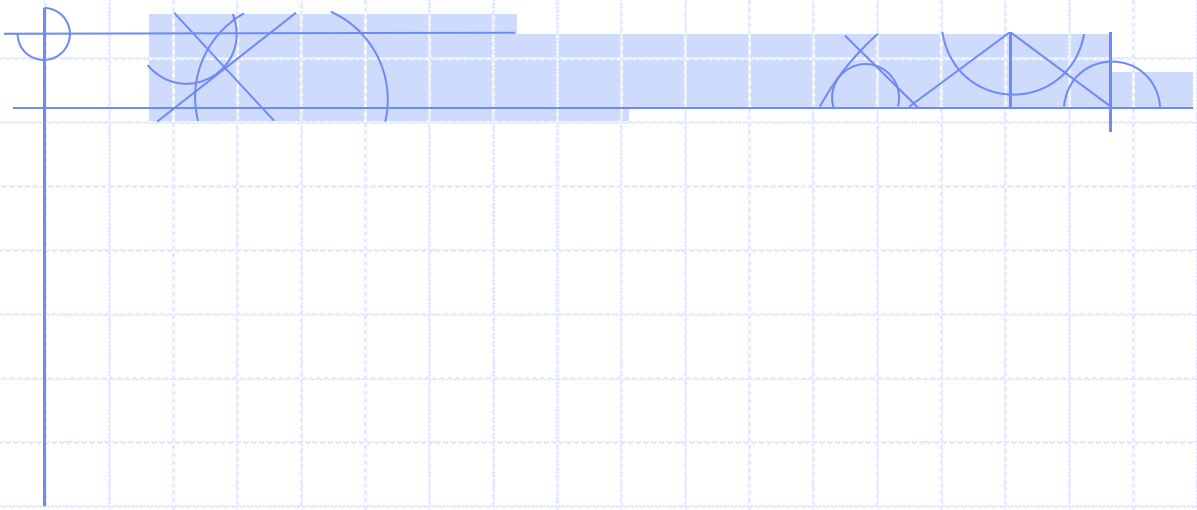
Visual Selection and Attention



Retrieve Information

- Select “what” to observe
  - No time to focus on every object
- Overt Selections
  - Performed by eye movements
- Covert Selections
  - Performed by visual attention

Two major functions

- Fixation
  - Position the target object in the fovea
- Tracking
  - Fixate on moving objects
- Processing is not *simultaneous*
  - Over time, objects and locations observed in sequence
  - Eye movements and attention shifts

Outline

- Eye Movement
  - Types of Eye Movements
- Visual Attention

Physiological Nystagmus

- Tiny, *involuntary* movements
- No selective function
- Image on the retina is changing
- Stationary retinal image
  - Disappears after a sometime
  - Movement is important for reconstruction of structure

Saccadic Movements

- Ballistic movement
  - Abrupt and Jerky
- Brings new objects of interest to the fovea
  - Saccades to a new position if target object has moved
- Takes 150-200ms to plan and execute
  - Max speed of 900 degrees per second
- Saccadic suppression
  - Misses the scene encountered during movement
  - Clarity on fixation

Smooth Pursuit Movements

- Tracks the position of a moving object
- Differences from saccades
  - Smooth and continuous
  - Constant feedback for tracking
  - Slower (100 degrees per second)
  - Acuity on tracked object only
- Depends on object's speed
  - Faster movements -> Harder to catch up
  - Improve with training
    - E.g. Baseball players

