehan WP, Shah AS. Postconcussion: Receded near point of convergence is not diagnostic of convergence insufficiency. *Amer J Ophthalmol*. 2019: 235-244

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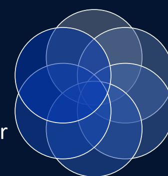
READING INTOLERANCE

Reading involves multiple regions of the brain



Visual Perceptual

Visual

Auditory Processing

Language

Oculomotor control

Cervical Stability

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Reading Intolerance Visual Processing & Oculomotor Cluster

Bonus: Ergonomics & Cervical Stability

Comprehend the text
- Language & Memory
- Sensory integration
- Visualization/Form Constancy/Spatial Relations

Recognize the text
- Visual Discrimination
- Visual Memory
- Visual Sequential Memory
- Visual Figure Ground

Need BOTH eyes conjugately track it
- Saccadic dysfunction (dysmetria/disconjugacy/fatigue)

Need BOTH Eyes to accurately point to it
- Ocular Posture (at near)
- Proximal CI (NPC)
- Fusional CI/CE (Fusional Vergences)
- *Vergence Infacility (Prism flippers)*

Need EACH Eye to See it
- Uncorrected Refractive Error
- Accommodative dysfunction (NPA/Facility)
- Fixational Eye Movements Abnormality
- Dry Eye

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Motion Sensitivity Cluster

Bonus: Ergonomics & Cervical Stability

Both Eyes need to stabilize images when the HEAD or BODY is in Motion
- VOR
  - Translational
  - Rotational

Both eyes need to stabilize images when Image is in motion
- Smooth Pursuit
- OKN

Both Eyes need to be Focused Accurately and Stably
- Accommodative Spasm
- Fixational Eye Movement Abnormality

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Symptom Clusters

Light Sensitivity
- Migraine (FL41)
- Cervicogenic Headache (Blue tints)
- Glare Sensitivity
  - Cervicogenic
  - Dry Eye
- Dark Adaptation
- Neuralgia
- Psychologic/Stress
- Sleep Deprivation

Diplopia
- Strabismus
- Convergence insufficiency
- Convergence Excess
- Accommodative Dysfunction

Visual Fatigue & Cognitive Fog
- Oculomotor Endurance
  - Accommodation
  - Convergence
  - Saccades
  - VOR/COR
- Cervicogenic Headache
- Dysautonomia/POTS
- Neuro-Endocrine Disorder
- Sleep dysfunction/apnea
- Nutritional imbalance
- Medication SE

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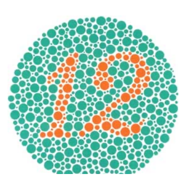
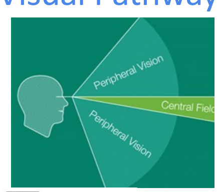
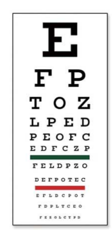
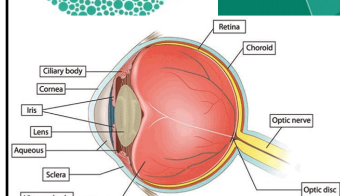
Afferent Visual Pathway – CN II









Barnett BP, Singman EL. Vision concerns after mild traumatic brain injury. *Curr Treat Options Neurol*. 2015;17:5 (1-14).

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Hands-On Demo #1: Accommodation

Equipment:
- Accommodative/Convergence Ruler

Accommodation
- Near Visual Acuity OD/OS
- Monocular NPA Testing x 3
  - 1 line suprathreshold
  - Norms (DS): 15-age/4
    - 1/DS = cm
  - Symptom Provocation?
- Monocular Facility
  - +/-1.50 if >13yo
  - +/-2.0 if ≤13yo
  - Norms: 12cpm
  - Symptom Provocation?
- Monocular Near/Far Screen

Patient Case
- Near VA
  - OD: 20/30
  - OS: 20/40
- NPA
  - OD: 16, 18, 20, 23, 25
    - (using 20/40 target)
    - (+) fatigue
  - OS: 21, 26, 27, 28, 29
    - (using 20/50 target)
    - (+) nausea/dizziness
  - Expected: 15-(38/4) = 5.5DS (18.18cm)

