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# Visual Deficits in Brain Injury: The Adult Neurological Perspective

Subah Gupta MHS, OTR, CBIS

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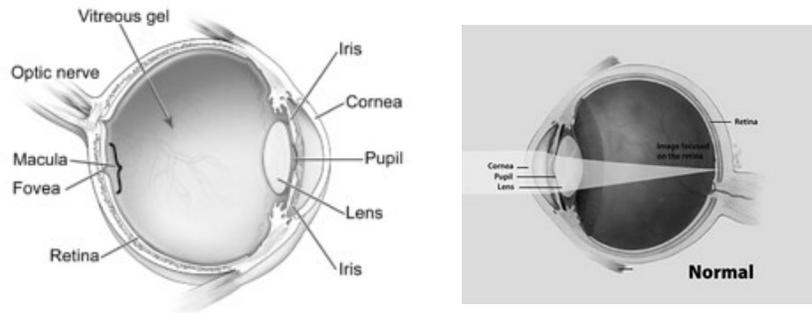
## Learning Outcomes

- After this course, participants will be able to list the anatomical as well as the neurological foundations of the visual system.
- After this course, participants will be able to describe differential screening for visual deficits.
- After this course, participants will be able to list appropriate intervention strategies for clients with acquired visual deficits towards independence in daily activities.

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## Functional anatomy – Anterior structures of the eye



Source: NEI/NIH

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## Establish eye dominance

CONTINUED

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## Reduced acuity is because of

Aging
Brain Injury / Trauma
Neurological / congenital eye diseases
All of above or any of above

CONTINUED

## Distance /Intermediate Visual Acuity

- Snellen Chart



- Stops at 20/200
- Testing distance – 20 feet

- Low Vision Distance Chart



- This extends it to 20/1000
- Testing distance is 1 meter
- Light source needs to be directed from behind the client
- Charts need to be held at the specified distance
- Chart needs to be evenly and adequately illuminated
- Test each eye separately and then together, wear glasses

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## Near Visual Acuity and CSF

### MNREAD Acuity Chart

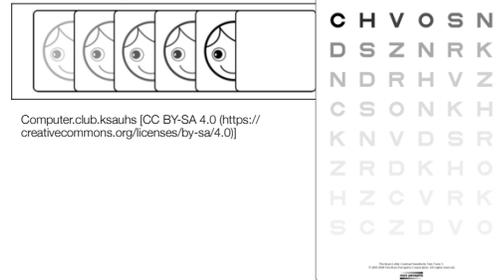
- 3<sup>rd</sup> grade reading level
- Print size is up to 8M
- Contextual



Image from precision-vision.com

### Contrast Sensitivity Function

- Contrast sensitivity is a measure of how faded or washed out an image can be before it becomes indistinguishable from the uniform background



Computer.club.ksauhs [CC BY-SA 4.0 (<https://creativecommons.org/licenses/by-sa/4.0/>)]

mersperceptrix.com

## Case Study - 1

- Age is 67
- Occupation – Owns his company and works on designs (bridges, farm equipment, joints)
- Diagnosis - Midline shift and left intra cranial hemorrhage involving the temporal and parietal lobes due to uncontrolled hypertension while driving a RV
- Burr hole with evacuation of the hematoma
- Reached home after month long inpatient intensive rehabilitation for right sided weakness and aphasia

