Vision to the Brain

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Overview

- Low Vision Rehabilitation – Why is it important to understand Brain Structure and function in relation to vision processing?
- Assessment of vision following Acquired Brain Injury.
- Impact of additional cognitive and physical deficits

Brain Injury – Why is your understanding essential?

- Knowledge of ABI will help to guide the Assessment process
- To assist the person with the ABI to understand the nature of their vision loss and the functional implications.
- Provide appropriate therapy interventions
- Identifying strengths that can be utilized in a therapy/rehabilitation program.

How do we assess vision following an ABI?

- Vision isn't just about how clearly we see or how much we see
- Vision is about how we interpret visual information and integrate this information with other cognitive, sensory and motor functions.
- If we understand how vision is processed by the brain then we will be able to determine the level of processing at which the deficit occurs.

What constitutes a Visual Assessment?

CLINICAL ASSESSMENT

- Defined by conventionally accepted measurements
- Quantifies vision deficit with a numeric value
- Applicable to research via statistical analysis of measurements
- Allows for accurate measurement of change over time
- Limited in scope of 'What' can be assessed by methods of measurement.
  - Example: How do you quantify a visual skill such as recognition of objects?

What constitutes a Visual Assessment?

FUNCTIONAL ASSESSMENT

- Applicable to ADL tasks that are difficult standardize
- Functional tasks selected for assessment are often related to the individual's goals
- Performance is influenced by many more variables
- Difficult to track changes over time

Functional Assessment

- 'Top down' approach to Assessment
- Observation of a person's behavior does not necessarily inform us as to *why* a task is not performed successfully
- One Example:
  - Orientation to a particular location or landmark
  - What are the possible causes of difficulty with this task?

Landmark Recognition – What's involved?

- Visual Acuity
- Visual Fields
- Integrity of Eye Movements
- Attention to task
- Attention to detail verses environment
- Systematic and complete search pattern
- Object Recognition
- Topographical orientation
- Visual Memory
- Goal directed behavior

Relating Brain Structure and function to assessment

- We can determine the role that each area or lobe of the brain plays in a particular task
- We can use the traditional 'hierarchy of visual skills' to structure our assessment process
- We can develop keen observational skills and methods of structuring functional assessments that highlight specific visual skills

