Visual Selection and Attention

CS 213
5/27/08
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Outline

- Eye Movement
  - Types of Eye Movements
- Visual Attention

Types of Eye Movement

- Physiological Nystagmus
  - Tiny, involuntary movements
  - No selective function
- Saccade Movements
  - Brings new objects of interest to the fovea
  - Ballistic movement
  - Saccadic suppression

Types of Eye Movement

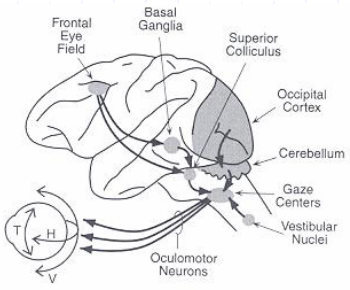
- Smooth Pursuit Movements
  - Tracks the position of a moving object
  - Differences from saccades
    - Smooth
    - Feedback
    - Speed
    - Acuity
  - The ability to track depends on object's speed
- Vergence Movements
  - Converges eyes to an object
  - Disconjugate movement

Types of Eye Movement

- Vestibular Movements
  - Help fixate eyes on an object when the head moves
  - Extremely rapid and accurate
- Optokinetic Movements
  - Similar to vestibular
  - Whole field of vision is moving
  - Optokinetic reflex

Physiology of the Oculomotor System

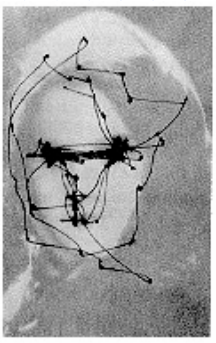
- Saccades
  - control by frontal eye fields in the frontal cortex
- Smooth pursuit movement
  - controlled by information from the motion channels in visual cortex
- Vergence movement
  - Controlled by visual feedback and occipital cortex
- Vestibular movements
  - Driven by three-neuron reflex arc that begins in the vestibular system
- Optokinetic movements
  - Controlled by the cortical motion pathway and subcortical pathway

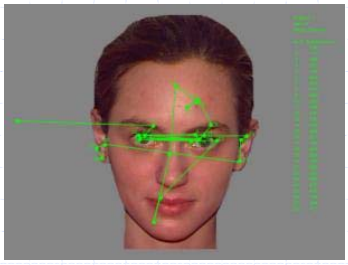


Saccadic Exploration of the Visual Environment

- Patterns of Fixation
  - Locations where eyes saccade to
  - Depends on the observer's motive
  - Scan path
- Transsaccadic Integration
  - Various fixations integrated into a single image
  - 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

Saccadic Exploration Example





Visual Attention

- Processes that enable an observer to recruit resources for processing selected aspects
- Properties
  - Capacity
  - Selectivity
- 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
- 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

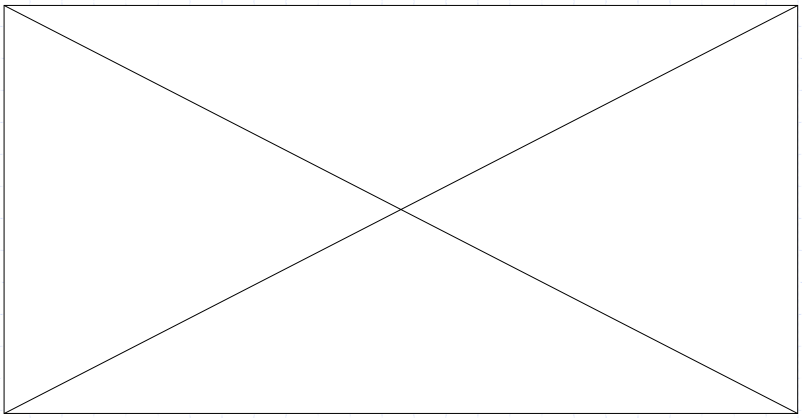
The Inattention Paradigm

- 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.

The Attentional Blink

- Perception is greatly reduced on a second object if it is presented within a half second of the first.
- No attention is available for 500 ms after the first object is perceived.
- Subject perceives object but it is not processed.

