NEUROLOGIC VISUAL FIELD LOSS

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Concussion Care Centre | Virginia Neuro-Optometry | Intrepid

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Financial Disclosures - Dr. Theis

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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

All risks have been mitigated

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Objectives

- Provides a comprehensive overview of hemianopic and homonymous vision loss in patients with acquired brain injury and neurological disease
- Review the visual field loss patterns depending on the anatomical injury to the afferent visual pathway in the brain
- Provide diagnostic "chairside" and "bedside" methods to test hemianopsia when patients cant take a visual field
- Review novel treatment methodologies for hemianopsia

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Anatomy of the Afferent Visual Pathway

- Retina → Optic Nerve→ Chiasm
- After Optic Chiasm "Optic Tract"
  - 90% of fibers go to the Lateral Geniculate Nucleus (LGN)
  - 10% of fibers go to superior colliculus/pretectal nucleus to help control pupil responses or circadian rhythm
- After LGN "Optic Radiations" → Primary Visual Cortex

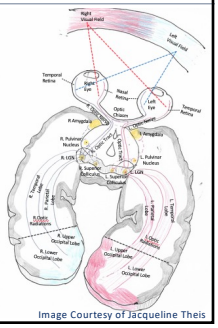

Image Courtesy of Jacqueline Theis

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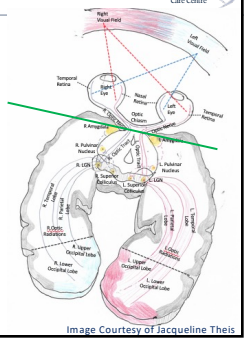
Anatomy of the Afferent Visual Pathway

- Pre-Chiasm = unilateral loss
  - Right eye vs. left eye
- Chiasm = bilateral, heteronymous loss
  - Bitemporal
- Post-Chiasm = bilateral, homonymous loss
  - Right side vs. left side



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Types of Visual Field Loss

- Absolute
  - Blind field, scotoma, patient is not able to consciously detect any stimulus
- Relative
  - Some detection for moving stimuli or stimuli with increased luminance
  - Usually at border of the lesion/scotoma
  - Can be found deep inside the blind field as islands of vision
- "Ocular"
  - Retina
  - Optic Nerve
- Neurological
  - Optic Chiasm
  - Optic Radiations
  - Occipital Lobe

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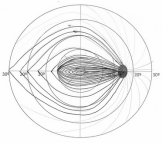
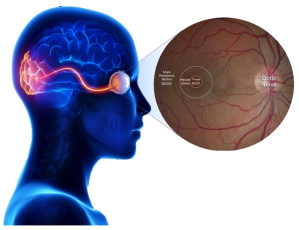
Types of Visual Fields

Central
- Amsler
- FDT
- HVF 10-2
- HVF 24-2
- HVF 30-2

Peripheral
- Goldmann
- Tangent Screen





- 60-70% of optic nerve fibers come from the central 30 degrees of the retina
- All other areas of the retina contribute to the "peripheral visual field"

Image Courtesy of Jacqueline Theis

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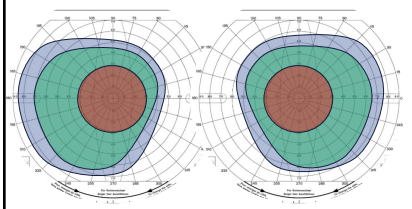
Types of Visual Fields



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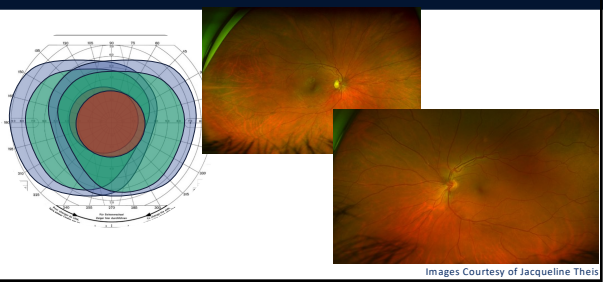
Types of Visual Fields



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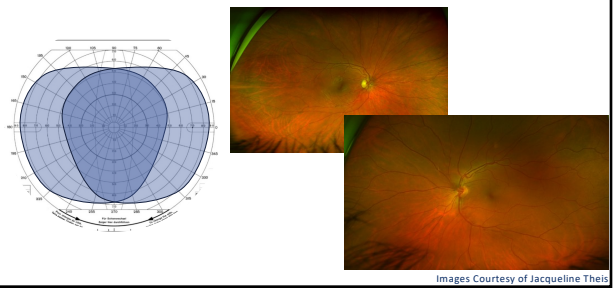
Binocular Visual Field



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Test Patterns and Strategies

Test Patterns	
5-2	5 degrees / 68-point grid Macula, retinal, neurological, advanced glaucoma, Plaquenil testing
10-2	10 degrees / 76-point grid Macula, retinal, neurological, advanced glaucoma, Plaquenil testing
24-2	24 degrees / 54-point grid Glaucoma, general, neurological Most cases will use the24-2 Pattern
24-2C	24 degrees / 64-point grid Glaucoma, general, neurological Many cases will use the 24-2C and 24-2 pattern
30-2	30 degrees / 76-point grid Glaucoma, retinal, neurological, general
Superior 36 (Ptosis HVF Template)	60 degrees, superior hemifield / 36-point grid Uses multiple Bottom LED fixation targets Fast Superior Field Screening, Ptosis
Superior 64 (Ptosis HVF Template)	60 degrees, superior hemifield / 64-point grid Uses multiple bottom LED fixation targets Superior Field Screening, Ptosis
Superior Kinetic (Ptosis Goldman Template)	60 degrees/ 8-point superior test Uses multiple LED fixation points Stimuli points fall from above into field of view
Esterman Binocular Visual Field	75 degrees / 120-point grid Uses multiple fixation points and tests both eyes at the same time
Full Field 120	60-degree eccentricity / 120-point grid Neurological exam

Test Strategies	
Full Threshold	6-9 minutes exam duration Rigorously tests all points in tested visual field
VRVF Standard	4-7 minutes exam duration A balanced testing method that is reliable, fast, and accurate
VRVF Fast	3.5-6 minutes exam duration A fast-testing method that is reliable, fast, and accurate
Screening	1-3 minutes exam duration Screening exams to find absolute and relative areas of defects
Suprathreshold (Ptosis)	The fastest test available To determine whether an absolute scotoma exists in patient visual field

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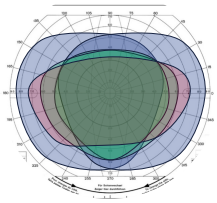
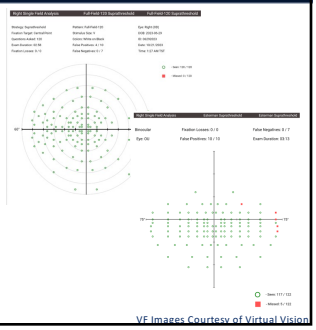
Binocular Visual Field





VF Images Courtesy of Virtual Vision

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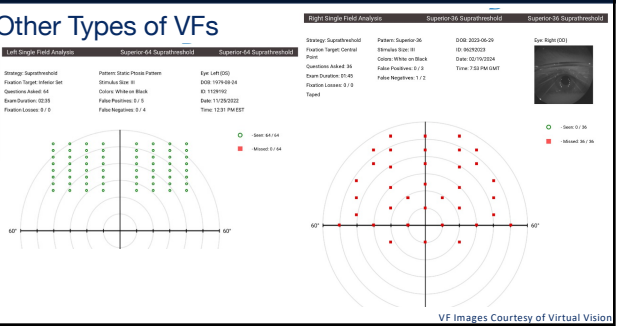
Other Types of VFs



VF Images Courtesy of Virtual Vision

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Changes in Technology

Virtual Reality Perimetry

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Changes in Technology

Hardware: More accessible for patients in wheel chairs or with spine pain/problems