‘Bottom up’ approach

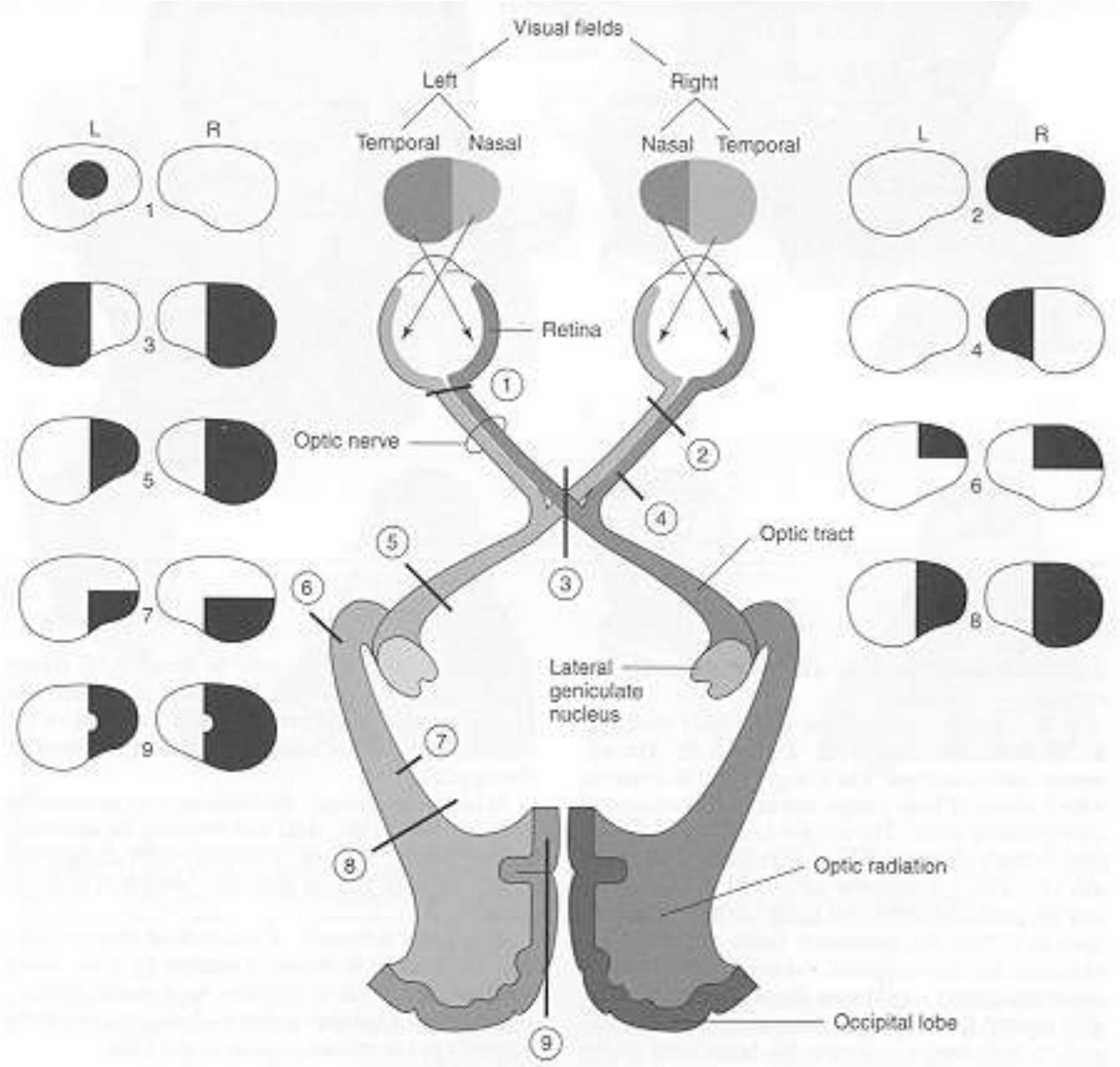
Looking at the Quality of ‘image’ or ‘information’ going to visual cortex

- Acuity
  - Static Acuity
  - Dynamic Acuity
  - Contrast Sensitivity
- Visual Fields
  - Hemianopsia, quadrant loss
- Ocular motor
  - Saccades
  - Convergence
  - Binocular Vision