Diagnosis:
- Accommodative insufficiency OS>OD

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Hands-On Demo #1: Accommodation

Equipment:
- Accommodative Flippers

Accommodation
- Near Visual Acuity OD/OS
- Monocular NPA Testing x 3
  - 1 line suprathreshold
  - Norms (DS): 15-age/4
    - 1/DS = cm
  - Symptom Provocation?
- Monocular Facility
  - +/-1.50 if >13yo
  - +/-2.0 if ≤13yo
  - Norms: 12cpm
  - Symptom Provocation?
- Monocular Near/Far Screen

Patient Case
- Near VA
  - OD: 20/30
  - OS: 20/40
- Monocular Facility
  - OD: Can't clear + or -
    - (using 20/40 target)
    - (+) fatigue/headache/nausea
  - OS: Can't clear -
    - (using 20/50 target)
    - (+) nausea/dizziness

Diagnosis:
- Accommodative insufficiency OS>OD
- Accommodative infacility OU
- Accommodative spasm OD

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HBO - Accommodation

- Monocular Pushups
  - Cover one eye. Bring the target as close to you as possible until it gets blurred. Try to clear past first blur if possible. When unable to push further, move it back just enough until it's clear again. Repeat 10 times or your symptoms are 7/10. Switch eyes
- Monocular Near/Far Hart Chart
  - Cover one eye. Put the large chart on the wall about 3 feet away. Hold the smaller chart in front of you at normal reading distance. Focus on the first letter of the first row of the small chart. When it is clear, change your focus to the first letter of the first row of the distance chart. When it clears, change your focus to the second letter of the small chart. Continue until you finish one chart or your symptoms are 7/10.

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VIRGINIA NEURO-OPTOMETRY

HBO - Accommodation

	1	2	3	4	5	6	7	8	9	10
A	O	F	N	P	V	D	T	C	H	E
B	Y	B	A	K	Q	E	Z	L	R	X
C	E	T	H	W	F	M	B	K	A	P
D	B	J	F	R	T	O	S	M	V	C
E	R	A	D	V	S	X	P	E	T	O
F	M	P	O	E	A	N	C	B	I	F
G	C	R	G	D	B	K	E	P	M	A
H	F	X	P	S	M	A	R	D	L	G
I	I	M	U	A	J	S	Q	G	P	B
J	H	O	S	N	C	T	K	U	Z	L

MEDIUM

	1	2	3	4	5	6	7	8	9	10
A	O	F	N	P	V	D	T	C	H	E
B	Y	B	A	K	Q	E	Z	L	R	X
C	E	T	H	W	F	M	B	K	A	P
D	B	J	F	R	T	O	S	M	V	C
E	R	A	D	V	S	X	P	E	T	O
F	M	P	O	E	A	N	C	B	I	F
G	C	R	G	D	B	K	E	P	M	A
H	F	X	P	S	M	A	R	D	L	G
I	I	M	U	A	J	S	Q	G	P	B
J	H	O	S	N	C	T	K	U	Z	L

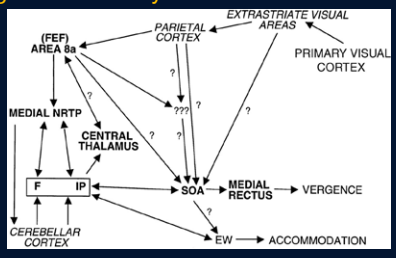
Small

Pearls:
1) Start with Distance/Medium Charts
2) Make small 5x5 charts if has trouble with crowding

34

VIRGINIA NEURO-OPTOMETRY

Vergence Pathway



Gamlin P. Neural Mechanisms for the Control of Vergence Eye Movements. Ann N Y Acad Sci. 2002 Apr;856:264-72

35

VIRGINIA NEURO-OPTOMETRY

Hands-On Demo #2: Vergence - Proximal

Equipment:
- Accommodative/Convergence Ruler
- Horizontal/Vertical Prism Bars

Vergence
- NPC Testing Break/Recovery x 3
  - 2-3 line suprathreshold isolated target
  - Norms: 6/8 x 3
  - Symptom Provocation?
- Cover Test:
  - DCT: 0-2XP
  - NCT: 0-6XP
- Fusional Vergences Norms:
  - BID: x/4/2
  - BOD: x/6/4
  - BIN: x10/8
  - BON: x/16/14
  - Vertical: 3/2
  - Symptom Provocation?