Vergence Movement

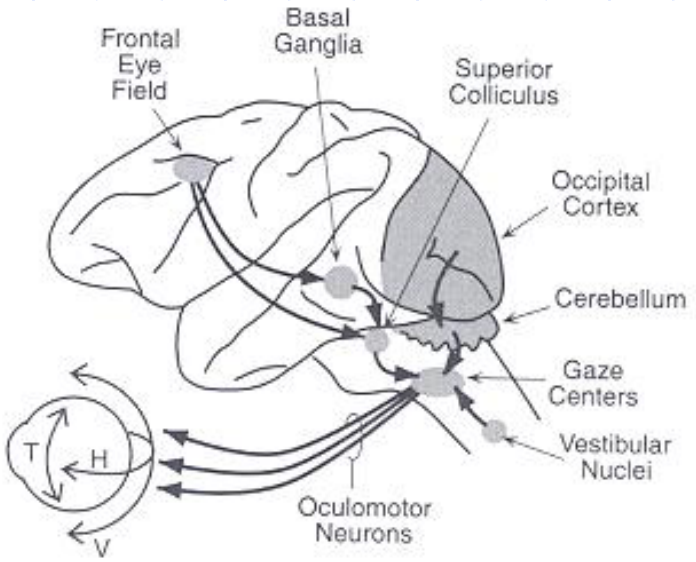
- Converges eyes to an object
  - Selects the *distance* of the object to focus
- Very slow (10 degrees per second)
- Disconjugate movement
  - Can move in different direction during the movement
- Can occur with saccades or smooth pursuit
  - When depth of the tracked or fixated object changes

Head Movements

- Maintain target object on fovea
- Vestibular
  - Slower than saccade
  - Faster than smooth pursuit
  - Extremely rapid and accurate
- Optokinetic Movements
  - Triggered movement of a large portion of visual field

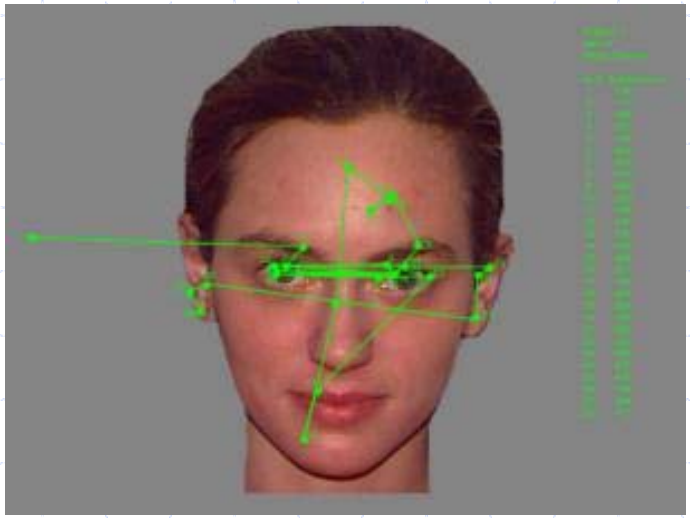
Controlled by Different Parts

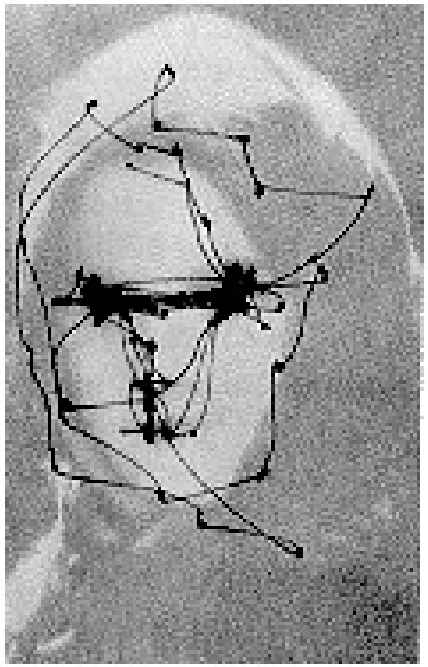
- Controls three pairs of muscles
  - horizontal, vertical, torsoinal
- Physiological Nystagmus
  - Tremors in eye muscles
- Saccades
  - Frontal eye fields in the frontal cortex
- Smooth pursuit movement
  - motion channels in visual cortex
- Vergence movement
  - visual feedback and occipital cortex
- Vestibular movements
  - Driven by three-neuron reflex arc that begins in the vestibular system
- Optokinetic movements
  - Controlled by the cortical motion pathway and subcortical pathway