Virtual Reality Perimetry

Software Customizable Features		
Instructions	Defaulted to ON Provides informative and brief pre-test tutorial and automated pre-test adjustments to patient	*Multi-lingual instructions
Binocular or Monocular Fixation	Defaulted to OFF Enables the fixation point to appear on both eyes during a monocular test For some patients, it may be more relaxing to fixate on this point when enabled	*Great for Unilateral Strabismus/ Eye-dominance issues with patching
Fixation Point Design	Defaulted to Standard (yellow circle) Provides alternative shapes and images to be used as a point of fixation and focus for the patient's gaze: Large Diamond, Small Diamond, Rocket Ship, or Flower	*Great for patients with low vision and peds
Foveal Threshold Testing	Defaulted to OFF Measuring light sensitivity in the patient's fovea in dB	
Self-Test Tutorials	Defaulted to OFF Provides automated pre-test adjustments and response times for patient	
Stimulus Speed (Reaction Response Times): Fast, Normal, Slow	Defaulted to Normal Provides alternative response times for patient Fast, Normal, Slow	*Great for patients with slow processing speed or hand-eye coordination

These modifications make visual fields more ADA/accessible to neurodiverse patient, aside from being super cool and saving your office space

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Ocular Visual Field Loss

Central Scotoma (spot missing)

- Macular Degeneration
- Macular Hole
- Macular Edema
- Macular Pucker (Epiretinal Membrane)

Peripheral Scotoma (Arcuate)

- Glaucoma – moderate stage
- Anterior Ischemic Optic Neuropathy
- Branch Retinal/Artery Vein Occlusion

Overall/Full Loss

- Glaucoma – severe stage
- Ischemic Optic Neuropathy
- Central Retinal/Artery Vein Occlusion
- Retinal Detachment
- Compressive optic neuropathy
  - within orbit

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Approximation of Degrees

At arm's length:

- 1 deg = 1 pinky finger
- 5 deg = 3 middle fingers
- 10 deg= 1 hands width

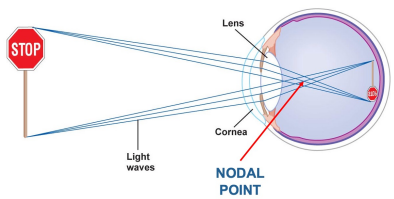

Image Courtesy of Chadwick Optical

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Pre-Chiasmal Neurological Visual Field Loss

"Ocular" Visual Field Loss

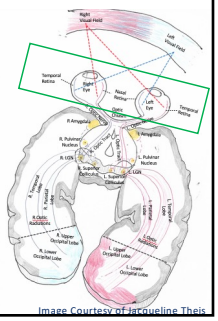

Image Courtesy of Jacqueline Theis

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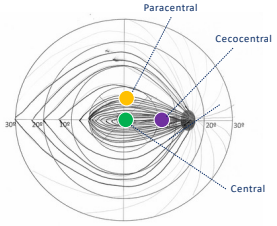
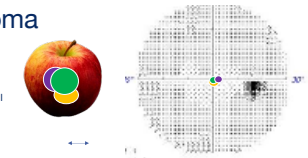
Unilateral Central Scotoma

Lesion: Macula





Superior Inferior

- "Respect" the horizontal midline

Difficulties:

- Detailed tasks – reading, sewing
- Facial recognition
- Driving if acuity is reduced

Modifiers

- Enlarge font
- Low Vision Optometrists

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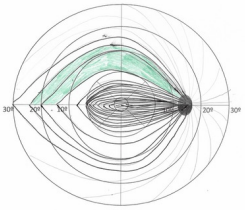
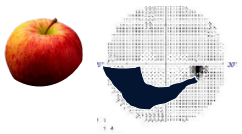
Unilateral "Peripheral" Scotoma



Lesion: Anterior Optic Nerve



Respects the horizontal midline

Difficulties:

- Ambulation – stairs, trees

Modifiers

- White cane training

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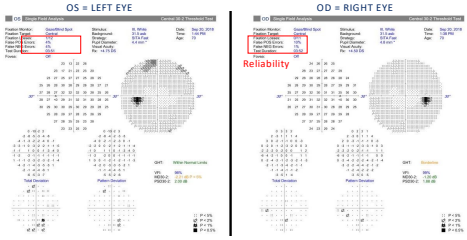
Automated Visual Field: Humphrey Visual Field 30-2

OS = LEFT EYE

OD = RIGHT EYE



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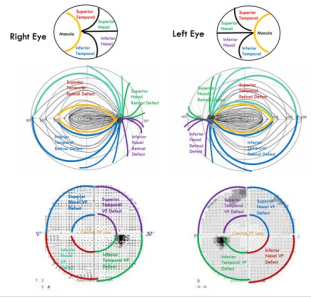
Retinal/Optic Disc Visual Field Loss

- Blind spot is on the side of that eye
  - Right side = right eye
  - Temporal retina
- Macular fibers take up 1/3 of the optic disc, even though it is only 1/20th of the retina
- Fibers from the peripheral retina are more superficial than those coming from the central retina



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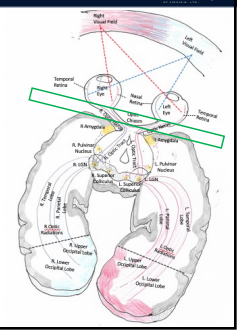
Pre-Chiasmal Optic Nerve Neurological Visual Field Loss



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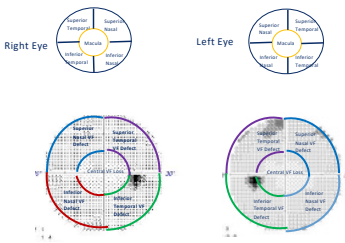
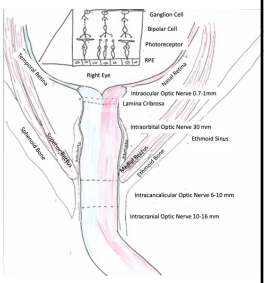
Optic Nerve Visual Field Loss (post-Lamina Cribrosa)





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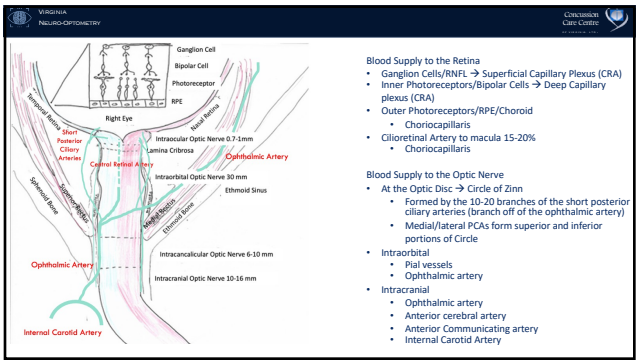

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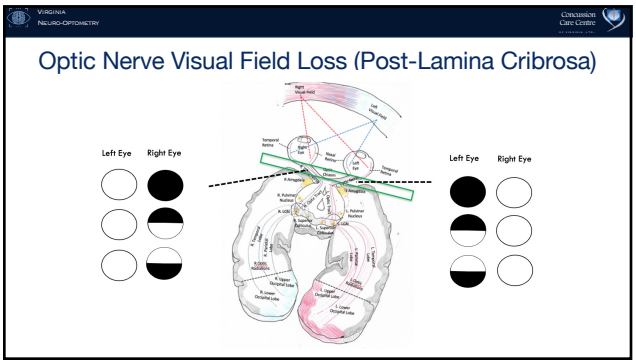

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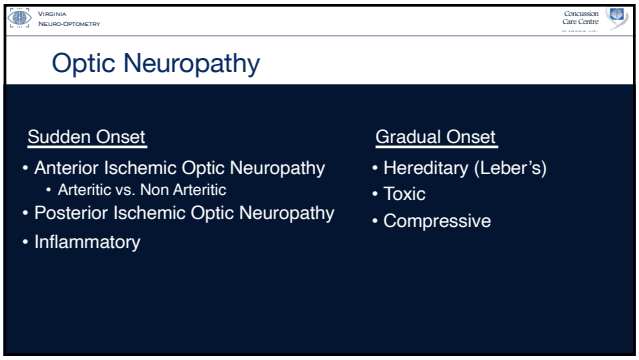