Patient Case
- NPC
  - 6/8, 10/15, 12/25
  - (+) dizziness/nausea

Diagnosis:
- Proximal Convergence Insufficiency
- Reduced recovery
- Fatigue effect

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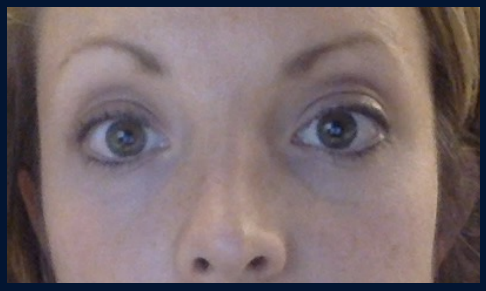
VIRGINIA NEURO-OPTOMETRY

NPC (Near Point of Convergence)



37

VIRGINIA NEURO-OPTOMETRY

Hands-On Demo #2: Vergence – Fusional

Equipment:
- Accommodative/Convergence Ruler
- Horizontal/Vertical Prism Bars

Vergence

- NPC Testing Break/Recovery x 3
  - 2-3 line suprathreshold isolated target
  - Norms: 6/8 x 3
  - Symptom Provocation?
- Cover Test:
  - DCT: 0-2XP
  - NCT: 0-6XP
- Fusional Vergences Norms:
  - BID: x/4/2
  - BOD: x/6/4
  - BIN: x10/8
  - BON: x/16/14
  - Vertical: 3/2
  - Symptom Provocation?

Patient Case

- Cover Test
  - DCT: Ortho, 0-1LHyper
  - NCT: 2XP
- Fusional vergences
  - BID: x/2/0
  - BOD: x/14/10 (+) dizziness
  - BUD: 1/0, BDD: 1/0
  - BIN: x/6/4
  - BON: x/20/15 (+) dizziness

Diagnosis:
- Exophoria – basic type (normal)
- Trace vertical phoria
- Proximal CI (+) Fatigue/Reduced recovery
- Fusional Convergence Excess
- Tight fusional vergence ranges

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VIRGINIA NEURO-OPTOMETRY

Hands-On Demo #2: Vergence – Facility

Equipment:
- Fused Prism
- Prism Flippers
- OMAT

Vergence Facility

- Fused Prisms
  - D: 2BI/6BO
  - N: 3BI/12BO
  - Norms: 16cpm
  - Symptom provocation?
- OMAT

Patient Case

- Vergence Facility
  - D6/2: unable to fuse 2BI
  - N3/12: 3cpm
  - (+) dizziness/nausea
- OMAT
  - 4/2/0/0
  - (+) dizziness/nausea

Diagnosis:
- Exophoria – basic type (normal)
- Trace vertical phoria
- Proximal CI (+) Fatigue/Reduced recovery
- Fusional Convergence Excess
- Tight fusional vergence ranges
- Vergence infacility

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VIRGINIA NEURO-OPTOMETRY

OculoMotor Assessment Tool Test

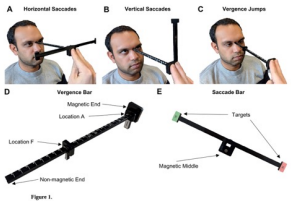

Figure 1.

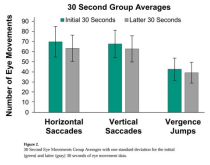

Figure 2.
30 Second Eye Movements Group Averages with one standard deviation for the initial (green) and latter (grey) 30 seconds of eye movement data.