Visual Acuity

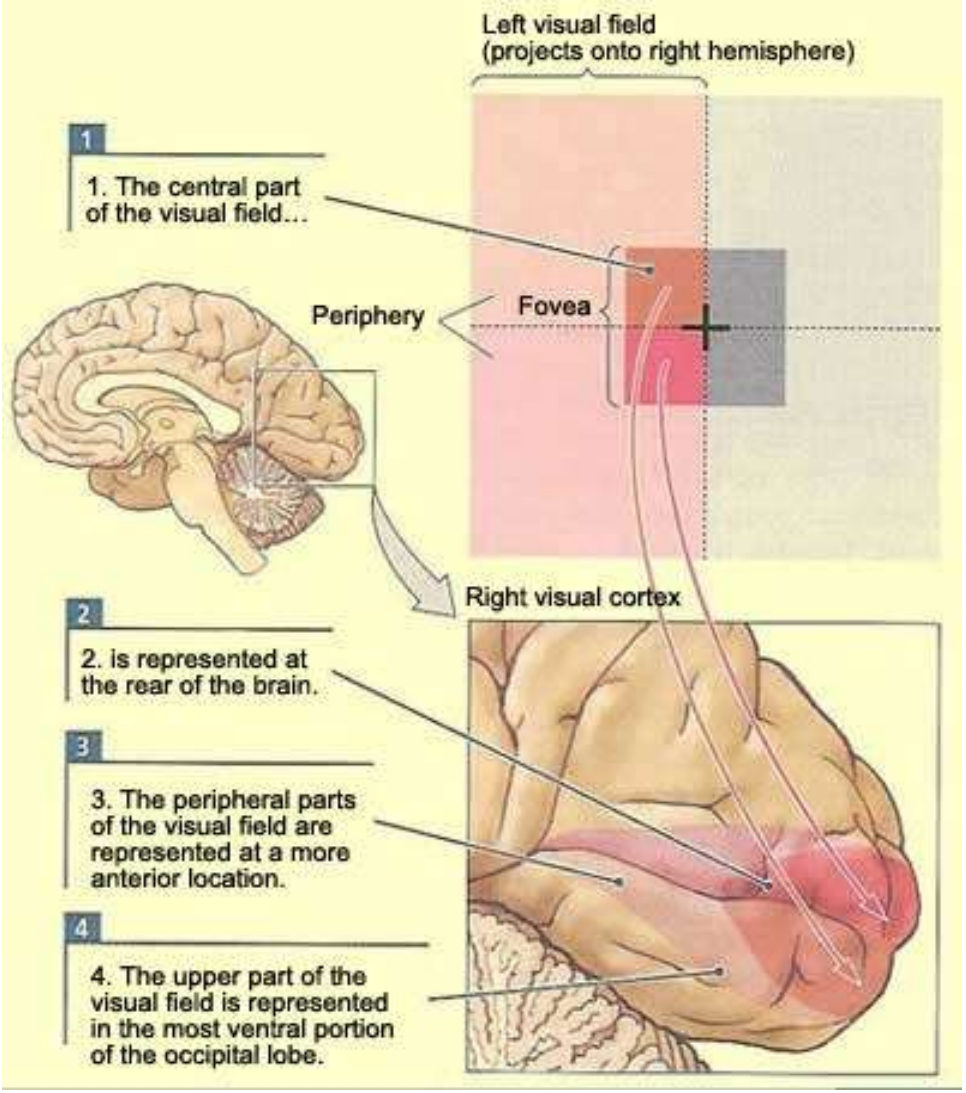
- **Static Visual Acuity** measured using stationary optotypes and a sitting observer.
  - In everyday life the identification of moving vehicles or persons is often required as we, as well as our surroundings, are continually moving.
- **Dynamic Visual Acuity** is rarely tested and often impaired by deficits in smooth pursuit eye movements, or nystagmoid fixation instability.
- **Contrast Sensitivity** is decreased following an ABI and is an indicator for function
- When acuity is reduced the increased effort required to process visual information should be a consideration
- Decreased acuity affects the CNS ability to selectively attend to relevant information.

Affects of specific lesion sites on Visual Fields



Macular Visual Fields

- Visual images related to Peripheral fields are processed more anterior area of the Occipital Lobe
- Central Macular images processed by the Occipital poles
- The presence of **Macular sparing vs. Macular splitting** is crucial for the presence of Hemianopic Alexia



Control of eye movement

- The two primary mechanisms that control eye movement are:
  - Central neural mechanisms
  - Cranial Nerve innervation of eye muscles

- Disruption of the ocular motor function can occur through damage to the neural structures in the brain, cranial nerve damage or weakness of the extra ocular muscles

- Any disruption of eye movement will diminish perceptual stability

Saccades and Pursuits

The **saccadic system** controls rapid conjugate eye movement and maintains fixation (foveation) on the object of regard.

- Horizontal saccades are controlled by contralateral frontal eye fields in the Frontal Lobe.

The **pursuit system** controls smooth tracking to follow slow-moving objects.

- The pursuit movements are controlled by the ipsilateral Parietal Lobe.

Most voluntary eye movements are a combination of saccade and pursuit eye movements.