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## Case Study - 1

### Therapy Screen

- VA with bifocals
  - OD 20/40
  - OS 20/40
  - Near 20/20
  
- CSF – Able to perceive 1.25%

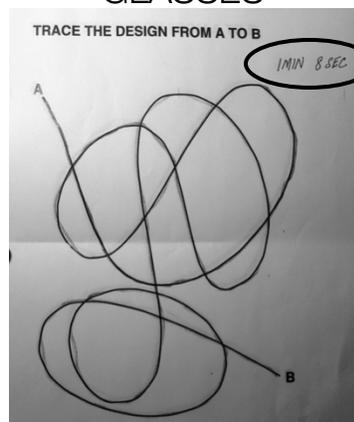
### Low Vision Provider

- VA
  - OD 20/400
  - OS 20/500
  - At near - 1.25M @30
  
- Astigmatism
  
- Eye health
  - Macular hole bilateral OU

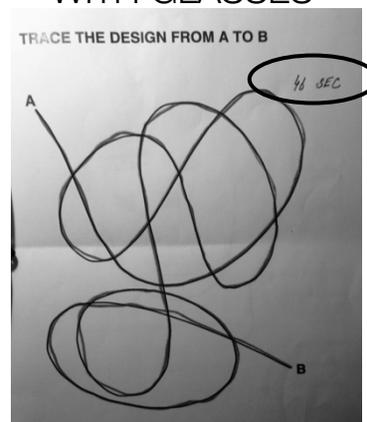
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## Wears Glasses

WITHOUT  
GLASSES



WITH GLASSES



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## Increase contrast by choosing light

Incandescent	Fluorescent	LED	Halogen	Full Spectrum
Warm yellowish light	Cool light	Offers a range	Warm light	Mimics natural light
Glare due to scatter on retina	Fewer shadows but may create glare	Depends on the color chosen	Minimal glare	Reduces glare
Excellent contrast	May not provide good contrast	Good contrast	Excellent contrast	Good contrast
Great for task lighting	Provides even lighting, best for overhead lighting	High intensity focused light	Even lighting, good for task and / or overhead	Even illumination though diffuse
Being phased out, not energy efficient	Can have the strobe effect, light flickers	Expensive but lasts for years	Light gets very hot – risk of burns or fire	Beneficial to have additional task lighting

ALLOW THE CLIENT TO CHOOSE WHAT LIGHT IS BEST FOR THEM

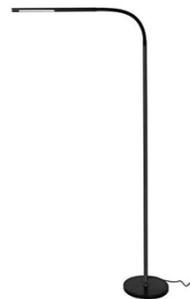
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Table gooseneck lamp



Long gooseneck lamp



Dimmable floor gooseneck lamp

Available on Amazon.com

- Position the light behind/next to the dominant eye
- Make sure light is shining on the page and not the eye
- Use the inverse square law of light – bring the light source closer to the surface
- Increase the lumens/wattage as needed

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## Increase contrast by modifying environment

Decrease visual clutter / decrease pattern

Use locator dots

Use bright duct tape

Andrew Riley [CC BY-SA 4.0  
[https://creativecommons.org/licenses/by-sa/4.0]]



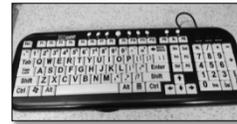
**Font is white on black**

Decrease pattern density  
by spacing text and  
increasing size

Choose wider monitors for increased field of view, flat screens are preferable

High contrast keyboard, keyboard overlays

For reading try ...Settings – General - Accessibility



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## Photophobia/Light Sensitivity

- Is usually because of meningeal irritation
- Use filters, sunglasses, hats or visors, outdoors and/or indoors
- Sheet covers or overlays (different colors) can be used
- Cover windows with blinds, use stick on window tints
- Use an umbrella outdoors
- Cover surfaces



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## Binocular Vision

- When information processed from each eye is same in size, detail, and form, it leads to binocular vision.
- If above is not the case then diplopia or double vision will happen.
- Double vision can also be perceived as blurred vision, ghosting of images and distortion.
- Cranial nerve lesion can lead to extra ocular muscle paralysis, hence causing diplopia.

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### Strabismus

- Could be in any direction
  - Esotropia – Eyes may turn in
  - Exotropia – Eyes may turn out
  - Hypertropia – Eyes may turn up
  - Hypotropia – Eyes may turn down

### Non strabismus

- Eyes have a tendency to turn but neuromuscular effort is being exerted to control this tendency
- Patients will try and eliminate it with muscular effort, which can lead to signs and symptoms of
  - Headaches
  - Inability to sustain attention for long periods
  - Eyestrain
  - Intermittent blurred vision and occasional diplopia
  - Difficulty reading

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## Third Cranial Nerve (Oculomotor) Palsy

- Innervates superior, medial, inferior rectus and inferior oblique
- Horizontal diplopia due to exotropia when viewing near objects
- Eye is “down and out”
- Lack of ability of the lens to focus due to lack of innervation of the ciliary muscle
- Lack of pupillary constriction – dilated pupil
- Ptosis