Yaramothu C, Morris CJ, d'Antonio-Bertagnolli JV, Alvarez TL. OculoMotor Assessment Tool Test Procedure and Normative Data. Optom Vis Sci. 2021 Jun 1;98(6):636-643. doi: 10.1097/OPX.0000000000001698. PMID: 34039908; PMCID: PMC8205981.

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VIRGINIA NEURO-OPTOMETRY

HBO - Vergences

- Binocular Pushups
  - Target: *1 bead brock string*, or Near hart chart or dot on a business card for presbyopes
  - With both eyes open, look at the target held at arms length. Slowly bring the target towards you until you see double (blur is okay). Slowly pull the target away from you until you see one target.
  - Goals: break at 5cm, recover quickly at 7 cm, asymptomatic
- Binocular Near/Far Hart Chart

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VIRGINIA NEURO-OPTOMETRY

Saccades and Reading

Cal has really great athletes. They are smart and enjoy going to class and to practice. When they are not on the field they are in the library.

Cal has really great athletes. They are smart and enjoy going to class and to practice. When they are not on the field they are in the library.

Observe accuracy, speed, fatigue, and symptom provocation

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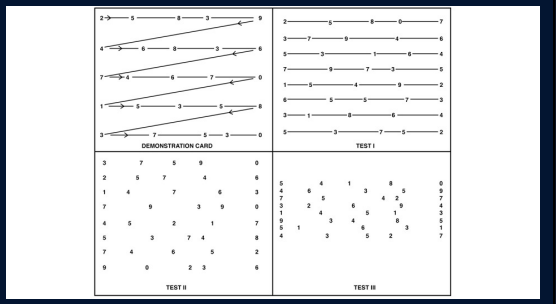
VIRGINIA NEURO-OPTOMETRY

King-Devick



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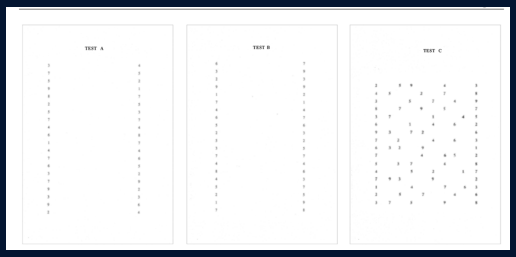
VIRGINIA NEURO-OPTOMETRY

Developmental Eye Movement (DEM) Test



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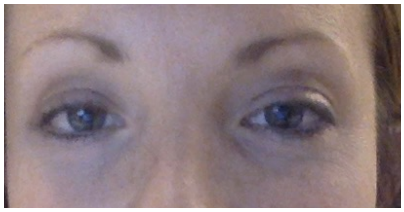
VIRGINIA NEURO-OPTOMETRY

Normal Saccades



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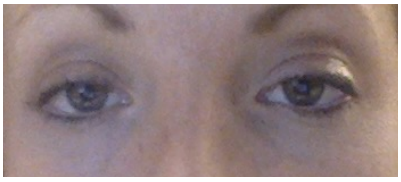
VIRGINIA NEURO-OPTOMETRY

Abnormal Saccades: Hypometric/Hypermetric (Accuracy) Slow (Speed)



Symptoms: Difficulties reading, difficulties "tracking", losing place while reading, re-reading

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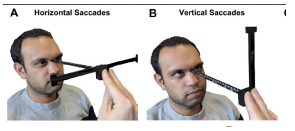
VIRGINIA NEURO-OPTOMETRY

Abnormal Saccades: Endurance

- OMAT



Test	Time interval	Average no. eye movements	Normal range (1 SD)
Horizontal saccades	Initial 30 s	69.9 ± 15.0	55–85
	Latter 30 s	63.4 ± 13.0	50–76
	60 s	133.3 ± 27.0	106–160
Vertical saccades	Initial 30 s	67.8 ± 13.5	54–81
	Latter 30 s	62.9 ± 13.0	50–76
	60 s	130.7 ± 25.6	105–156

Yaramothu C, Morris CJ, Antonio-Bertagnolli JV, Alvarez T. OculoMotor Assessment Tool Test Procedure and Normative Data. Optom Vis Sci 2021.