Deficits of ocular motor function

Vision Deficit	% Occurrence in Visually Symptomatic TBI	% Occurrence in Stroke
Blurred vision	41% (Accommodation)	32% (Convergence)
Slower inaccurate reading skills	51%	26%
Diplopia eliminated with monocular occlusion	56%	16%
Visual- vestibular deficits	56% - 58%	12%
Decreased contrast sensitivity	Not recorded	82%
Visual field deficit	38%	24%
Light Sensitivity	49%	Not recorded

Visual Scanning

- There are two major factors influencing scanning:

  - **Visual attention**
  - **Visual fields**

- **One or both may be affected by the injury**

Scanning the environment

Visual Scanning

- Lack of scanning or ‘neglect’ of a particular area will contribute to a lack of awareness of the environment as a whole leading to poor orientation
- Object (pattern) recognition is dependent on organised, thorough scanning.
- Effective scanning consists of a series of foveal fixations executed in an orderly, sequential fashion in which the most important details are re-examined several times to ensure accurate identification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Inefficient Scanning

- Visual field deficits can result in poor scanning patterns or inefficient eye movements towards the affected field
- Tendency to search intact visual field first, then to make small stepwise eye movements towards the affected field
- Leads to difficulties when viewing moving objects

Visual Attention

- Visual attention is a crucial lower level skill.
- A person may be unable to utilise **selective visual attention** to meet the demands of complex visual tasks.
- The complexity of the task or the environment can lead to apparent inconsistencies in perception and functioning.

Hemispheric differences in Attention

The Left Hemisphere

- Mechanism for **directing attention to the right visual field.**
- **Focal , detailed** analysis
- Advantage for focal information related to reading analysis

The Right Hemisphere

- Mechanism for **directing attention to Right and Left visual fields.**
- Provides for a **broad , global view**
- General , non-detailed analysis
- Assists with spatial relationships (object to object, and object to self)

Focal brain injury leads to a bias in Attention

Left Hemisphere Deficits:

- Lesions of the Left Temporal region result in decreased focal recognition of written language
- A more random approach to scanning resulting in a poor search pattern
- Focus on the ‘big picture’, unable to easily detect the detail.