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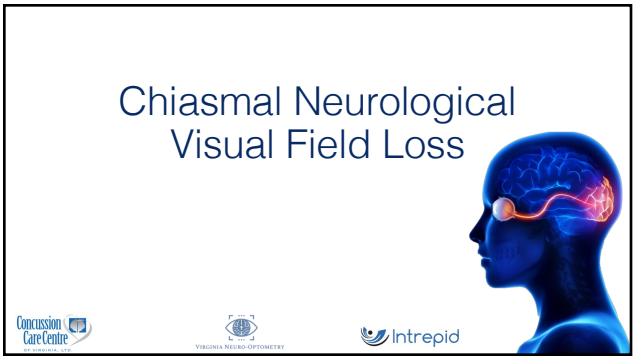

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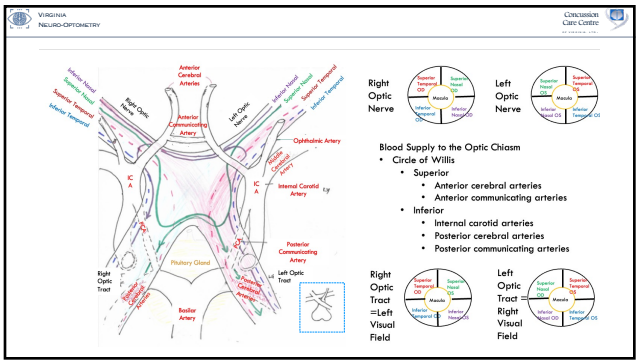

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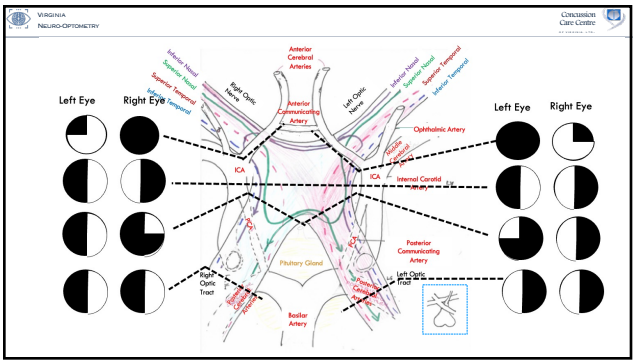

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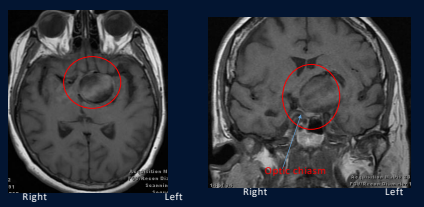
Giant Aneurysm with Optic Chiasm compression OS>OD



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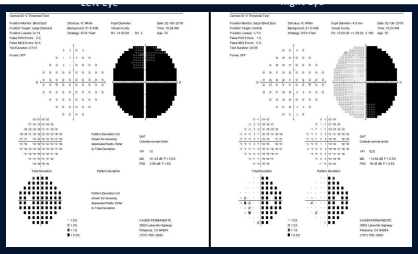
Bitemporal Hemianopsia with additional Right hemifield loss OS



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Post-Chiasmal Neurological Visual Field Loss

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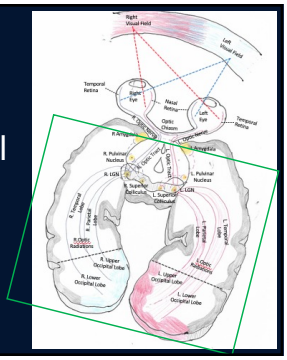
Post-Chiasmal Neurological Visual Field Loss



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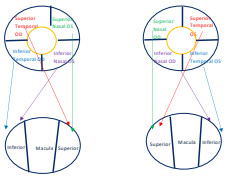
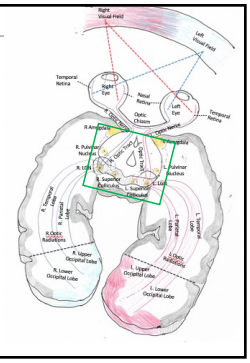
Optic Tract→LGN

Right Optic Tract =Left Visual Field



Left Optic Tract = Right Visual Field



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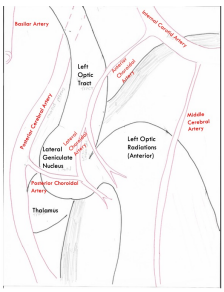
Blood Supply to the Optic Tract
- Anterior Choroidal Artery (branch of the Internal Carotid/Middle Cerebral Artery)

Blood Supply to the LGN
- Anterior Choroidal Artery
- Lateral and Posterior Choroidal Artery (branch from the Posterior Cerebral artery)



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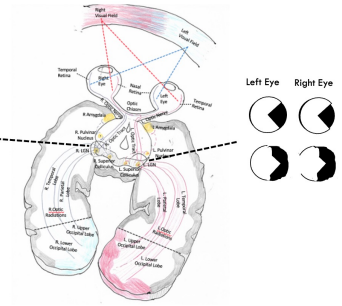
POST-CHIASMAL HOMONYMOUS NEUROLOGICAL VISUAL FIELD LOSS: LGN

Left Eye Right Eye



Left Eye Right Eye

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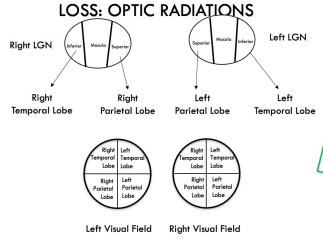
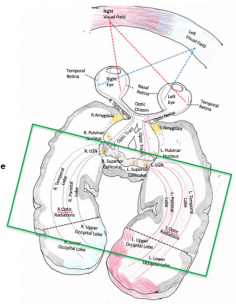
POST-CHIASMAL NEUROLOGICAL VISUAL FIELD LOSS: OPTIC RADIATIONS





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Homonymous Quadrantanopia

- Parietal lobe – inferior
- Temporal lobe – superior
  - PITS
- Occasionally middle and posterior cerebral artery infarcts

Rowe FJ, Wright D, Brand D, Jackson C, Harrison S, et al. A prospective profile of visual field loss following stroke: prevalence, type, rehabilitaton, and outcome. *Biomed Research International*. 2013: 1-12.

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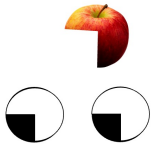
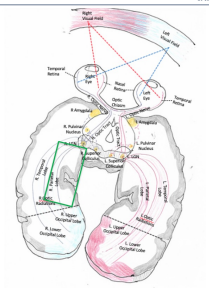
Right Parietal Lobe

Visual Field Defect: Left homonymous inferior hemi-defect/quadrinopsia



Left Eye Right Eye



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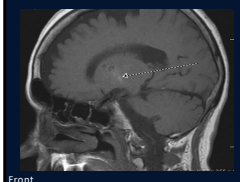
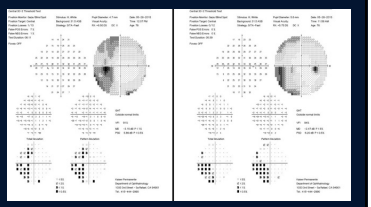
Right Temporal-parietal lobe Stroke



Front Back



Partial Left Inferior Quadrinopsia

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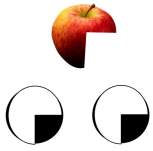
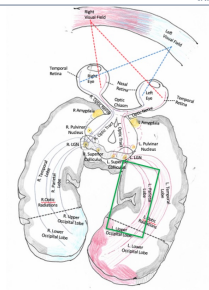
Left Parietal Lobe

Visual Field Defect: Right homonymous inferior hemi-defect/quadrinopsia



Left Eye Right Eye



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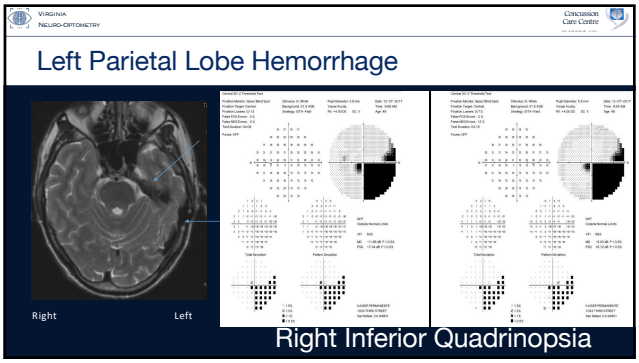