Saccadic Exploration of the Visual Environment

- Patterns of Fixation
  - Locations where maximum information is available





Saccadic Exploration of the Visual Environment

- Patterns of Fixation
  - Locations where maximum information is available
  - Depends on the observer's motive
    - Airplanes?
    - People?
  - Sequences of fixation
    - Often reccurs
    - Called scan path

Transsaccadic Integration

- Multiple fixations integrated into a single image on retina
- Two theories on integration
  - Spatiotopic fusion hypothesis
    - Mapped into spatially organized memory array
    - Experiments proved this wrong.
  - Schematic map
    - Encodes spatial relations among the various parts of an object, encodes information of expected results from prior experience
    - Can often see illusory objects if they are commonly expected

Visual Attention

- Recruiting
  - Gathering visual information from multiple resources
  - Concerned with *capacity*
  - Depends on alertness, motivation, time of day
- Focusing
  - Selectivity to function in the presence of limited capacity
  - First, overt movements
    - Use low level information to locate areas of interest
  - Then, covert movements
    - Selection of the most important object, property or phenomena

Visual Selection

- Spatial Selection
  - Restricted region of the visual field
  - Information gathered from that region
- Property Selection
  - Retrieving properties or features
  - Focus is on specific object

Early vs. Late Selection

- Paradox of Intelligent Selection
  - If selection operates early…
  - If selection operates late…
- Selection is based on heuristic of importance
  - Important for survival (i.e. moving objects)
  - Specific to individual (i.e. your name)

Auditory Attention

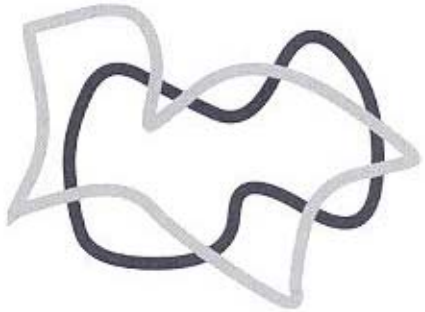
- Research on auditory focus
- Shadowing Task
  - Repeat aloud message coming in from the selected side
  - Ask what the subjects perceive on the other side
  - Can process low level info (e.g. male/female, not language)
- Filter theory
  - Retrieve gross information
  - Selects items of interest for further processing.
- Attenuator theory
  - Leaky version of Filter theory
  - Second phase uses dictionary units against thresholds

The Inattention Paradigm

- Attention is not focused on object of interest
- Simple sensory properties could be perceived without attention
  - Location
  - Color
  - Number
- Inattention blindness
  - Not perceiving change if no attention is given.
- Results suggest that late selection is performed.

Intentionally Ignored Information

- Ignored object is not fully perceived due to active suppression
- Negative priming effect
  - takes time to suppress attended object before attending to target object.
- Attention helps perceive focused object
- Attention inhibits perception of other objects



The Attentional Cuing Paradigm

- Attentional Cuing Paradigm
- Subject is cued to look to the left or right
- Object could appear on either side
- Example test (-> look right, <- look left, + could be either or)
- Correct cuing
  - Decrease in response time by 30 ms (benefit)
- Incorrect cuing
  - Increase in response time by 30 ms (cost)

Shifts of Attention

- Voluntary shift symbols are called "push" cues
  - Shift due to a cue
- Involuntary shift symbols are called "pull" cues
  - Moving object in a static scene

- Differences:
  - Pull cues produce benefits with no cost
  - Pull cues work faster (100ms vs 200-400ms)
  - Pull cues cannot be ignored

- Three components of shifting attention
  - Disengagement
  - Movement
  - Engagement
- Each component is controlled by a different part of the brain

Metaphors for Attention

- Internal Eye Metaphor
  - Fovealike center where processing is concentrated
  - Problem: infinite regress (internal eye of the internal eye)
- Spotlight Metaphor
  - Area of attention is illuminated
  - Predictions
    - Rate of motion: Time proportional to distance
    - Illuminates the path
  - Problem
    - Fixed size
    - Unitariness – cannot be divided into regions
- Zoom-lens Metaphor
  - Zoom in to small and big
  - Takes time to adjust to the change in amount of focus
  - Alleviates problem of Spotlight metaphor