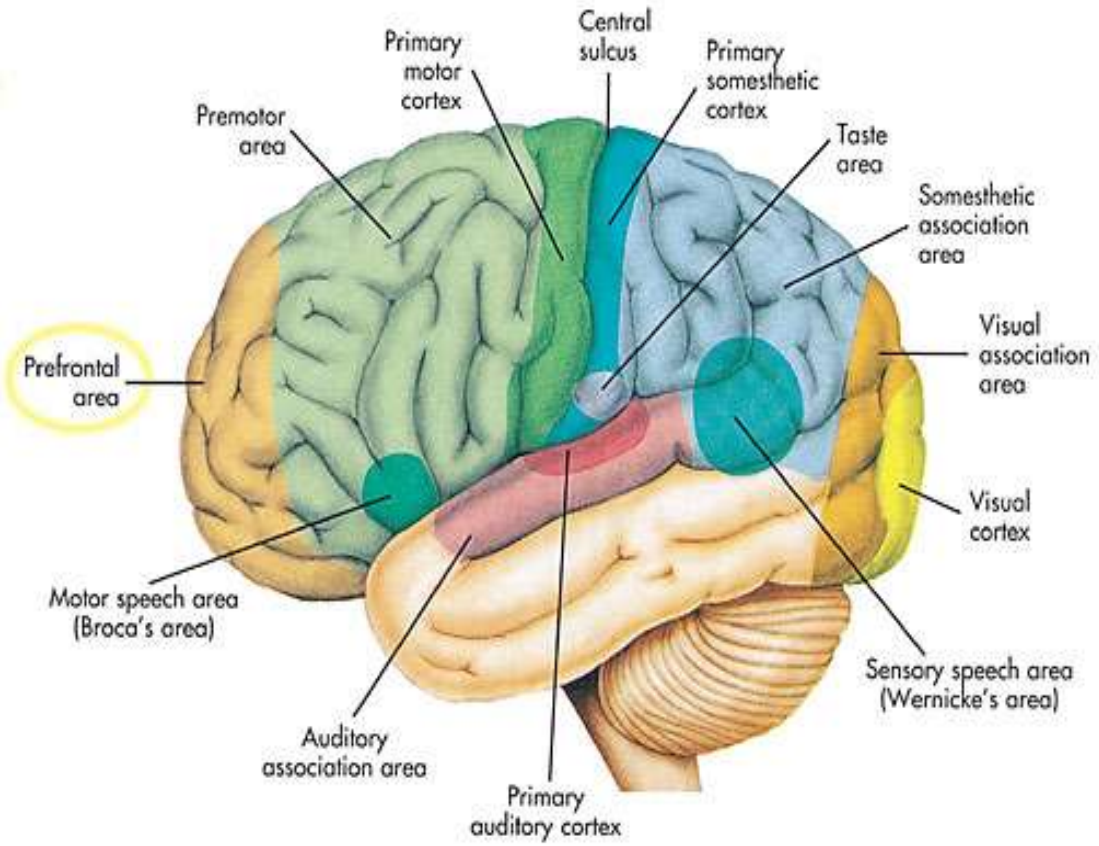
Attention – Right Hemisphere Deficits

- Avoidance in eye shift towards the left affected side
- Poor awareness of the environment
- Tendency to fixate on visual stimuli on right side first, then difficulty disengaging from the stimuli
- Lesions of the right parietal lobe are associated with a greater incidence of **visual neglect syndrome**


TO WARDS, THERAPY
OUTPATIENTS

Levels of processing visual information

- Primary – Visual cortex
- Secondary – Association areas lie adjacent to primary visual processing areas
- Tertiary – Boundary between Parietal, Occipital and Temporal Lobe
- Greater asymmetry of function occurs at the secondary and tertiary level of processing within each hemisphere



Secondary Visual Cortex (Association Areas)