Wang Y, Wang XH, Tian MM, Xie CJ, Liu Y, Pan QQ, Lu YN [CC BY 4.0 (<https://creativecommons.org/licenses/by/4.0/>)]



Primal Pictures

Rucker and Tomsak, 2005

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## Fourth Cranial Nerve (Trochlear) Palsy

- Innervates superior oblique ‘cheater’ muscle
- Eye drifts upwards
- Hypertropia worsens with ipsilateral head tilt
- Compensatory contralateral head tilt
- Hallmark symptom is vertical diplopia, looking down or reading
- If bilateral, patient will move head instead of eyes to look down



Wang Y, Wang XH, Tian MM, Xie CJ, Liu Y, Pan QQ, Lu YN [CC BY 4.0 (<https://creativecommons.org/licenses/by/4.0/>)]

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## Sixth Cranial Nerve (Abducens) Palsy

- Innervates the ipsilateral lateral rectus muscle
- Difficulty moving the eye away from nose (abduct)
- Esotropia at primary gaze
- Horizontal diplopia viewing far away objects

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## Near Point of Convergence

- Patient is upright with head unsupported if possible.
- Instruction: " Watch the target as long as you can."
- Hold a target (pencil topper) at eye level about 15 inches away from the face. Move the target closer to the nose.
- Observe as one eye usually drifts out (normally this is between 2-4 inches) leading to double vision followed by recovery at 4-6 inches. Importance is placed to what you see over what is reported.

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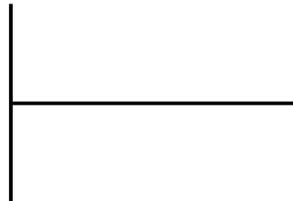
## Observations

- Head tilt and to which direction?
- Do the pupils constrict?
- Are the pupils dilated?
- Is there ptosis?
- Is there nystagmus?
- Are they closing one eye? Does vision improve (single vision restored) when one eye is occluded?
- Ask for diplopia?
  - Is double vision horizontal or vertical?
  - Is double vision constant or intermittent?
  - Is double vision at near or at far distances?

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## Positions of Gaze

- With glasses if patient wears them
- Both eyes open
- Follow the target with eyes, leave the head still
- Excursion (pursuit movement) is 12- 15 inches from the face



- Look for deviations
- Ask patient to report if they see double or blurred

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## What can we do ...

### Complete Occlusion

- One eye is completely occluded
- Eyes can be switched
- Liked because it is easy to do
- Disliked because peripheral vision is blocked which affects balance and gait and patients may not like their dominant eye being patched

### Partial Occlusion

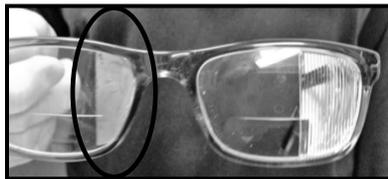
- Spot Occlusion – A small piece of circular tape or strip is applied over the lens to cover the pupil
- 3M transpore frosted plastic tape on the back of the lens is applied
- Peripheral vision is not affected, it is used for balance and spatial orientation, leads to improved compliance
- Taping does not need to be alternated

The physician needs to be informed of occlusion.

CONTINUED

## Partial Occlusion

- Third Nerve Palsy - Diplopia viewing near objects
  - Tape the nasal portion of the lens of the paretic eye
- Fourth Nerve Palsy - Diplopia in reading position
  - Tape lower half of the lens in front of the paretic eye



Tape is applied from the nasal / bottom of the rim to the center till the patient reports 'No diplopia', width of the tape is reduced as the paresis resolves.