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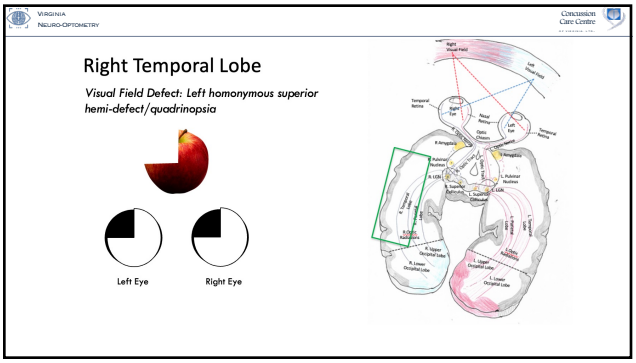

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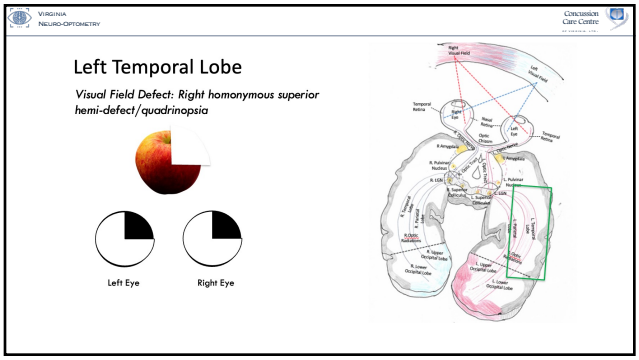

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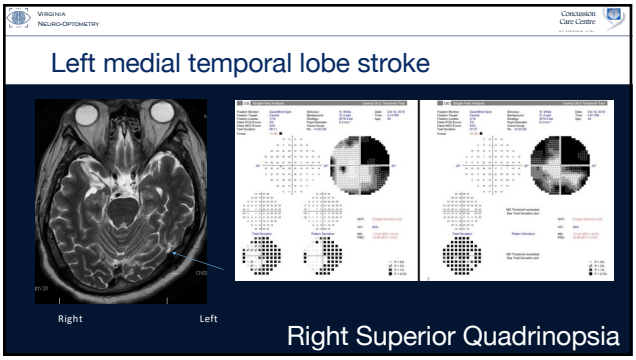

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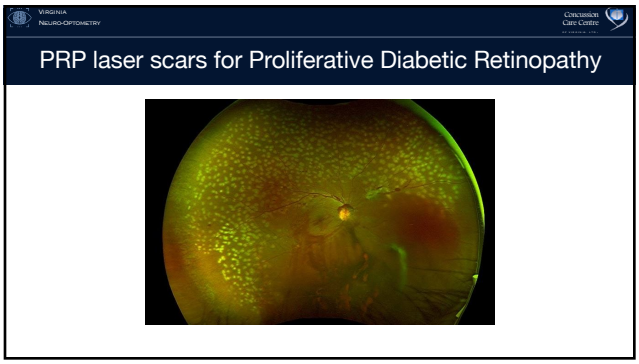

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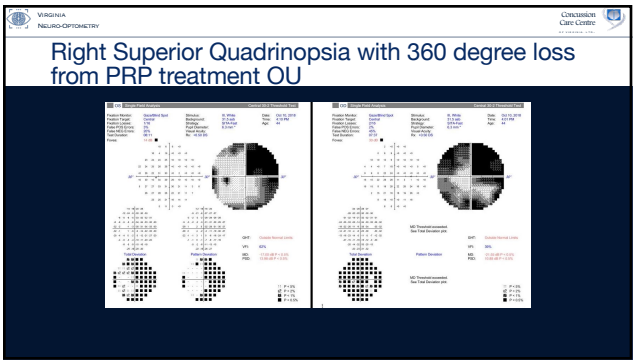
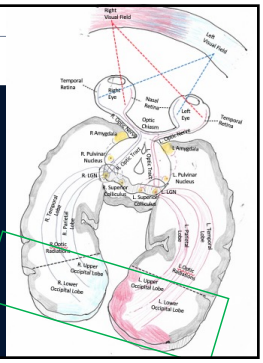


48

Post-Chiasmal Neurological Visual Field Loss: Visual Cortex

- Blood Supply to the Occipital Lobes/Visual Cortex
  - Posterior Optic Radiations
    - Posterior Cerebral Artery/Calcarine Branch
    - Middle Cerebral Artery – Deep Optic Branch
  - Striate Cortex
    - Calcarine branch of the Posterior Cerebral Artery main supply
    - *Other Posterior Cerebral Artery branches (Posterior-Temporal, Parieto-Occipital) and Occipital branch of the Middle Cerebral Artery*



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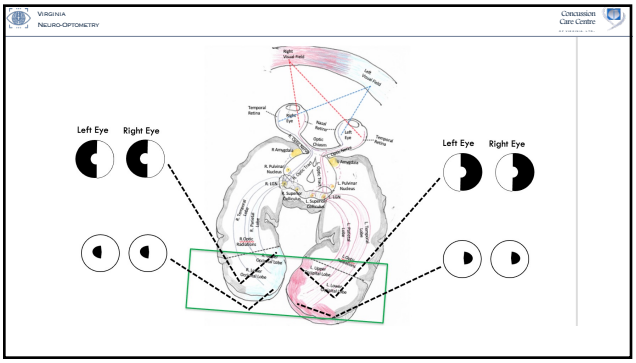

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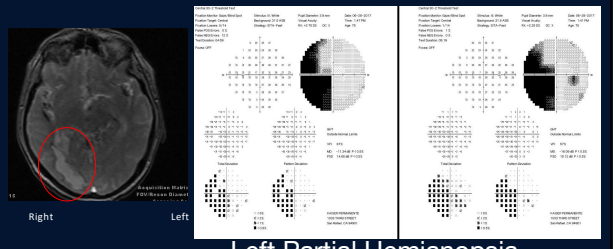
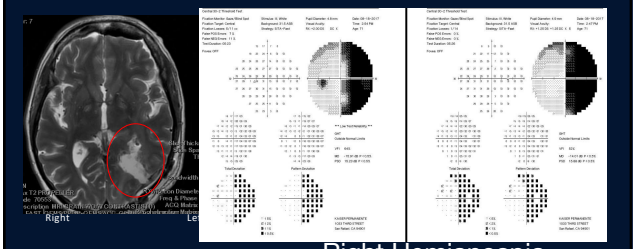
Right Occipital Lobe Hemorrhage



Left Partial Hemianopsia

51

Left Parieto-Occipital Glioblastoma (post craniotomy)



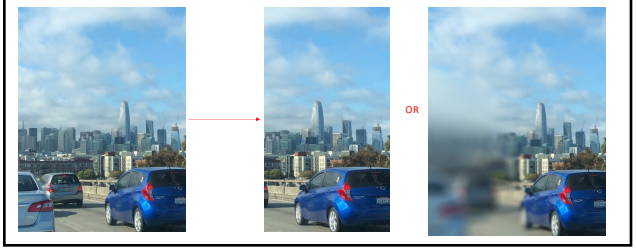
Right Hemianospia

52

Signs and Symptoms of Neuro-VF Loss

53

Signs and Symptoms of Neuro-VF Loss



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Symptoms of Visual Field Loss

- See people/objects "too late"
- Vision is "too slow"
- Bump into things
- Get lost in busy places (supermarkets, crowded areas)
- Get surprised easily
  - Objects suddenly appear and disappear
    - Sometimes get suddenly bigger/smaller
    - Small children/dogs
- Get frustrated in crowded places

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Functional Consequences of Visual Field Loss

- Association of visual impairment and disability in ADLs
  - Reading
  - Writing
  - Figure drawing
  - Grasping and pointing
  - Shopping
  - Cooking
  - Handling finances
  - Returning to work
  - Walking/ambulation, crossing the street in traffic
  - Cycling
  - Driving a Car, identifying hazards
  - Motor activities that are visually guided (manipulating an object, body posture, walking in crowded areas)
  - Increased visual search times
- Increased risk of falling, walking into objects, tripping
- Feel unsafe, scared, lose self-confidence → depression, anxiety, social isolation
- Get lost or panic in crowded or unfamiliar areas
- May impact ability to participation in rehabilitation

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Neurologic Visual Field Loss

20-67% of stroke patients have some type of visual field defect

Lobe	Field Loss
50% Occipital Lobe	Hemianopsia
30% Parietal Lobe	Inferior Quadrinopsia
25% Temporal Lobe	Superior Quadrinopsia
5% Optic Nerve and LGN	Scotoma

Zhang X, Kedar S, Lynn MJ, Newman NJ, Biousse V. Homonymous hemianopias: clinical-anatomic correlations in 904 cases. *Neurology.* 2006:66(6):906-910.