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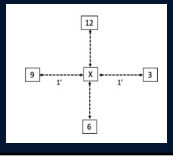
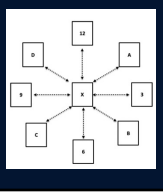
VIRGINIA NEURO-OPTOMETRY

HBO - Saccades

- Wall-Clock saccades
  - Place 12 post-it notes on the wall in a circle like a clock and 1 post-it note in the middle. Place an X in the center post-it note: Move your eyes as quickly as you can from the Center post-it note to each "clock" post it note as quickly as you can. Ex: Center to 12 oclock, center to 1 oclock, center to 2 oclock. Complete 1-2 minutes (or 7/10) symptoms then go counterclockwise
  - How to make it harder:
    - Put numbers in the sticky notes
    - Use smaller sticky notes/numbers
    - Perform with balance task
    - Add music/background noise
  - Goals: No symptoms





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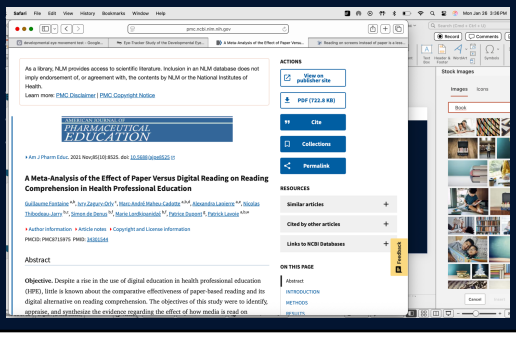
VIRGINIA NEURO-OPTOMETRY

Why Screens are Worse than Paper



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VIRGINIA NEURO-OPTOMETRY

Why Screens are Worse than Paper

- Binocular instability
- Tactile memory reinforcement
- Saccades in Free space
- Cognitive/Visual Load
- Scroll/Pursuit Demand
- Ergonomics
- Visual Motion

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VIRGINIA NEURO-OPTOMETRY

Smooth Pursuit

- Symptoms of Pursuit Dysfunction
  - Visual motion sensitivity
  - Dizziness/Nausea in the car
  - Difficulty with scrolling on the computer/phone

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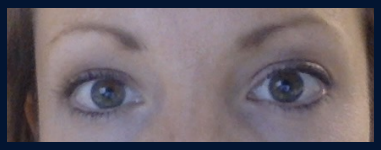
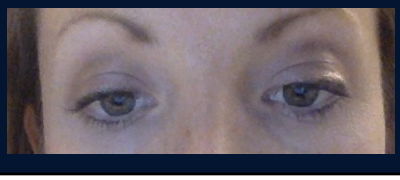
VIRGINIA NEURO-OPTOMETRY

Normal Smooth Pursuits



Abnormal Pursuits (i.e. Saccadic Intrusions)



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VIRGINIA NEURO-OPTOMETRY

HBO - Pursuits

- Smooth Pursuits
  - Sit comfortably in a chair, facing a blank wall. Hold onto a target (pen, dot on a business card, your finger). SLOWLY move the target side by side and up and down in a Cross and/or figure H pattern until symptomatic 7/10, then stop. Repeat
  - How to make it harder
    - Use a smaller target
    - Perform in a circle/figure 8 (integration)
    - Add balance
  - Goals: No symptoms

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VIRGINIA NEURO-OPTOMETRY

HBO – Visual Motion

- Perform Smooth pursuits with a crowded background (pictures on the wall, TV in the background).
- Add Dual Sound Tasking

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VIRGINIA NEURO-OPTOMETRY

Pathophysiology of FEMs

BRAIN STRUCTURE	ROLE
OMNIPAUSE NEURONS in PPRF	• Sustained firing during fixation • Inhibitory influence on Saccades
SUPERIOR COLLICULUS	• Contains retinotopic map • Bursts during saccades to re-foveate
MEDIO-POSTERIOR CEREBELLUM	• Determine exact direction of gaze • Adaptive control of gaze
CEREBRAL CORTEX • Frontal eye fields • Parietal/frontal cortex	• Subcortical control