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## Case Study 1

### Therapy Screen

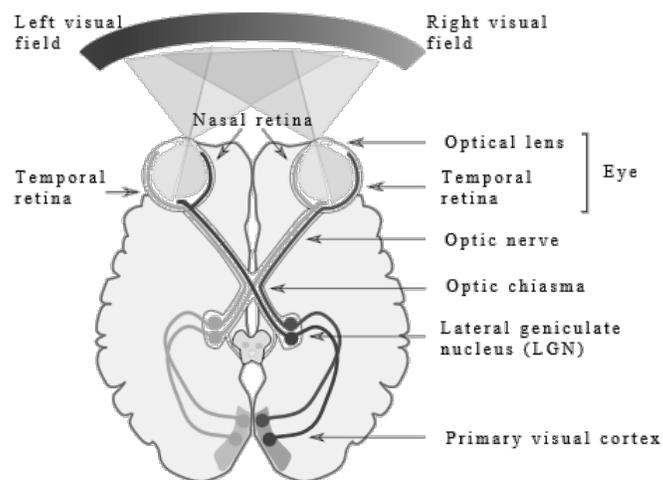
- Pupils constrict
- Patient reports blurred vision
- Ocular motility (cardinal points of gaze) – Unsure of exotropia
- Near point of convergence – break at 8 inches
- Subjectively saccades were accurate , pursuits on the right were impaired

### Low vision findings

- Pupils constrict
- Cover Test –Distance -8 Exo XT, R Hypertropia, near – intermittent XT
- Near point of convergence - break at 8 inches
- His prescription included bifocals with prisms

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## Visual Pathways and Hemianopia



[https://commons.wikimedia.org/wiki/File:Human\\_visual\\_pathway.svg](https://commons.wikimedia.org/wiki/File:Human_visual_pathway.svg)

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## Common Presentation

- Right homonymous hemianopia is a result of involvement of left geniculocalcarine tract and vice –versa
- A posterior or a middle cerebral artery stroke can lead to homonymous hemianopia
- Involvement of parietal loop of the geniculocalcarine tract leads to inferior quadrantanopia
- Involvement of the temporal loop leads to superior quadrantanopia
- With macular sparing patient will have central vision and can read

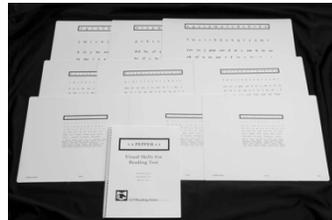
## Visual Field Tests

### Confrontation Testing

- Patch one eye of the patient (right), conversely patch your left eye
- Have the patient fixate on a central target
- Present the stimuli half way in between you and the patient in 4 different quadrants
- Test each quadrant by counting the number of fingers shown

### VSRT

- 6<sup>th</sup> to 8<sup>th</sup> grade reading level
- Print size is up to 4M
- Non contextual



<https://www.lowvision-simulators.com/products/pepper-vsrt>

Select a reading chart in their primary language  
 Select a chart at an appropriate reading grade level  
 Test is completed using both eyes  
 Client wears glasses  
 Be aware which test requires a reading distance and which doesn't

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# Functional Deficits

## Functional Mobility

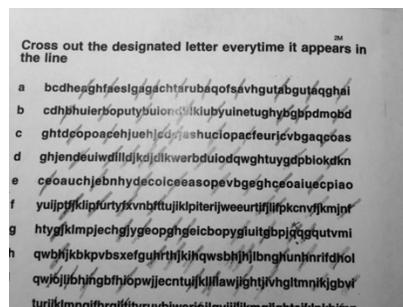
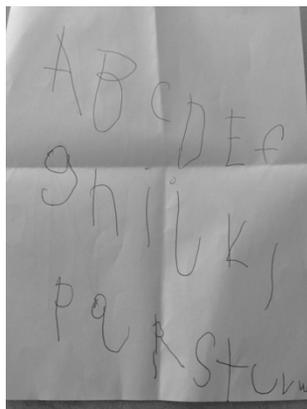
- Do not want to ambulate alone
- Do not want to navigate alone
- Less reaction time
- Slow, stiff gait
- Decreased arm swing
- Stop multiple times
- Shoe gazing
- Bump into objects or doors
- May have hand out for identifying objects

## Reading and Writing

- Reduced speed as well as accuracy
- Reading span is decreased
  - within is with
  - disappear is appear
- Right HH is more debilitating as perceptually we have a bigger reading span on the right with a loss of anticipatory parafoveal scanning
- With Left HH, patient may skip lines
- May write uphill or downhill if the hemianopic side is same as the dominant hand