The Attentional Blink



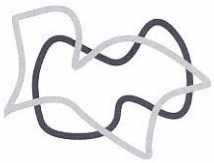
- http://psych.hanover.edu/JavaTest/Cognition/Cognition/attentionalblink_instructions.html

Change Blindness

- Cannot detect change on things that are not in focus.
- There are 4 differences

Intentionally Ignored Information

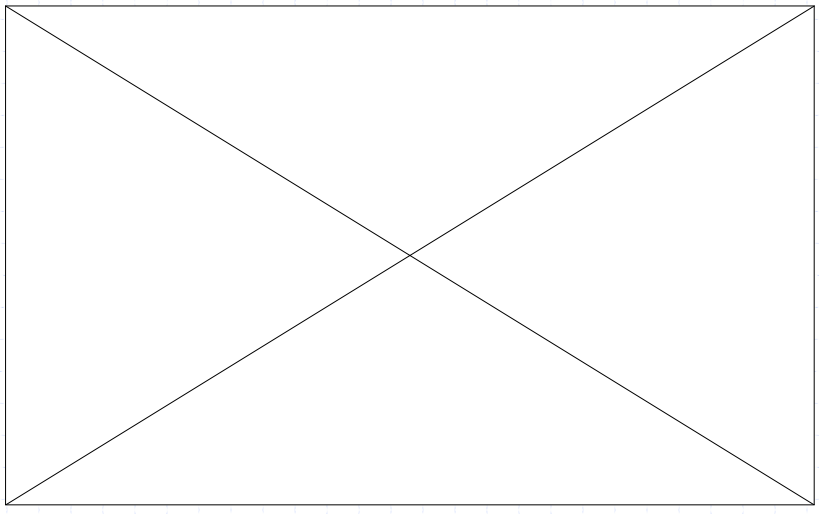
- Ignored object is not fully perceived due to active suppression
- Negative priming effect
  - takes time to suppress attended object before attending to target object.
- Attention helps perceive focused object
- Attention inhibits perception of other objects



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)

The Attentional Cuing Paradigm



Shifts of Attention

- Voluntary shift symbols are called "push" cues
- Involuntary shift symbols are called "pull" cues
- Differences:
  - Pull cues produce benefits with no cost
  - Pull cues work faster
  - 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
  - Movement from object to object
  - 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, trajectory, size, unitariness
  - Problem: size of area covered and focus can change
- Zoom-lens Metaphor
  - Similar to spotlight metaphor
  - Can go in and out of focus
  - Takes time to adjust to the change in amount of focus

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

- Need to consider different properties of an object
  - The Stroop Effect
  - Integral vs. Separable Dimensions

The Stroop Effect

- A demonstration of interference in the reaction time of a task

Green Red Blue Yellow Blue Yellow	Blue Yellow Red Green Yellow Green

Integral vs. Separable Dimensions

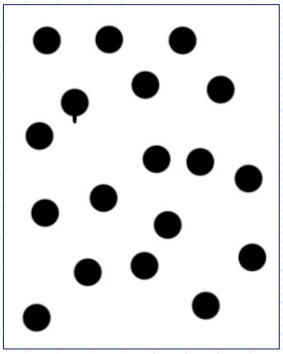
- Integral Dimensions
  - Cannot selectively attend to one without perceiving the other
  - i.e. saturation and lightness of a color
- Separable dimensions
  - Can selectively attend to one or the other without perceiving other properties
  - i.e. color and shape of an object

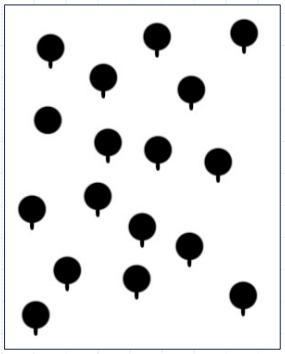
Distributed vs. Focused Attention

- Distributed attention
  - 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