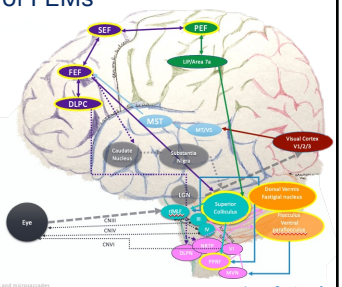

Image Courtesy of Jacqueline Theis

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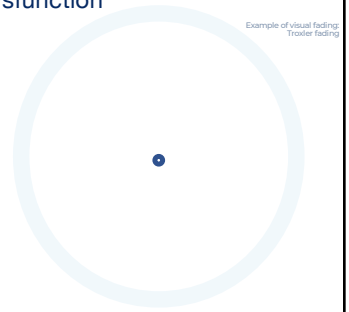
VIRGINIA NEURO-OPTOMETRY

Symptoms of FEM Dysfunction

If the eyes **do not move enough**

THEN

VISUAL LOSS due to neural adaptation and visual fading



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VIRGINIA NEURO-OPTOMETRY

Symptoms of FEM Dysfunction

If the eyes **move too much**

THEN

Blurred and unstable vision

The goal of FEMs is to overcome neural adaptation while maintaining
(1) precision vision and
(2) optimize visual processing

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VIRGINIA NEURO-OPTOMETRY

VOR – Vestibular Ocular Reflex (From the Eye's perspective)

- Stabilizes images on the retina during head movements
  - Eye movement in an equal velocity (gain)/opposite direction of head movement
- Involves
  - Vestibular (afferent/efferent)
  - Oculomotor (efferent)

- If the image slips on the retina (blurs) then VOR must adapt to stabilize the image on the retina to see

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VIRGINIA NEURO-OPTOMETRY

VOR

- Dynamic Visual Acuity Test
  - Shake head side to side and read a letter chart
  - Normal
    - Able to read 1 line above threshold
    - Asymptomatic
  - Abnormal
    - Able to read ≥2 lines above threshold due to blur
    - Symptomatic – oscillopsia, headache, nausea, dizziness, etc

- Other Tests down in Physical Therapy
  - Head Thrust Test
  - Head Shake Nystagmus Test

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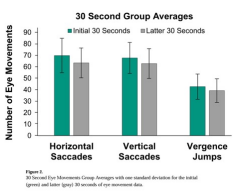
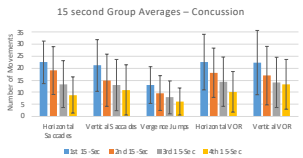
VIRGINIA NEURO-OPTOMETRY

OculoMotor Assessment Tool Test





Yaramothu C, Morris CJ, d'Antonio-Bertagnolli JV, Alvarez TL. OculoMotor Assessment Tool Test Procedure and Normative Data. Optom Vis Sci. 2021 Jun 1;98(6):636-643. doi: 10.1097/OPX.0000000000001698. PMID: 34039908; PMCID: PMC8205981.

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VIRGINIA NEURO-OPTOMETRY

HBO - VOR

- *Only perform if no neck problems – otherwise refer!*
- VOR – 2 targets
  - Place two X targets on the wall side by side. Sit about 3 feet away. Look at/face target on the left. Move your eyes to the target on the right, then move your head towards the target on the right. Pause to regain stability, then switch to the leftward target. Repeat for 30 seconds then take a break
- VOR – 1 target
  - Place one target at the wall at eye level. Sit about 3 feet away. While maintaining your gaze straight ahead, slowly rotate your head side to side at a consistent speed until symptomatic or 30 seconds. Then stop, let symptoms resolve, then repeat
  - Goal: 8 reps of 30 seconds without symptoms
  - How to make it harder
    - Perform standing
    - Perform balancing on one leg
    - For athletes – perform on a stationary bike/elipitical (if physical activity is allowed by physician)

X

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VIRGINIA NEURO-OPTOMETRY

Prescribing Pearls – When Glasses don't Help

- Problems with Progressives
  - Exacerbate Vestibular Dizziness
  - Exacerbates Cervicogenic Dizziness/Headache
  - Does not fix asymmetric traumatic accommodative dysfunction
- Prism is a static solution to a dynamic problem ≠ cure
- Tints ≠ full-time solution