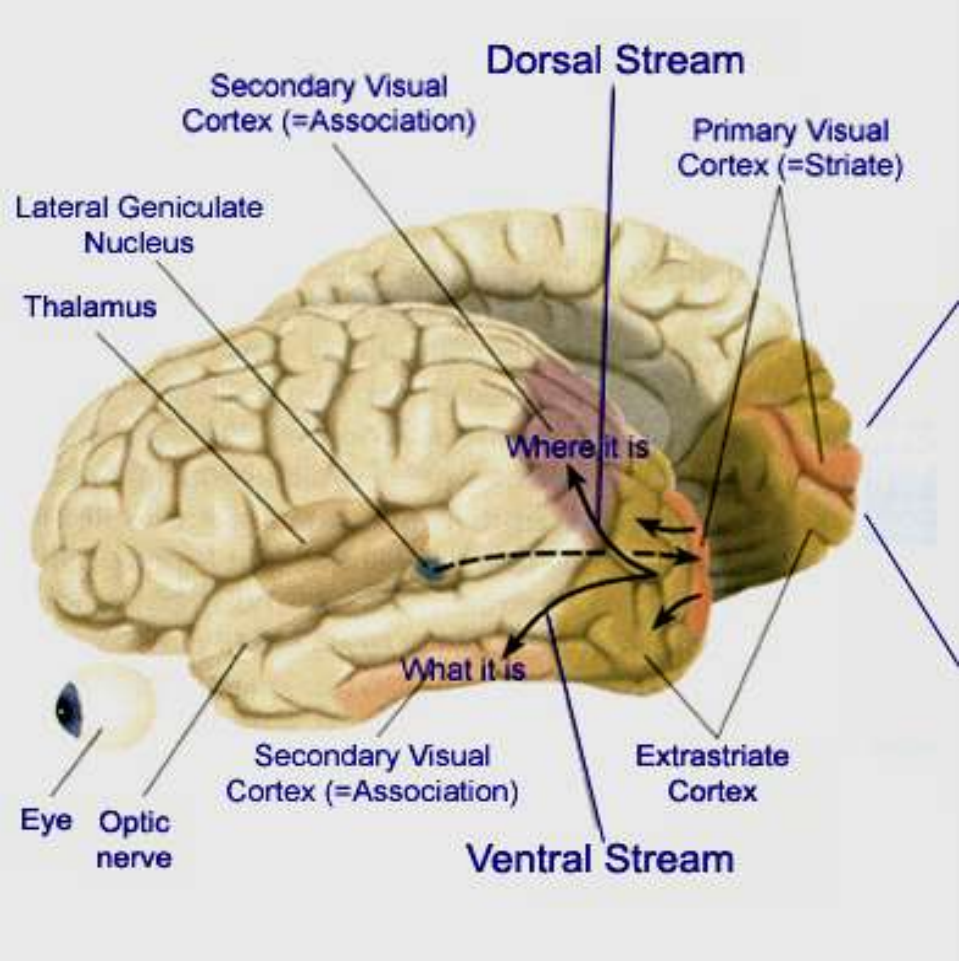
Interpretation of visual information

What is it?

- Visual information such as shape, colour, form

Where is it?