Space-Based vs. Object-Based Approaches

- Previous metaphors have been space-based.
- Object-based approaches claim that attention is given to objects, not areas
- Current debate implies mutual exclusion
- Could actually occur on different levels

Selective Attention to Properties

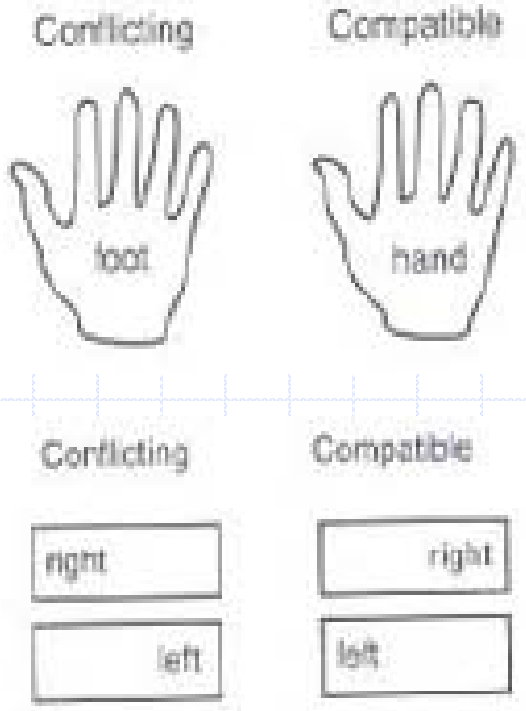
- Can people attend to different properties of the object independently?
  - The Stroop Effect
  - Integral vs. Separable Dimensions

The Stroop Effect

Green Red Blue
Yellow Blue Yellow

Blue Yellow Red
Green Yellow Green

- Interference in the reaction time of a task
- J. Ridley Stroop in 1935



Integral vs. Separable Dimensions

- Integral Dimensions
  - Cannot selectively attend to one without perceiving the other
  - E.g. saturation and lightness of a color
- Separable dimensions
  - Can selectively attend to one or the other without perceiving other properties
  - E.g. color and shape of an object

Integral vs. Separable Dimensions

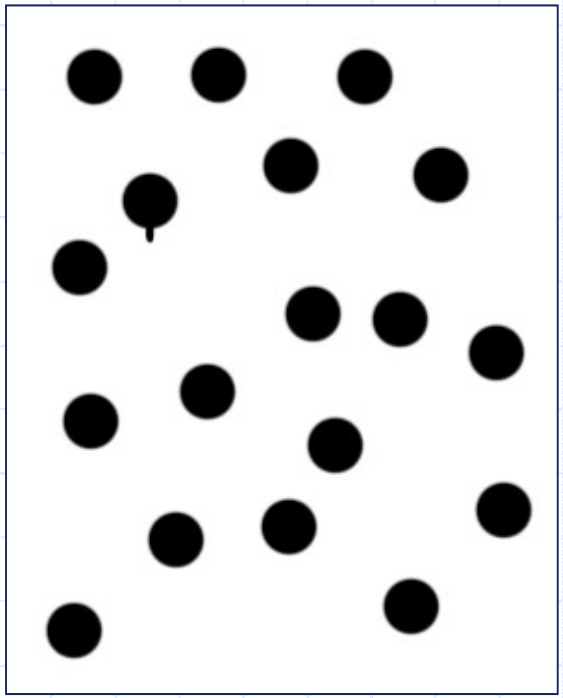
- Asymmetrical Integral Dimensions
  - First property separable from second but second is integral with first
  - E.g. Color and word in Stroop effect
- Configurable dimensions
  - Combination creates a new property
  - E.g. open and close parenthesis