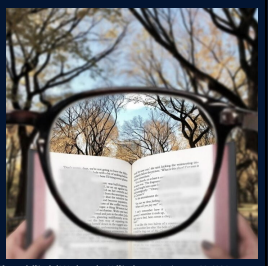

Image from https://cdn.shopify.com/s/files/1/0601/5415/1102/files/poressive-lenses-700x698.jpg

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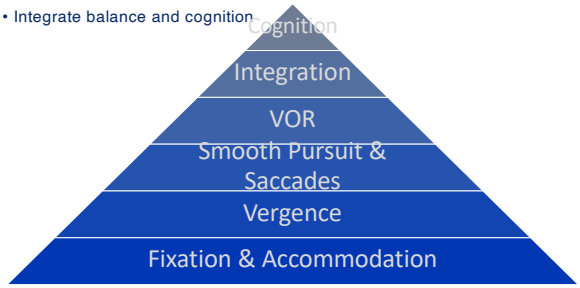
VIRGINIA NEURO-OPTOMETRY

Vision Rehabilitation Principles

- Start monocular
- Build tolerance
- Integrate balance and cognition



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TBI and Blue Light

> Neurobiol Dis. 2020 Feb;134:104679. doi: 10.1016/j.nbd.2019.104679. Epub 2019 Nov 18.

A randomized, double-blind, placebo-controlled trial of blue wavelength light exposure on sleep and recovery of brain structure, function, and cognition following mild traumatic brain injury

William D S Killgore [1], John R Vanuk [2], Bradley R Shane [2], Mareen Weber [2], Sahil Bajaj [2]

> J Head Trauma Rehabil. Sep/Oct 2020;35(5):E405-E421. doi: 10.1097/HTR.0000000000000579

Daily Morning Blue Light Therapy Improves Daytime Sleepiness, Sleep Quality, and Quality of Life Following a Mild Traumatic Brain Injury

Adam C Raikes [1], Natalie S Dailey, Bradley R Shane, Brittany Forbeck, Anna Alkozei, William D S Killgore

Affiliations + expand

PMID: 32472836 DOI: 10.1097/HTR.0000000000000579

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Blue Light and Circadian Rhythm/Alertness

- Light suppresses melatonin in humans – strongest response from short=wavelength light 446-477nm
- Blue monochromatic light shown to be more effective than longer-wavelength light for enhancing alertness

West, K. E., Jablonski, M. R., Warfield, B., Cecil, K. S., James, M., Ayers, M. A., Maida, J., Bowen, C., Sliney, D. H., Rollag, M. D., Hanifin, J. P., & Brainard, G. C. (2011). Blue light from light-emitting diodes elicits a dose-dependent suppression of melatonin in humans. *Journal of applied physiology (Bethesda, Md. : 1985)*, *110*(3), 619–626. https://doi.org/10.1152/japplphysiol.01413.2009

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Blue Light Blockers vs. Computer (Night-Mode) Modifications

- Compared the radiation produced by smartphones that reaches the eye when using night-mode functions vs blue light reducing lenses
- To determine impact they had on visual and nonvisual (circadian) parameters to compute a melatonin suppression value (MSV)
  - Night-mode functions reduced MSV by up to 93%
    - Warmest mode produced the least suppression
  - Blue light reducing spectacles reduced melatonin suppression by 33%
    - Coated lenses more efficient than tinted lenses

Teran, E., Yee-Rendon, C. M., Ortega-Salazar, J., De Gracia, P., Garcia-Romo, E., & Woods, R. L. (2020). Evaluation of Two Strategies for Alleviating the Impact on the Circadian Cycle of Smartphone Screens. *Optometry and vision science : official publication of the American Academy of Optometry*, *97*(3), 207–217. https://doi.org/10.1097/OPX.0000000000001485

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TBI Photophobia - Management

- Sunglasses outside OKAY
- Sunglasses inside
  - AVOID or ENCOURAGE?
  - ACUTE vs. CHRONIC?
  - Wearing dark glasses indoors → dark adaptation of the retina → aggravation of light sensitivity
- Visors/Hats
- Transitions Lenses
- Mild Tints
  - Wavelength matters
    - Rose
    - Blue
    - Blue-Blockers
- *Orthoptics?*

Katz BJ, Digre KB. Diagnosis, pathophysiology, and treatment of photophobia. *Surv Ophth*. 2016;61:466-477

Theis J. Differential diagnosis and theories of pathophysiology of post-traumatic photophobia: A review. NeuroRehabilitation. 2022;50(3):309-319. doi: 10.3233/NRE-228014. PMID: 35311724.