- Spatial relationships, motion



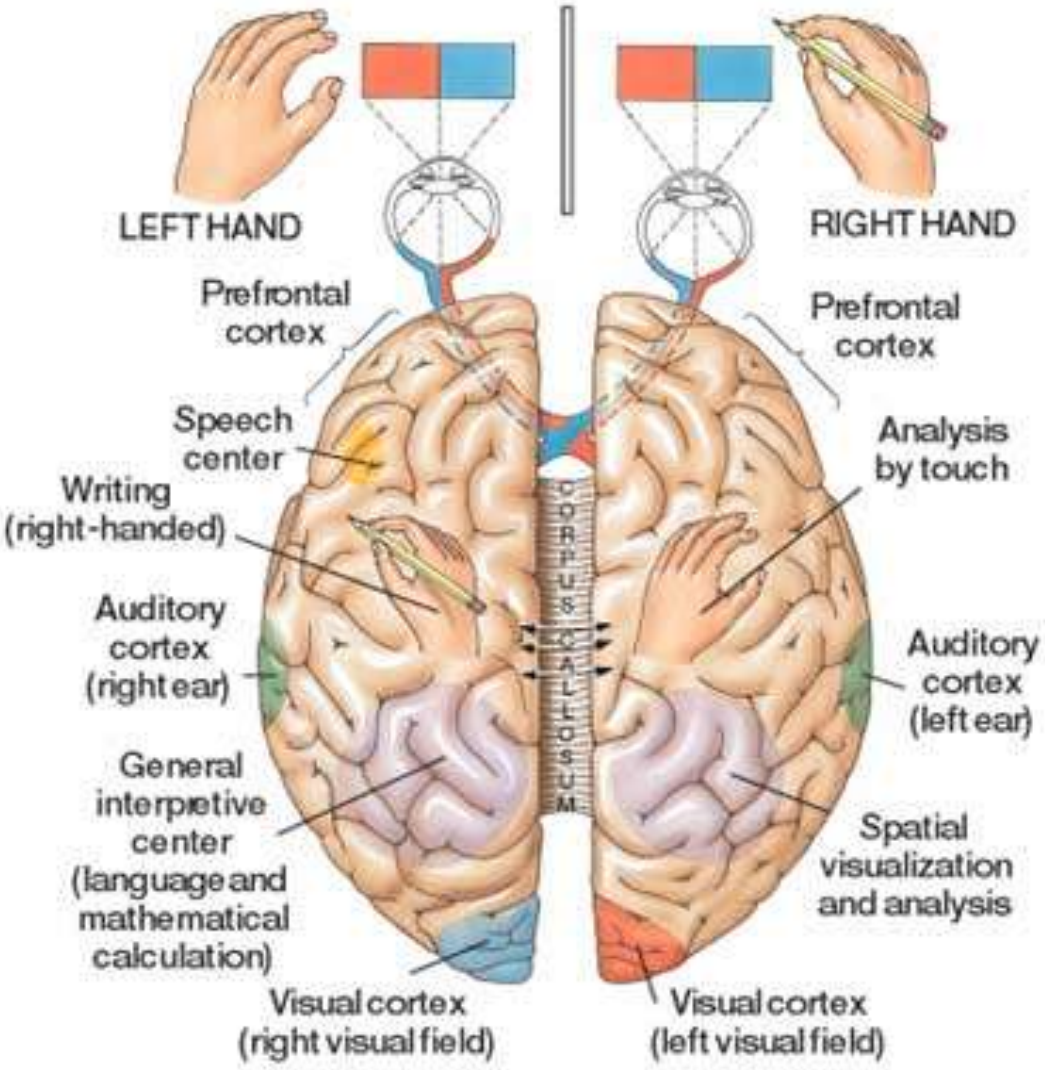
Hemispheric localization of Function

Left Hemisphere

- Object recognition – recognition of symbols for language, mathematics

Right Hemisphere

- Spatial visualization and analysis
  - In relation to ourselves and other objects
  - Detecting motion



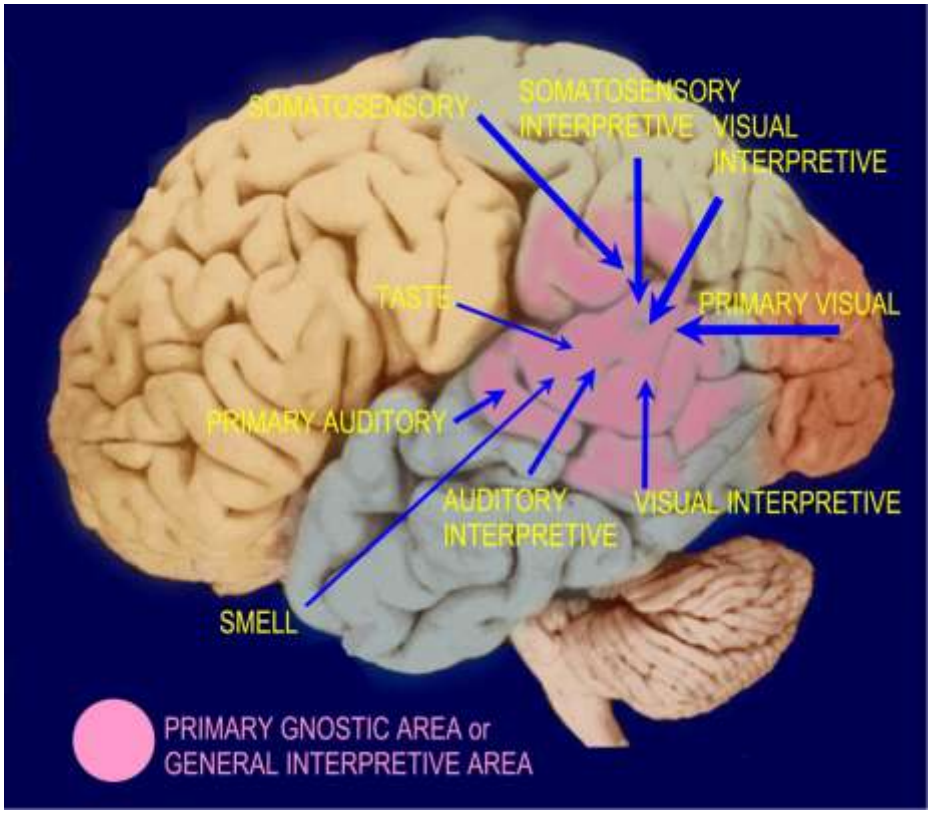
Visual Cognition

- The ability to mentally manipulate visual information

- Integrate visual information with other information in order to solve problems, formulate plans and make decisions
- Examples:
  - Speed of processing
  - Spatial reasoning