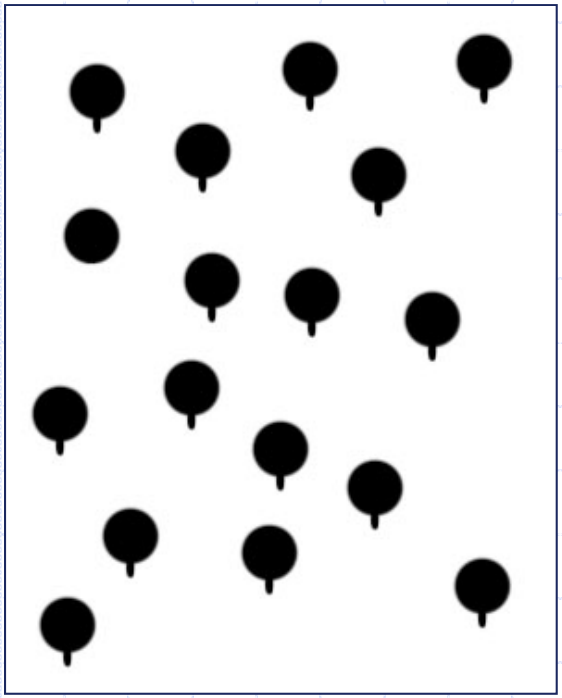
Distributed vs. Focused Attention

- Distributed attention (Pre-attentive)
  - when targets appear in any location
  - Parallel processing
  - Retrieves general information
  - Visual pop-out
- Focused attention
  - A single object to perceive
  - Serial processing
  - Retrieves more specific, detailed information

Visual Pop-Out

- When an object stands out from others
- Detected through distributed attention
- Only works when there's an extra feature



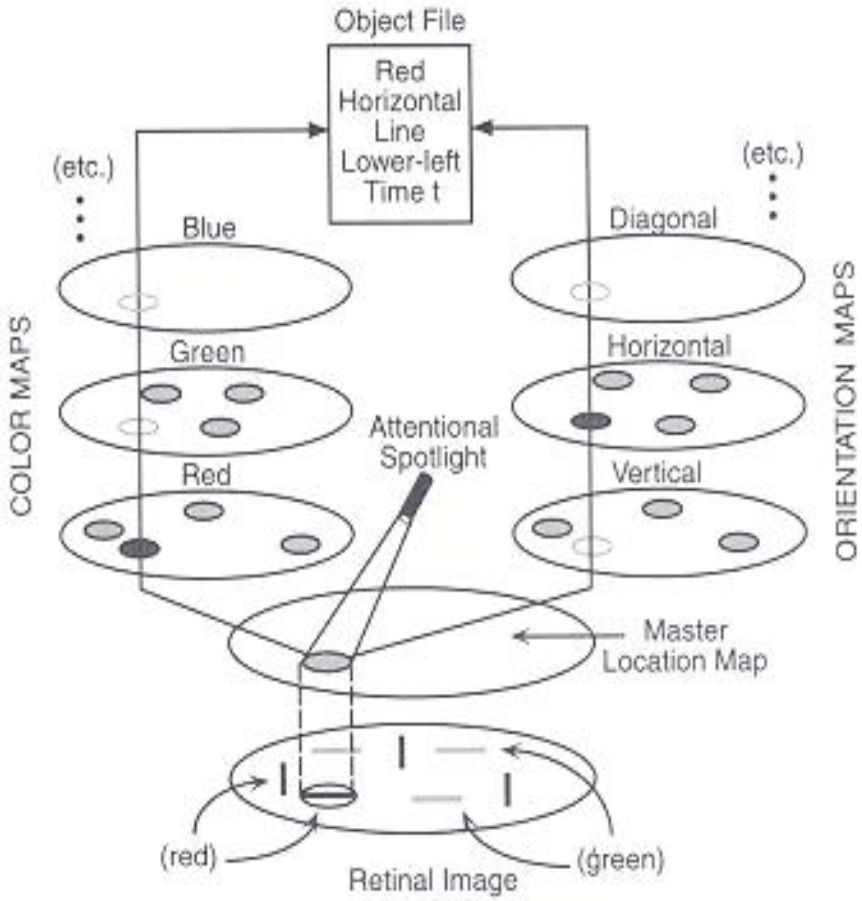


Feature Integration Theory

- Binding with attention
  - Process of conjoining different properties into visual objects