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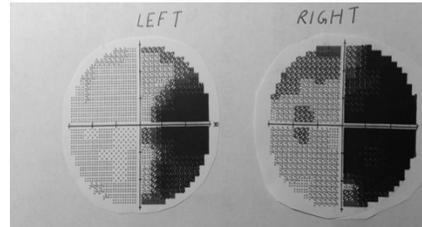
# Samples



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# Case Study 1

- Confrontation testing was negative, patient has expressive as well as receptive aphasia and is very aware of his central and peripheral vision as he was a pilot
- Complains that he misses words on his right, attempted 1 min. informal read aloud test which was frustrating
- Did a walk activity where he completely missed a hospital bed on his right and was surprised when he saw it on his way back



- Perimeter Evaluation – Gray Scale Diagram (Black area is the loss of visual field)
- Incomplete Incongruent Right Homonymous Hemianopia
- No optical aids recommended as there is enough sparing

CONTINUED

# Case Study 1

Screens and test for visual perceptual skills, visual motor skills and cognition

- Trails A
- Trails B
- MOCA
- VMI
- MVPT

School/City: Waltham Examiner: \_\_\_\_\_

Reason for Testing: \_\_\_\_\_  
*See page 4 for Clinical History*

Date of Test: 12/27 / 10 / 27  
 Date of Birth: 1977 / 5 / 15  
 Chronological Age: \_\_\_\_\_  
\*Do not round months up by one if days exceeds 15.  
47 years, 4 months

Confidence Interval Values	
Age	Confidence Level
4-7	±11 ±12
8-10	±8 ±10
11-84+	±8 ±8

TEST RESULTS		PERFORMANCE PROFILE		
Comparison to Same-aged Peers	Raw Score	Standard Score	Comparison to Same-aged Peers	Percentile Rank
Raw Score	<u>10</u>	145		>99
Standard Score		140		>99
Conf. Interval	<u>±9 %</u>	133		99
Percentile Rank	<u>27%</u>	130		98
Age Equivalent		125		95
		120		91
		115		84
		110		75

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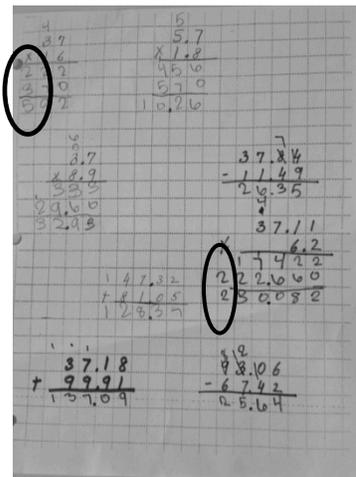
## Case Study 2

- Age 15
- Occupation – Student
- Patient underwent a right parietoccipital frontal craniectomy, elevation of depressed skull fractures, removal of bone and bullet fragments and debridement of necrotic bone tissue.
- Rehabilitation stay – PICU to rehabilitation hospital to outpatient clinic. Referred to OT by outpatient ST as she noticed motor deficits on the left. Patient also mentioned to her that vision is blurry. Patient wears a helmet.
- Patient reported that she did wear glasses but had no idea where they were
- Confrontation test was completed in quadrants using fingers, no deficit was identified
- Considering the diagnosis, patient was also being evaluated for left inattention

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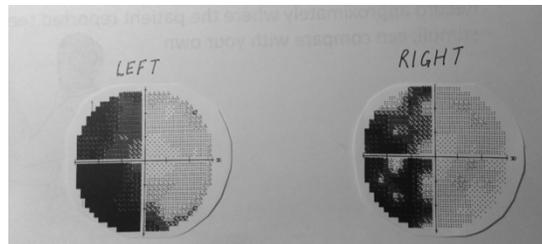


Recreated drawing from study by Ting et al., 2011



CONTINUED

## Left Homonymous Hemianopia



## Visual Search Training

- Find sticky notes placed in order of 1-20 on the blind side
- Place sticky note on affected (more) and non affected (less) side
- Equally place the sticky notes on either side
- Notes can be placed in sequence and then random order
- Add visual detail (Adapted from Warren)
- Increase difficulty
  - speed - slow to fast
  - uncluttered wall to cluttered
  - predictable points to unpredictable
  - completing the activity in a busy environment