Tertiary Processing – Integration

- Combines information from parietal, temporal and occipital lobes
  - **<u>Gnosis</u>– recognition beyond sensory input**
  - **<u>Praxis</u> – ideation concept formation, planning & motor execution**
  - **<u>Body Scheme</u> – perception of one's own body position and the relationship of ones body parts.**



Frontal Lobe functions in Vision

- Prefrontal cortex responsible for Visual Executive functions
  - Motor planning required to shift, or sustain eye movements when carrying out visually guided tasks.
- Initiates visually guided movements via the **frontal eye fields** and primary motor cortex
- Frontal eye fields responsible for voluntary ocular motor and saccadic eye movements
- Injury impacts on fixation, pursuit and saccades

Frontal Lobe functions

- Filtering out extraneous information
- Selective focus of attention on important visual input
- Planning and problem solving
- Goal directed behavior
- Initiation and self monitoring
- Impulse control
- Insight

Speed of Processing

May be due to:

- Inability to obtain a clear image (primary processing)
- Slow recognition of object (secondary association area)
- Slow integration with other sensory information (tertiary processing)
- Slow reaction times – integration with motor planning via prefrontal cortex (frontal lobe)

Other Physical deficits

Balance

- Attention to balance takes precedence over all other processes
- Poor balance narrows the attention –people reduce visual and vestibular input by looking at the floor.
- Poor balance results in a restricted range of head and eye movement to decrease the vestibular input

- Coordination
  - Cerebellar damage will influence coordinated movement of the trunk or limbs

The involvement of language

- Adequate language skills are required for any assessment of function following a brain injury.
  - Understanding instructions
  - Communicating a verbal response
  - Imparting an understanding of the strategies that may assist to compensate for any deficits present

Therefore a basic understanding of the nature of language deficits following ABI is essential knowledge for all practitioners working in the area of vision rehabilitation .

Questions related to language

- Where is the Brain Injury; Left, right or bilateral?
- What is the hemispheric dominance; are they right handed?
- If language is involved, is it receptive, expressive or both?
- If it is a receptive language problem, is verbal and written information affected?
- What were their language skills prior to the brain injury?

Visual Memory

- Making sense of the image is essential to being able to lay down new memory traces and recalling it at a later date
- All new visual information is compared to our memory of previous information to aid speed of recognition
- Damage to the Frontal Lobe and anterior Temporal Lobe will effect memory

Where we assess vision

- Visual demands – lighting, clutter, figure/ground
- Environments demands – static or dynamic
- Additional physical demands – balance
- Additional sensory demands – filtering and selective attention
- Memory – familiarity of the task and environments

When we assess Vision

- When the person is fatigued
- Impact of fatigue on **attention** and the subsequent affect on perception.
- Increased fatigue due to the effort required for focal attention and fine discriminative vision
- Visual Perception is not a stable, constant but fluctuates in a similar way to other aspects of function following brain injury

Overcoming additional deficits

- Using the strengths
  - Verbal verses visual
- Planning & problem solving
  - Establish a routine
  - practice at strategies to apply in the event that the unexpected occurs
- Memory deficits
  - Practice and repetition
  - Then more practice and repetition
  - Build upon familiar tasks

Take up the challenge

- Insist on having access to a comprehensive history of the brain injury
- Understand what functions might be affected in light of the location and type of brain injury
- Become keen observers and solvers of puzzles
- Use the strengths to overcome the deficits
- Foster a team approach as there are many benefits of working as part of an multi-disciplinary and interdisciplinary team
- Document what works and share your experience

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On line training programs in Acquired Brain Injury and Neurological Vision Loss

Thank you for inviting me to Little Rock.