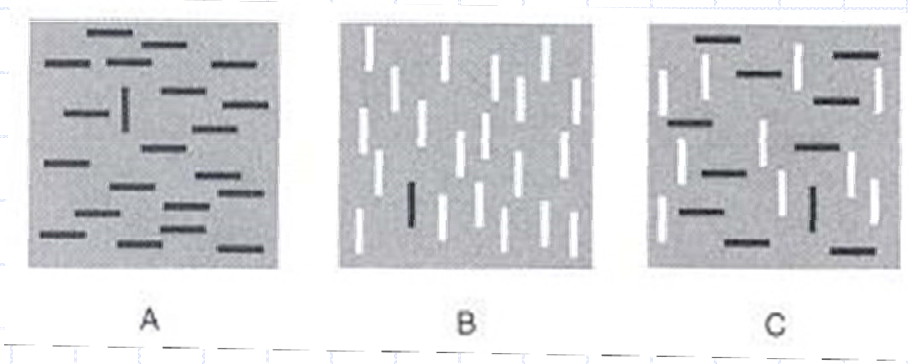
Feature Integration Theory

- Features are stored in features maps
  - Conjunction search
  - Texture segregation
  - Illusory Conjunctions

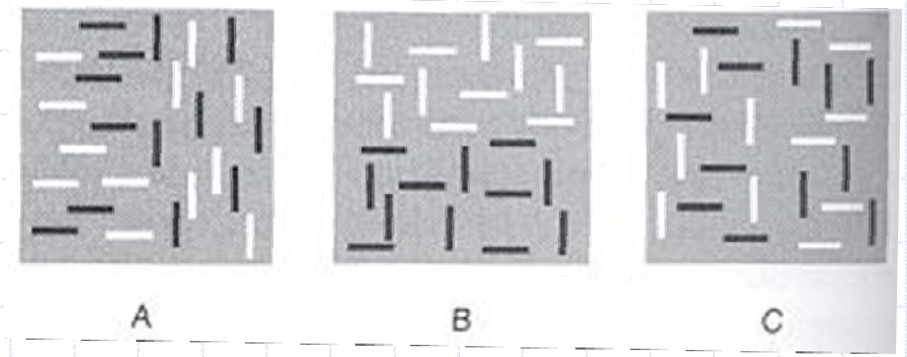


Feature Integration Theory

- Conjunction search



- Texture segregation



- Illusory Conjunctions

2 X S T 5

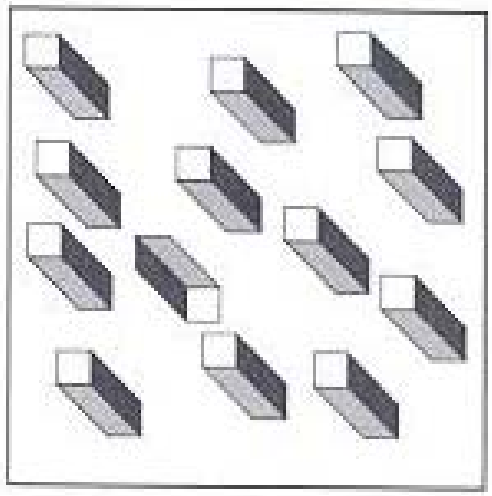
Stimulus

2 X T 5

Perception

Problems with Feature Integration Theory

- Conjunction search in parallel vs. serial
- Master location map is not coded in retinal locations
- Pop-out of high-level features in 3D pattern