Use light boards, stickers, flashlights, laser pointers and pathways/courses



## Ocular Motility Skills

### Fixation

- Patient should be able to maintain precise fixation on a target for 10 seconds with no observable movement

### Saccades

- Eye movements should be effortless, quick and should land precisely on a target

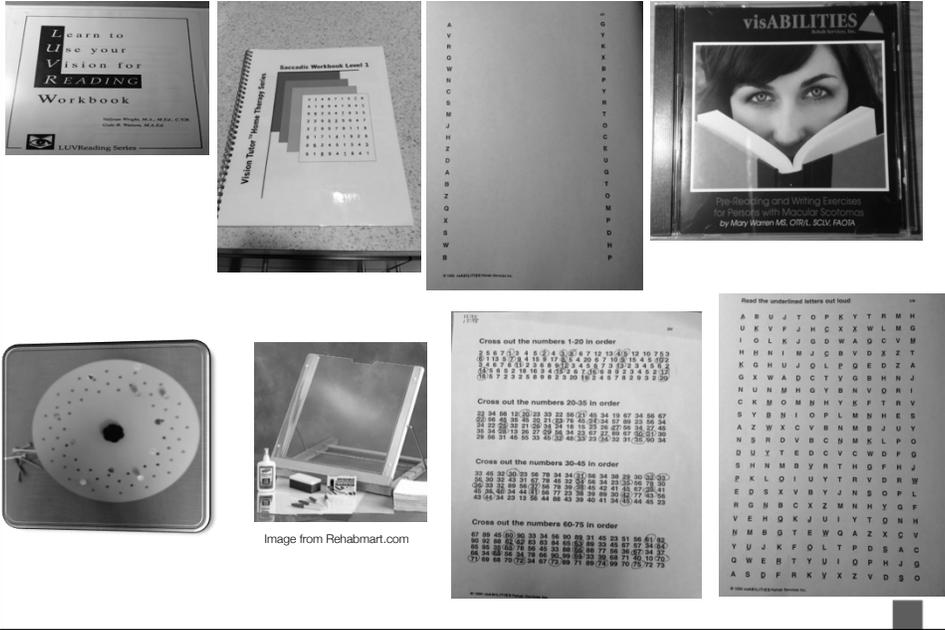
### Pursuits

- When tracking, eye movements should be smooth

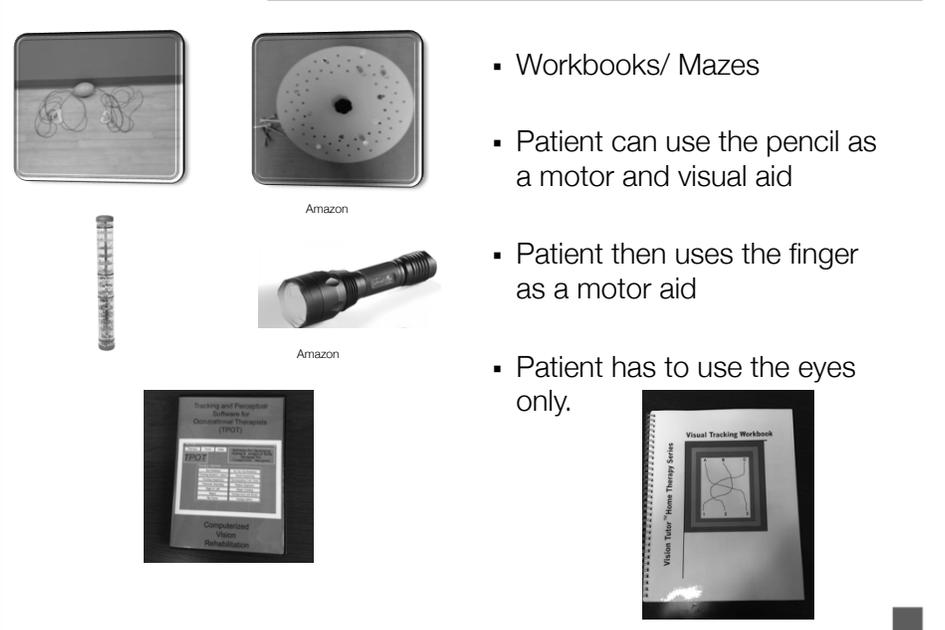
## Treatment Guidelines

1. Saccades – large to small, horizontal, vertical and circular
2. Pursuits – small to large
3. Eliminate head movements - use weights on head or have the patient tuck a ball under the chin and hold it
4. Increase difficulty by using bosu, astro turf, balance beam, metronome or adding cognitive tasks
5. Add distractors to the environment
6. Change environment to help with transfer of learning -same demands with same accuracy
7. Have the patient instruct the therapist to complete the task for internalization of the task

continued Saccades



continued Pursuits



- Workbooks/ Mazes
- Patient can use the pencil as a motor and visual aid
- Patient then uses the finger as a motor aid
- Patient has to use the eyes only.

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## Unilateral Neglect

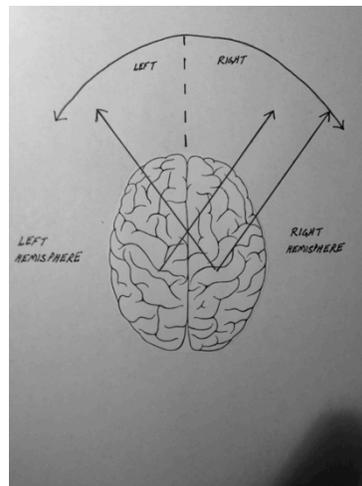
- It is a disorder of spatial exploration, orientation and cognition (Sprenger, Kompf, Heide, 2002)
- It is the inability to integrate and use perceptual information from one side of the body and /or environment. Left neglect as compared to right neglect is frequent, severe and long lasting
- It is not a disorder of sensory processing but can be made worse if hemianopia is present
- Predominantly it is a result of damage to right fronto parieto-temporal circuitry
- It is a visual attention deficit and is multimodal