Suchoff, I., et al. "The Frequency of Occurrence, Types, and Characteristics of Visual Field Defects in Acquired Brain Injury: A Retrospective Analysis." Journal of the American Optometric Association 79.5 (2008): 259-65.

Pollock A, Hazelton C, Rowe FJ, Jonuscheit S, Kernohan A, et al. Interventions for visual field defects in people with stroke. *Cochrane Review* 2019;5: 1-172.

57

Types of Visual Field Loss

- N=479 recruited patients with VF impairment post-stroke
  - Types of visual field loss
    - 54% complete, 19.5% partial homonymous hemianopsia L>R
    - 15.2% superior or inferior quadrantanopia
    - Other:
      - Temporal crescent defect 0.2%
      - Constriction 9.2%
      - Bilateral hemianopia 1.7%

Rowe FJ, Wright D, Brand D, Jackson C, Harrison S, et al. A prospective profile of visual field loss following stroke: prevalence, type, rehabilitation, and outcome. *Biomed Research International.* 2013: 1-12.

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Confrontation Visual Fields

- N=184
- Compared automated perimetry to confrontation visual fields for patients with optic neuropathy (ischemic, infiltrative, compressive), glaucoma, intracranial tumors (parasellar, other), and strokes
- High sensitivity for altitudinal, central, homonymous hemianopsia, junctional scotoma)
- Low sensitivity for glaucoma, parasellar tumors, compressive optic neuropathy

TABLE 2. SENSITIVITY OF CONFRONTATION TESTING

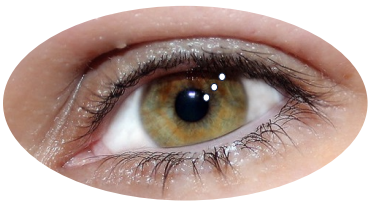
Visual Field Defects	CT/AP Defects*	Sensitivity (%)
Anterior Defects	33 of 124	26.6 [40]†
Altitudinal scotoma	7 of 7	100
Central/centrocecal scotoma	6 of 6	100
Monocular hemianopsia	2 of 3	66.7
Constriction	5 of 10	50
Paracentral scotoma	1 of 3	33.3
Arcuate scotoma	9 of 46	19.6
Patchy defects	3 of 49	6.1
Posterior Defects	28 of 41	68.3
Homonymous hemianopsia	19 of 25	76
Junctional scotoma	3 of 4	75
Bitemporal hemianopsia	6 of 12	50

*CT/AP represents the ratio of visual field defects identified by confrontation test to automated perimetry.
†Sensitivity in brackets excludes patchy defects.

Johnson LN, Baloh FG. The Accuracy of confrontation visual field test in comparison with automated perimetry. *J Nat Med Assoc.* 1991;83(10):895-898

59

Penlight Confrontation Fields



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Visual Field Loss - Awareness

- N=479 recruited patients with VF impairment post-stroke
  - 84% were symptomatic, 10.6% asymptomatic
    - 47.2% sole complaint was visual field loss
    - 42.2% had additional visual symptoms
      - Reading difficulty
      - Blurred vision
      - Diplopia
      - Visual perceptual abnormalities

Rowe FJ, Wright D, Brand D, Jackson C, Harrison S, et al. A prospective profile of visual field loss following stroke: prevalence, type, rehabilitation, and outcome. *Biomed Research International*. 2013: 1-12.

61

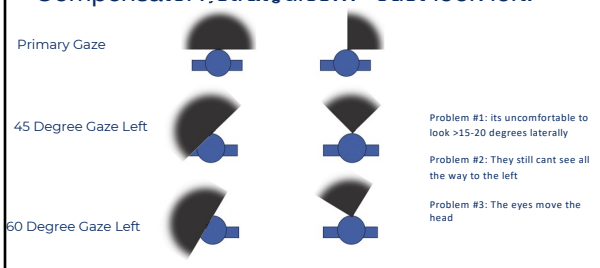
Associated Visual Impairments

- 31% visual field loss only
- 28.6% visual field loss + low vision
- 28.2% visual field loss + eye movement abnormalities
- 25% visual field loss + visual perceptual difficulties (19.4% visual inattention)
- Visual disorders can directly affect cognitive performance or exacerbate cognitive deficits

Rowe FJ, Wright D, Brand D, Jackson C, Harrison S, et al. A prospective profile of visual field loss following stroke: prevalence, type, rehabilitation, and outcome. *Biomed Research International*. 2013: 1-12.

62

Compensatory strategies… "Just look left!"



Problem #1: its uncomfortable to look >15-20 degrees laterally

Problem #2: They still cant see all the way to the left

Problem #3: The eyes move the head

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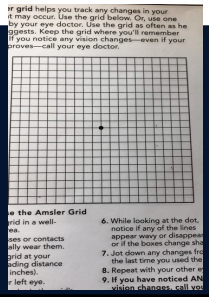
"Kinetic" Amsler Grid Visual Fields

*50% of occipital cortical surface is devoted to the central 10 deg of the visual field (which is only 1% of the visual field)

Zihl J. Rehabilitation of Visual Disorders after brain injury. 2nd edition. Psychology Press. 2nd ed. 2011. New York, NY

"Tell me when the pen tip appears"



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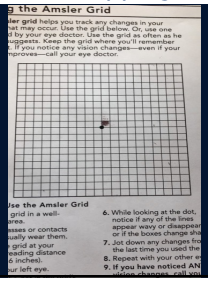
Amsler Grid Visual Fields: Scotoma Mapping

"Tell me when the marker tip disappears"



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Visual Field Loss and Reading

- Clinical signs/symptoms problems
  - Increased reading time (reduced reading speed)
  - Omission of words
  - Disorganized oculomotor reading pattern
    - More saccades and smaller saccadic amplitudes
    - Longer scan patterns/more fixations
    - Longer fixation duration
    - Higher fixation repetitions
- Poorest performance if have <3 deg of macular sparing

Zihl J. Rehabilitation of Visual Disorders after brain injury. 2nd edition. Psychology Press. 2nd ed. 2011. New York, NY

66

Hemianopic Alexia

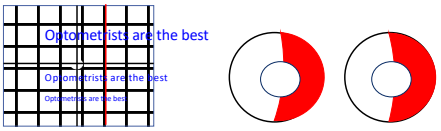
- Acquired reading disorder
- Homonymous parafoveal visual field loss causes persistent and severe difficulties in word identification and reading eye movements despite NORMAL language functions
  - Macular sparing <5 deg typically associated with impaired reading
  - 70% of patients with visual field loss will have some central vision <5deg
    - Major source of visual disability in brain injury
- Spontaneous recovery of hemianopic alexia
  - 30% over years, 16% over 6 weeks
  - Less likely to occur if patient has injury to the white matter, occipito-parietal structures, posterior thalamus
    - Usually only occurs for patients with optic radiation or occipital striate cortex damage ONLY

Zihl J. Rehabilitation of Visual Disorders after Brain Injury 2nd edition. Psychology Press. 2nd ed. 2011. New York, NY.

67

Hemianopic Alexia

- Results from loss of parafoveal/macular field
- Perceptual reading requires ~ 13 letters to the right (5deg) and 6 letters to the left of fixation (3deg)
- Right Hemianopia = impairs full word detection/sight reading, reading speed, re-reading
- Left Hemianopia = missed first letters/starts of sentences



Rowe FJ, Wright D, Brand D, Jackson C, Harrison S, et al. A prospective profile of visual field loss following stroke: prevalence, type, rehabilitaton, and outcome. *Biomed Research International*. 2013: 1-12.