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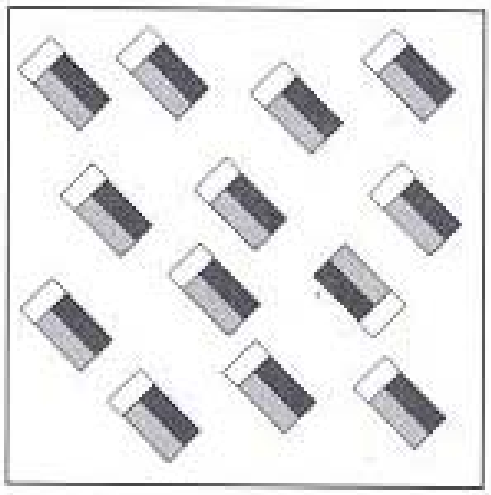


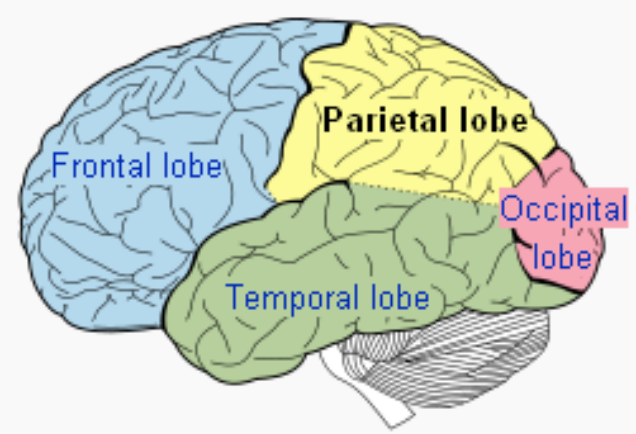
B

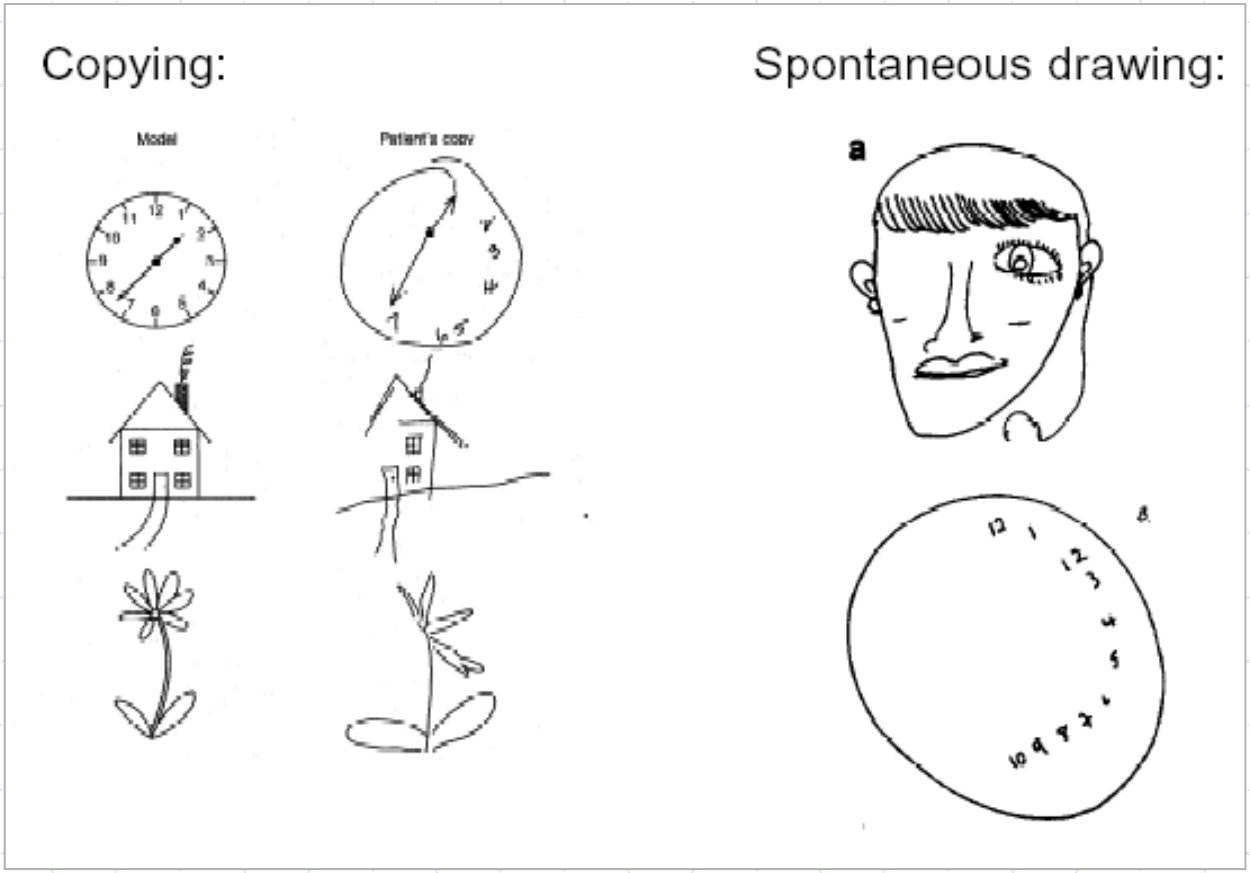
The Physiology of Attention

- On the contrary to behavioral methods, how is visual attention accomplished by neural mechanisms in the brain?
  - Unilateral Neglect
  - Balint's Syndrome
  - Brain Imaging Studies
  - Electrophysiological Studies

Unilateral Neglect

- Caused by brain injuries in certain location, especially parietal lobe of the right hemisphere
- Fail to notice objects on the opposite side of their brain injury





Balint's Syndrome

- An almost complete inability to notice anything except a single fixated visual object
  - Ocular apraxia
  - Simultagnosia
  - Spatial disorientation
  - Optic ataxia

Brain Imaging Studies

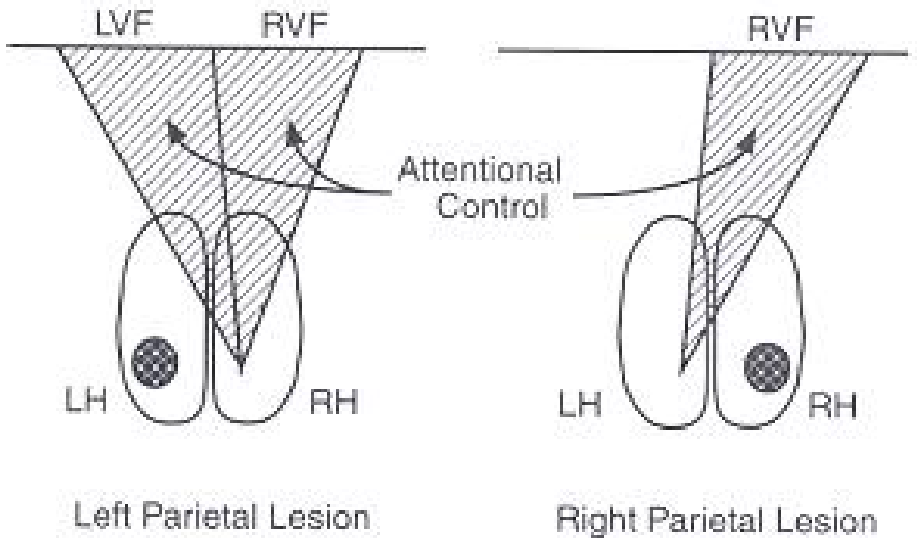


Figure 11.2.32 Attentional control with left versus right parietal damage. When the left parietal lobe is damaged, the right parietal lobe can still control attention on both sides of the visual field. When the right parietal lobe is damaged, the left parietal lobe can control attention only in the right visual field.

Electrophysiology Studies

- Selective attention to a given spatial location and object:
  - Restricts the functional size of a cell's receptive field
  - Increases its resolution for responding to specific features

Pre-motor theory

- Eye movements follow attentional movements
- Covert shifts of visual attention
- Overt eye movement

Summary

- Close relationship between eye movements and attention as mechanisms of visual selection
- Attention derives eye movements
- Attention is the major mechanism of visual selection