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## Cause

Disruption of the network in between prefrontal, frontal, temporal, parietal and occipital lobes and the network between brainstem, thalamus and cerebellum (Adair & Barrett, 2008)

Spatial Bias - Right hemisphere can attend to left and right space where as left can attend to right space only



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## Manifestation

- Conceptualization of space is impaired because of impaired spatial cognition and orientation where the brain loses the ability to map left space
- Working visual memory is severely impaired
- Spatial bias is exacerbated where there is complete unawareness of the left side, patient misses landmarks, objects, events on the left with poor or no insight into the deficit

CONTINUED

## Manifestation

- Difficulty sustaining attention
  - Patient drifts off, lose their train of thought
  - Decreased ability to respond
  - Patients cannot sustain active search patterns
- These patients lack cognitive flexibility , which is why it is very difficult for them to be independent
- They lack internally generated maps to show goal directed behavior

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# Behaviors and Evaluation

- Personal neglect – Does not shave one side of the face, anchors eye glasses over one ear only
- Peripersonal neglect – Ignores objects placed on one side of the body like coffee mug and phone
- Extrapersonal neglect – Patient is unable to wheel self through doorways, hits the door frame, gets stuck on the right side, unable to incorporate left side even with cuing

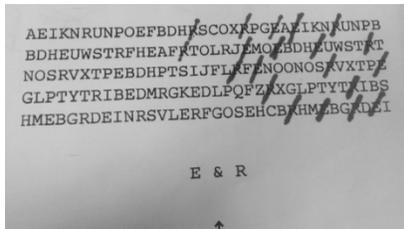
## Asymmetrical search patterns

- Search is initiated on the right
- Search is limited to the right side
- Cannot engage with left space
- Results in difficulty reading
  - Dyslexia