67

Common Clinical Pitfalls

- Over-prescribing prism
- Over-prescribing PALs
- Ignoring Endurance
- Ignoring Dry Eye
- Ignoring vestibular & cervical drivers
  - Not referring to PT/Psych/PMR

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REHAB PEARLS

REHAB PRIORITY ORDER (SEVERE CASES)

- Vestibular PT • BPPV
- Cervical PT • Manual Therapy • Pain Management • Balance
- Vision Therapy • Accommodation • Vergence
- Visuo-Vestibular Therapy • Saccades • Pursuits • Gentle VOR
- Cognitive OT/Speech
- Integrative Rehab • Intense VOR/balance • Sensory Integration

Priorities

1) Sleep
2) Pain
   1) Occipital Neuralgia
   2) Cervicalgia
3) Mood
   1) Anxiety
   2) Depression

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Red Flags You Should Not Miss

- True cranial nerve palsy
- RAPD
- Progressive or any visual field loss
- Papilledema
- Angle closure
- Flashes/Floaters – Retinal Tear/Detachment
- Traumatic Horner's

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Angle Closure

Medications that can Cause Angle Closure

- Anticholinergics/Antimuscarinics
  - Scopolamine Patches
  - Ipratropium, tiotropium (inhalers)
  - Oxybutynin, tolterodine, solifenacin (overactive bladder meds)
- Adrenergic/Sympathomimetic Agents
  - Phenylephrine (including decongestant eye drops)
  - Pseudoephedrine (Sudafed)
  - Ephedrine
  - Amphetamines & amphetamine-like stimulants (Adderall, Vyvanse, etc.)
  - Dopamine agonists
- Topiramate
- Antidepressents & Anxiolytics
  - SSRIs (sertraline, fluoxetine, escitalopram, citalopram, paroxetine)
  - SNRIs (venlafaxine, duloxetine)
  - TCAs (amitriptyline, nortriptyline, imipramine)
  - MAOIs
- Antihistamines
  - Diphenhydramine
  - Hydroxyzine
  - Loratadine, cetirizine, fexofenadine
- Antipsychotics
  - Cloozapine
  - Olanzapine
  - Quetiapine
  - Risperidone
  - Thioridazine

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VIRGINIA NEURO-OPTOMETRY

What Determines Concussion Resolution?

- Balance Recovery <7 days
- Symptom Scores 5-14 days
- Cognitive Recovery 7-21 days
- Oculomotor Recovery 21-28 days

Other Factors

- Litigation
- Worker's Compensation
- Individual Motivation (Athlete, Military)
- Age
- Gender
- Concussion History
- Premorbid Factors
- Injury Severity
- Type/Timing of Treatment

Collins M, Kontos A, Okonkwo D. et al. Statements of Agreement from the Targeted Evaluation and Active Management (TEAM) Approaches to Treating Concussion Meeting Held in Pittsburgh, October 15-16, 2015. *Neurosurgery*. Dec 2016;79(6):912-929.

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VIRGINIA NEURO-OPTOMETRY

Prognosis, Pitfalls, & Take Homes

- Concussion disrupts integration it takes a multi-disciplinary approach
  - Patients recover faster with targeted, active, evaluation and management
- If you don't know how to evaluate the oculomotor system – learn it or refer it – don't gaslight the patient
  - VT is an active treatment for concussion
- It's not just CI – Accommodative dysfunction occurs just as if not more commonly – even in presbyopes
- Single Vision modalities are your friend (and so am I)

Questions?

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