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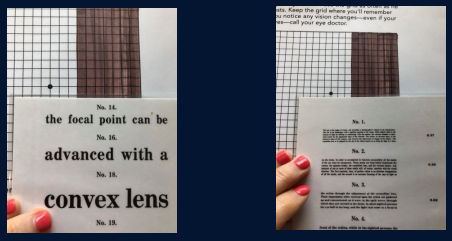
Bigger isn't always better!



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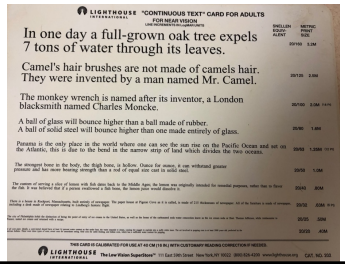
Right Visual Field Loss and Reading

You need at least 5 degrees of right-sided macular sparing to read fluently

- Difficulty finding the end of a line or word
- Appear to be "stuck on the word" and hesitant to move on



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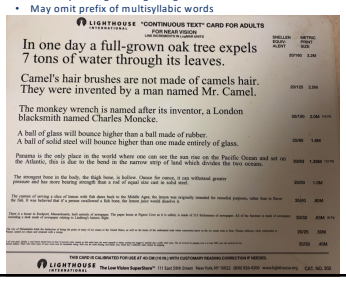
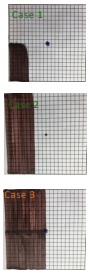
Left Visual Field Loss and Reading

Need about 3 degrees of left-sided macular sparing

- >5deg of left-sided macular sparing = normal reading performance
- Difficulty finding the beginning of a line or word
- May omit prefix of multisyllabic words





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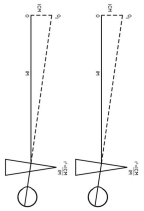
Yoked Prism Review



- A Prism Diopter (Δ) is defined as a deviation of 1 cm at 1 meter. For angles under 45° (or 100Δ), each degree (°) of angular deviation equals approximately 2Δ (Approximation Formula).

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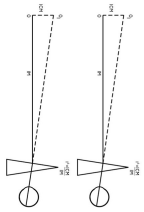
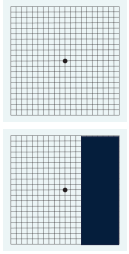
Yoked Prism Review





Each box = 0.5cm, and each box = 1deg and you hold the test 40cm away,

Then Δ= (deg)(0.5)/0.4

So if you need 2deg of field expansion/shift

Then 2(0.5)/0.4 = 2.5 Δ

Deg Needed	Approximate prism
1	1.25
2	2.5
3	3.75
4	5
5	6.25

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Adaptations - Reading

- Increase or Decrease Font Size/spacing
  - E-readers/tablets
  - Magnifiers
- Line guide (ruler, marker, book mark) at start/end of lines
- Reading columns
- Apps to help with reading, typing
- Bright colored labels
- Positioning things/self to nonaffected side
- Yoked prism referral

Rowe FJ. Stroke survivors' views and experiences on impact of visual impairment. *Brain and Behavior*. 2017:7:1-9

74

Can we just tell them to read more?... No

- Patients start too early with semantic (higher order language) processing of the text material they have seen (extraction of meaning) despite missing text information on the right/left → word is guessed and not looked at = premature extraction of meaning from the incompletely perceived word = hinders further acquisition of text information
- Patients must learn to visually apprehend before they comprehend the word/text
- HOWEVER – still encourage patients to continue regular reading of newspapers or books at home

Zihl J. Rehabilitation of Visual Disorders after brain injury. 2nd edition. Psychology Press. 2nd ed. 2011. New York, NY

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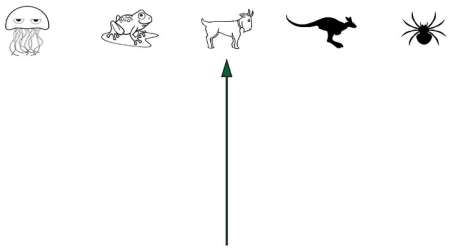
Yoked prism – Keep in mind



Images courtesy of Chadwick optical

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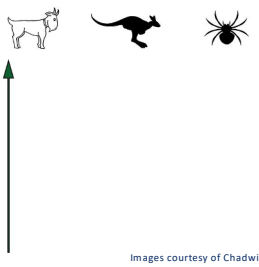
Yoked prism – Keep in mind



Images courtesy of Chadwick optical

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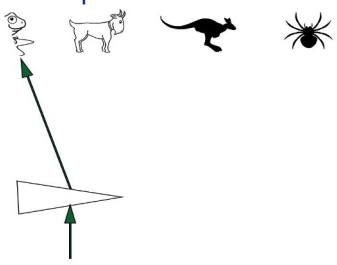
Yoked prism – Keep in mind



Images courtesy of Chadwick optical

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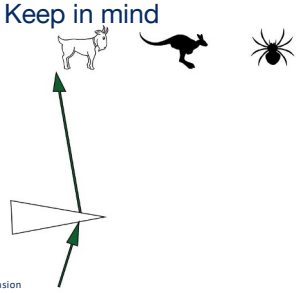
Yoked prism – Keep in mind



Pearl

2-6 pd yoked helps with reading expansion

They still need to move their material to the seeing side for the most benefit

Images courtesy of Chadwick optical

79

Can you used yoked prism for walking?

- You can try… but if their complaint is bumping into things on the side this is unlikely because you need much larger prism amounts and then the glasses get super heavy.

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Unilateral Sector Prisms

Base in the direction of the field loss

Usually placed a few millimeters into the field loss on the eye with the temporal defect

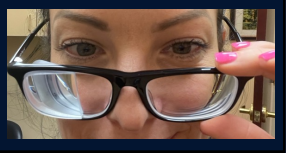
I place it right at the edge of the field cut

Diplopia or other "undesirable" effect when looking into the sector prism

I use the diplopia to prompt people to look

Measurable by perimetry at gaze shift, but tolerable?

Yes, very, literally life changing for people



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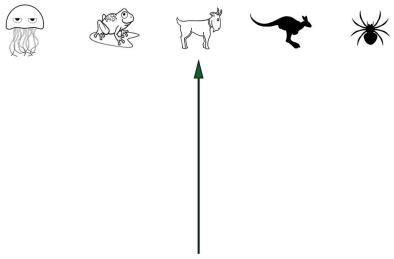

Images courtesy of Chadwick optical

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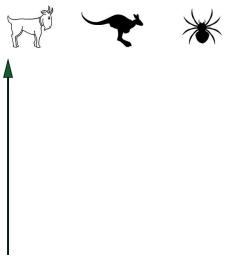

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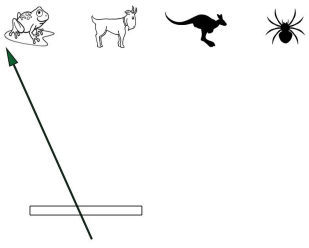

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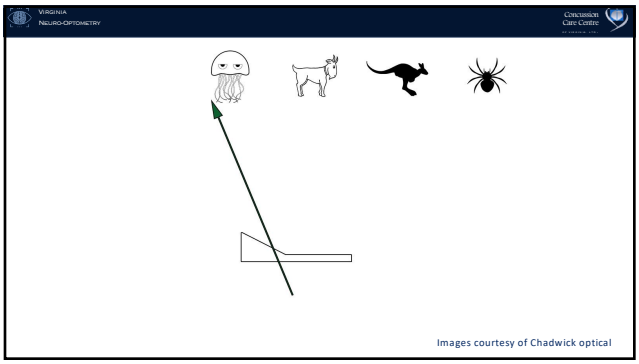