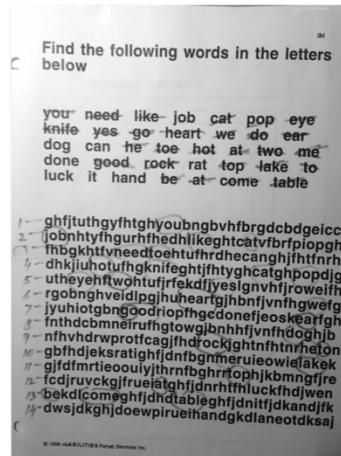
(Warren, 2016)

# Cancellation Tasks

## Left Unilateral Neglect

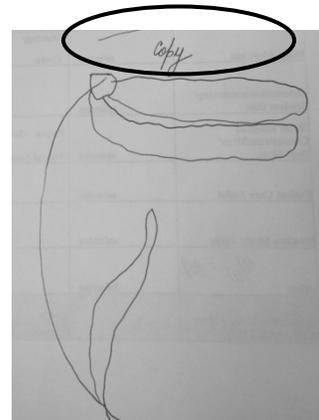
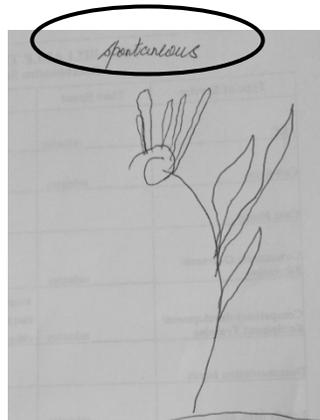


## Left Hemianopia



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## Collect Evidence



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## Visual Scanning Training

- Start search from the left by using the 'pop out' effect
- Use a linear left to right pattern for near space tasks like reading and a circular left to right pattern (clockwise or counterclockwise) for far away tasks like scanning a room (Cicerone et al., 2000)
- Engage with objects in left space and if possible identify visual detail.
- Repetitive motor memory may assist conceptualization of left space.



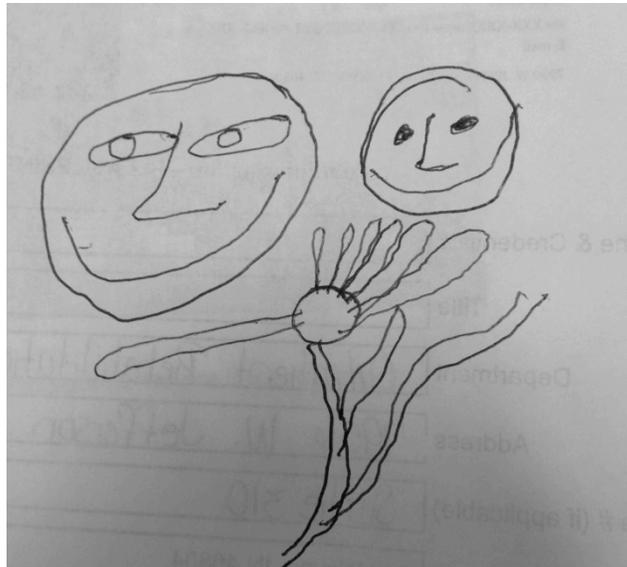
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## Provide Sensory Input

- Visual – Occlude the right half of the visual field in each eye, prism adaptation (Newport & Schenk 2012; Smania et al., 2013)
- Vibratory – Neck muscle vibration induces lasting recovery when given as a supplement to conventional exploration training (Schindler et al., 2002)
- Tactile – Do compression, weighing down the left side, therapeutic brushing to improve attention to left space?
- Vestibular – Do postural or equilibrium righting reactions improve attention to left space?

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## Elicit Sustained Attention

- Choose activities that are emotionally relevant and meaningful
- Provide clear goals
- Provide context
- Meta cognitive approaches – Use language and cognition to redirect search
- Examples – Hobbies, Dynavision



Thank You  
subahg06@gmail.com

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## Resources

- [www.visionaware.org](http://www.visionaware.org)
- [www.nei.nih.gov](http://www.nei.nih.gov)
- [www.loc.gov/nls/](http://www.loc.gov/nls/)
- [www.strokengine.ca/](http://www.strokengine.ca/)
- [www.strokecenter.org](http://www.strokecenter.org)
- National Federation for the Blind  
<https://www.nfb.org>
- American Foundation for the Blind  
<https://www.afb.org/>

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