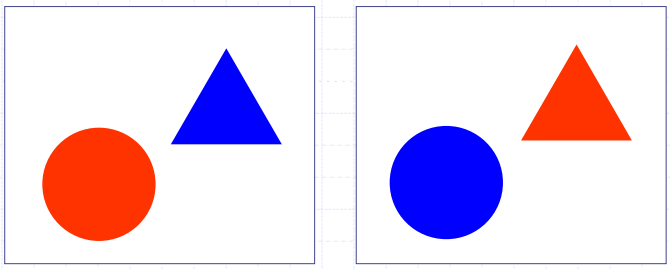
- When an object stands out from others
- Detected through distributed attention
- Only works when there's an extra feature





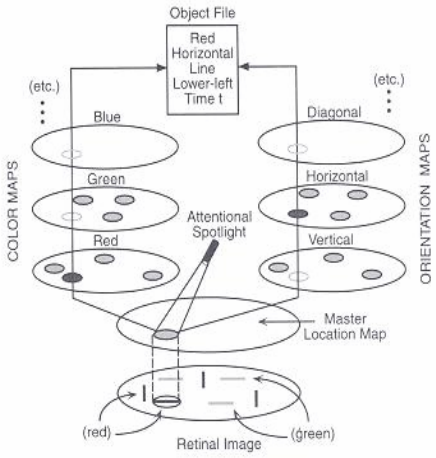
Feature Integration Theory

- Binding
  - Process of conjoining different properties into visual objects



Feature Integration Theory

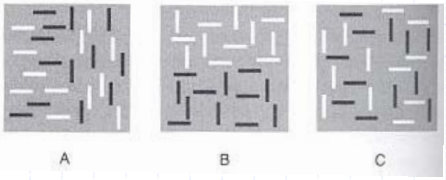
- Features are stored in features maps
  - Conjunction search
  - Texture segregation
  - Illusory Conjunctions



Feature Integration Theory

- Conjunction search

- Texture segregation



- Illusory Conjunctions

2 X S T 5

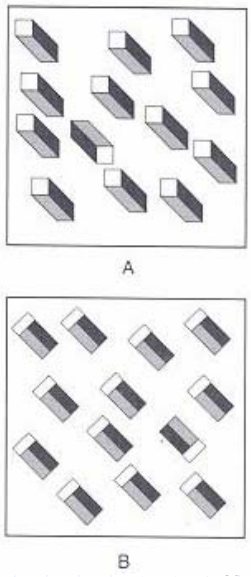
Stimulus

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

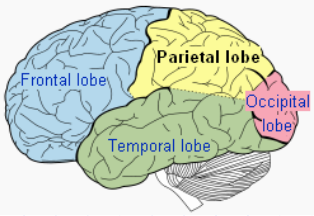


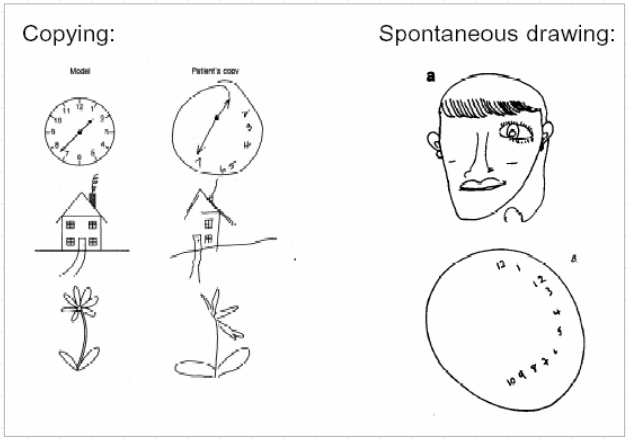
The Physiology of Attention

- 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

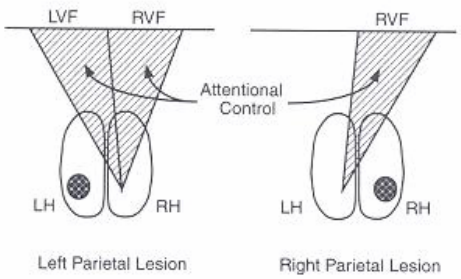


Figure 11.2.32 Attentional control with left versus right parietal damage. When the left parietal lobe is damaged, the right parietal lobe can still control attention on both sides of the visual field. When the right parietal lobe is damaged, the left parietal lobe can control attention only in the right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