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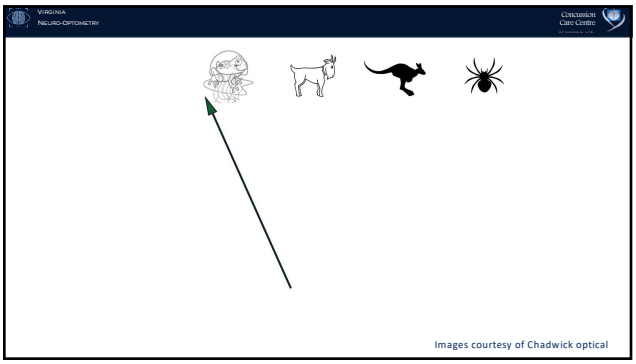

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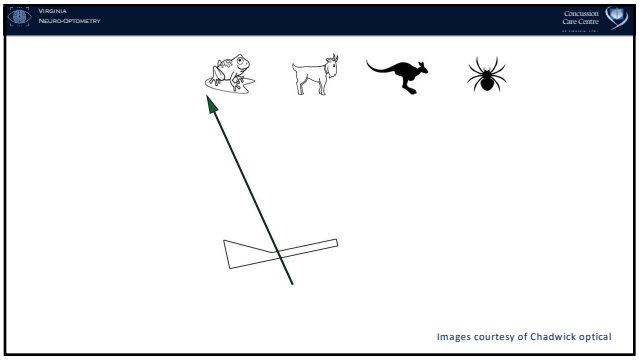

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Unilateral Sector Prisms - Steps to See Frog

1. Turn Eyes
2. See froggy-fish
3. Figure out that a froggy-fish is half frog, and you want to see a frog.
4. Move head until you see just a frog.
5. Look at Frog

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Unilateral Sector Prisms – How much to prescribe?

- Depends on their processing speed and how big of a person they are
- Wider shoulders = bigger prism
- Slower processor = bigger prism

If object is 3 ft away

Prism	Clearance at 3ft
20	0.67ft
25	0.83ft
30	1ft
35	1.15ft

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Unilateral Sector Prisms – How to fit it "Theis" style

At the edge of the visual field cut
Then back it off 1 mm

Use a Fresnel prism first for a few weeks

Be wary of large pupils for night time

90

Associated Visual Impairments

- 31% visual field loss only
- 28.6% visual field loss + low vision
- 28.2% visual field loss + eye movement abnormalities
- 25% visual field loss + visual perceptual difficulties (19.4% visual inattention)

- Visual disorders can directly affect cognitive performance or exacerbate cognitive deficits

Rowe FJ, Wright D, Brand D, Jackson C, Harrison S, et al. A prospective profile of visual field loss following stroke: prevalence, type, rehabilitation, and outcome. *Biomed Research International*. 2013: 1-12.

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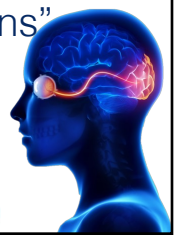
Other Neurological Visual Field "phenomenons"



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Anosoagnosia (unaware) of VF defect

- Many patients are unaware of their visual field loss
  - 19% in ischemic stroke
- Anosoagnosia – failure to recognize the existence of a functional disorder (ex: impaired vision), even upon confrontation
- Associated to damage to areas involved in visual awareness
  - Lingual gyrus (medial occipital lobe)
  - Cuneus and posterior cingulate
  - Corpus callosum
  - *V1 is necessary for normal visual perception, but it not sufficient for visual awareness*
  - **The more posterior the lesions, the less awareness**
- Anton's Syndrome – denial of loss of vision in patients with bilateral occipital lobe strobe (rare)

Baier B, Geber C, Muller-Forell W, Muller N, Deiterich M, Karnath HO. Anosognosia for obvious visual field defects in stroke patients. *Brain Struct Funct*. 2015;220:1855-1860

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Anosoagnosia (unaware) of VF defect

- Types/Degrees of Awareness
  - Grade 0 – patient mentions/is aware of visual field loss
    - Full awareness and understanding of the hemianopia
    - Awareness of visual defect to one side, but misinterpreted as missing vision in one eye
  - Grade 1 – patient aware after being questioned of a possible VF defect
    - Realization that something is wrong with vision but nature of defect is not understood or can be described
  - Grade 2 – patient denies visual problems despite being specifically asked
    - "projection" of the defect – rationalizing it as being due to other factors (poor illumination)
  - Grade 3 – patient insists they have no visual field defect despite demonstration of disorder by testing
    - unaware of the defect, but recognizes the consequences (bumping into people, being surprised by objects)
    - Total lack of awareness

Baier B, Geber C, Muller-Forell W, Muller N, Deiterich M, Karnath HO. Anosognosia for obvious visual field defects in stroke patients. *Brain Struct Funct*. 2015;220:1855-1860
Zihl J. Rehabilitation of Visual Disorders after brain injury. 2nd edition. Psychology Press. 2nd ed. 2011. New York, NY

94

Riddoch Phenomenon

- Motion perception remains despite occipital lobe damage
- Patient may be able to locate and respond to stimuli even though they cannot consciously see it
- Possibly due to projections directly between extrastriate occipital cortex and the LGN or pulvinar nuclei being preserved

Goodwin D. Homonymous hemianopia: challenges and solutions. *Clin Oph*. 2014;8:1919-1927

95

Blindsight

- Definition
  - Residual perceptual capacities exist deep in the field of "absolute" blindness

- Types
- 1 – No awareness
- 2 – limited awareness
- Conscious vision

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Sightblind

- Deficient perceptual functions in the "normal" intact visual field
- Reduced contrast sensitivity in "normal" (ipsilesional) visual field
- Longer reaction times
- More false positives when in a noisy background
- Reduced contour interaction
  - Need more time to detect the target/stimuli
- Difficulties with environmental visual search with eye movements → disorientation, difficulty avoiding obstacles
  - Perceptual or temporal processing deficits in the intact field
- Perceptual distortion
  - Shapes may be elongated toward the scotoma (aka maladtaptive visual cortex retinotopic mapping)

Bola M, Gall C, Sabel BA. "Sightblind": perceptual deficits in the "intact" visual field. *Front Neur*. 2013;4:1-5

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Sightblind

- Pathophysiology
  - Lesion-induced disturbance of the inter-hemispheric interactions
  - Cortical lesions may lead to retinotopic reorganization of visual cortex in the area adjacent to the scotoma → perceptual distortions and impacted activity of downstream processes
- Clinical Implications
  - Perimetry underestimates extent of FUNCTIONAL deficits
    - Temporal processing speed in intact field relative to distance to scotoma (ie the closer to the scotoma, the longer the reaction time)
    - Intact field performance dependent on scotoma size (ie the larger the sotoma, the longer the reaction time)
  - Intact field deficits influence the subjective quality of vision
    - Worse detection accuracy of figures on a noisy background (simultanagnosia)
    - Worse accuracy in detection/categorization

Bola M, Gall C, Sabel BA. "Sightblind": perceptual deficits in the "intact" visual field. *Front Neur*. 2013;4:1-5

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Visual hemineglect

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Visual Hemineglect

Definition

- Lesion outside of primary visual pathway
  - Right inferior or posterior parietal lobe
    - Sometimes – right inferior frontal lobe, basal ganglia, thalamus, reticular formation, limbic/cingulate gyrus
- Similar to visual field loss – but patient is completely unaware of left side due to cognitive deficit
- For all intensive purposes the left side doesn't exist

Symptoms

- Can impact ADLs - May shave, groom, or dress right side of face/body only
- May leave food on left half of plate
- May omit reading left half of each sentence
- May have large margin on left hand side of paper while writing
- May veer left while walking or bump shoulder into left doorframe

Cooper SA, O'Sullivan M. Here, there, and everywhere: higher visual function a stream. *Pract Neurol*. 2016;16:176-183

100

Left Hemineglect

- Pathophysiology
  - Right hemisphere modulates attention to BOTH the left and right side
    - Damage to the right parietal lobe (middle cerebral artery infarcts, aneurysms, etc) causes marked loss of left sided attention
  - Left hemisphere modulates attention ONLY to the right side
    - Damage to the left parietal lobe causes imbalance of attention away from the right side, but still present due to right parietal lobe sparing

Suter PS, Harvey LH. Vision Rehabilitation: Multidisciplinary care of the patient following brain injury. CRC Press. 2011. Boca Raton, FL>

101

Hemineglect, Unilateral spatial Inattention or Hemianopsia?

- Patients with homonymous hemianopsia AND hemineglect do not respond as well to scanning training
- Symptoms of left hemianopia and left hemineglect can be similar

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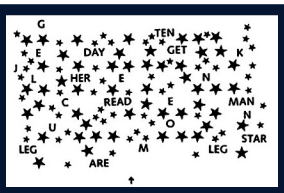
Hemineglect Testing

- Star Cancellation
  - (most sensitive)
- Copying tasks
  - Clock
  - House
  - Daisy
- Line Bisection
- Observation on reading
  - Starts 3-4 words into line from the left
- Behavioral Assessment – BIT, CBS



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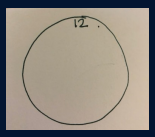
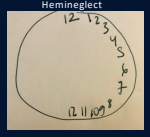
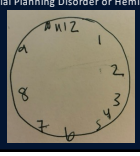
Hemineglect Copy Test - Clock



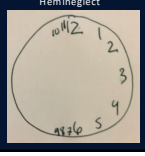
Hemineglect



Spatial Planning Disorder or Hemianopsia



Hemineglect



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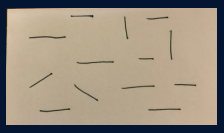
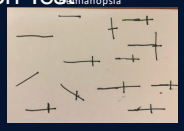
Hemineglect - Line Bisection Test

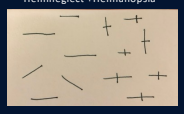


Hemianopsia



- Draw horizontal and vertical lines of various lengths (3-10cm) on the right and left of center of the page.
- Tell pt to work from the top of the page to the bottom and cross out each line in half
  - Mild neglect - get all lines but will perceive the neglected end of the line and will bisect the line away from the neglected side (to the right)
  - Moderate/severe neglect –will miss lines on left side of the page
  - Hemianopia = will bisect the line in the opposite direction – toward the defect (to the left)
  - BOTH VSN and hemianopia = will bisect lines accurately
    - Must combine with visual field test

Hemineglect +Hemianopsia



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Hemineglect Testing

Pencil Layout

- Space 10 pencils evenly and parallel to each other in front of the patient across the midline – ask the patient to count the pencils
  - Hemineglect = miss pencils on the left

Other

- Hart chart/acuity test observation
  - Miss letters on the left
- Picture scanning – wide angled detailed picture and ask to describe the objects in the picture

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Hemineglect Testing

Extinction

- Present a hand in the patient's right visual field (he will see it).
- Present it in the left visual field (he will see it in the absence of a field defect)
- Present hands simultaneously in the right and left field and patient will often not be aware of the left side hand → this process of left stimulus suppression with bilateral simultaneous presentation is call extinction
  - Can perform with flashing fingers simultaneously and only count fingers in unaffected field

Number Cross

- Center at zero, and numbers from 0-14 vertically and 0-28 on each side, hold card 10 inches in front of the patient
- Ask the patient to tell the evaluator which number is the farthest left/right (WITHOUT restricting eye or head movement)
- If have left hemineglect – less than 28 identified on the left

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Abnormal Egocentric Location (AKA Visual-Spatial Midline Shift)

- If a patient with left hemineglect has a visual midline shift, that will cause even further reduction in left side awareness

- Diagnostics
  - Stand to patients right side and present a vertical pencil at eye level move the pencil laterally from right to left (then left to right) and have the patient tell you when the pencil appears to be in the middle of the patients nose (nothing in the background)
  - Patients with midline shift will tell you it is centered when it is in front of the right eye (if they also have left hemineglect

108

Neurological Visual Field Loss: Prognosis

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Visual Field Loss Outcome

- 7.5% full field recovery of field loss
  - 17-19% of post-stroke patients with total HH have complete recovery within 1 month
  - 55% of HH have some improvement in the first month ZHANG ET AL 69
  - Recovery decreases with increasing time from injury – most of the improvement occurs within the first 2 months, unlikely after 6 months unless the ynderlying cause resolves
- 39.2% partial improvement
- 52.3% unchanged visual field loss
- 1% further loss of visual field

- No identifiable factor associated with those with restoration of their field
  - Age at stroke onset, gender, area of stroke lesion, type of stroke
- Most recovery within first 10-14 days, up to 6-12 months

Rowe Fj, Wright D, Brand D, Jackson C, Harrison S, et al. A prospective profile of visual field loss following stroke: prevalence, type, rehabilitation, and outcome. *Biomed Research International*. 2013: 1-12.

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Spontaneous Recovery of VF loss

- Bilateral loss
  - 73% showed some recovery
    - 6% complete recovery
  - Normally occurred within 8-12 weeks, up to 2 years
    - 50% of cases with spontaneous recovery occurred within 1 month
- Unilateral loss
  - 12-16% recovery
    - Patients with macular sparing<5deg less likely to recover
    - Majority (83.9%) of patients with recovery had macular sparing>5 degrees at initial testing

Bergman OS. Cerebral blindness. *Archives of Neurology and Psychiatry*. 1957:78:568-584

111

Stages of Recovery

- Light perception
  - "Undifferentiated sensation"
  - Unable to indicate direction or speed of movement, but can report the location
    - NOT the Riddoch phenomenon
  - Vague impression of objects and contours
    - Vision is foggy
    - Counting fingers acuity
    - Colors are pale/less saturation

Gloning I, Gloning K, Tschabitscher H. Occipital blindness on vascular basis. *Von Graefes Archiv fur Ophth*. 1962:165;138-177.

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Spontaneous Adaptation and Adaptability of Visual Field Loss

- 25% of patients able to spontaneously learn to adapt to their visual field loss by using gaze shifts

- So what do we do for the other 75%?
  - Without rehabilitation, the majority of hemianopsia patients will adapt a disorganized scan path with multiple refixations in the blind and intact fields

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Neurological Visual Field Loss and Saccades

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Saccadic Dysmetria in Hemianopsia

- Microsaccades (<1 deg)
  - Function:
    - High resolution of vision,
    - Refresh vision/prevent fading of vision, correct binocular disparity
    - Facial recognition
  - Can cause subjective blurred vision/low visual acuity
  - In hemianopia
    - Decreased inhibition of superior colliculus → microsaccadic amplitude enlargement and prolongation of duration → reduced vision
    - Disturbed calibration of eye movements → uncoordinated binocular eye movements
    - Velocity not impaired, but microsaccadic direction bias TOWARDS seeing field = attention allocation towards seeing side in 50% of patients
    - More severe in patients with older lesions (ie gets worse)

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Saccadic Dysmetria in Hemianopsia

- Macrosaccades (1-30 deg)
  - Function:
    - Used to move eyes from one object to another
  - Can cause subjective blurred vision/low visual acuity
  - In hemianopia
    - Decreased inhibition of superior colliculus → macrosaccadic amplitude enlargement and prolongation of duration → reduced vision
    - Disturbed calibration of eye movements → uncoordinated binocular eye movements
    - Velocity not impaired, but macrosaccadic direction bias TOWARDS seeing field = attention allocation towards seeing side in 50% of patients
    - More severe in patients with older lesions (ie gets worse)

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Saccadic Dysmetric in Hemianopia

- Saccades are hypometric TOWARDS the hemianopic side
  - *Depending on the injury, can have impaired oculomotor skills in general*
- Increased number of fixations = increased time and laborious visual search
- Clinical impact – the slowness of visual search impairs global perception, especially in crowded areas (supermarkets, crosswalks) which can cause serious disability and risk (bumping into people, missing people or obstacle)

117

Peripheral Vision and Driving

- Viewing area of windshield + dashboard
  - 15 deg superiorly
  - 30 deg inferiorly
  - 60 deg right and left
- Lower and left fields associated with elevated crash risk

Huisingh C, McGwin G, Wood J, Owsley C. The driving visual field and a history of motor vehicle collision involvement in older drivers: a population based exam

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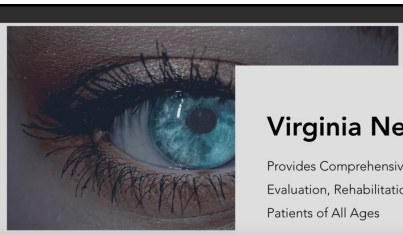

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