

Human Visual Attention

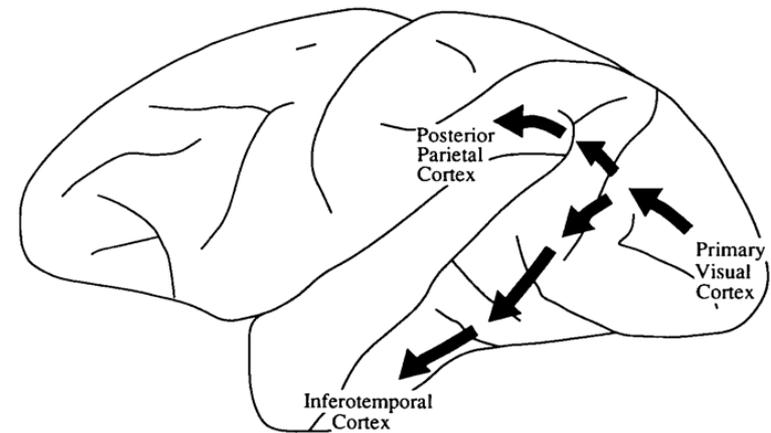
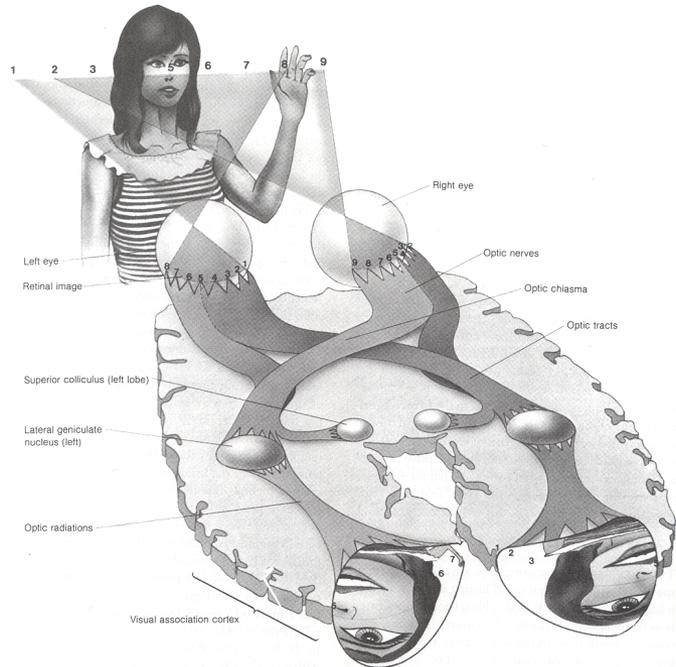
Lecture #2

CS510, Spring 2018

Colorado State University



Review: Human Vision System



D. Milner & M. Goodale,
The Visual Brain in Action, p. 22

What is attention?

- “The selective aspect of processing” – Kosslyn¹
- “processes that enable an observer to recruit resources for processing selected aspects of the retinal image more fully than nonselected aspects” – Palmer²

Overt vs. Covert Attention³

- Overt attention: observable movements of eyes, head & body to orient eyes
 - Foveas: 90% of receptors, $\pm 2^\circ$
 - Allocation to 3D point in space
 - Vergence & focus
 - Average dwell time: $\sim 300\text{ms}$ ⁴
 - Saccadic movement
 - Very fast: $\sim 30\text{ms}$, up to $900^\circ/\text{sec}$
 - Suppression: no input during saccade
 - World appears as sequence of displaced, small, high resolution, stereo images with low resolution peripheries

Overt vs. Covert Attention (II)

- You don't process all the data in your foveal image
- Covert attention: selection of retinal data to process ("inner eye")
 - Cannot be observed directly
 - Its existence is not in dispute
 - Its form is a matter of intense debate
 - Assumption: insufficient resources necessitate covert attention.
- Covert attention is the subject of this talk

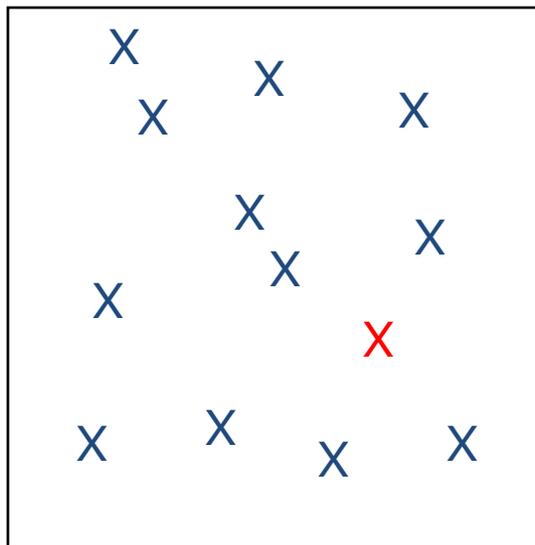
3 Models of Covert Attention

1. Feature Integration Theory⁵

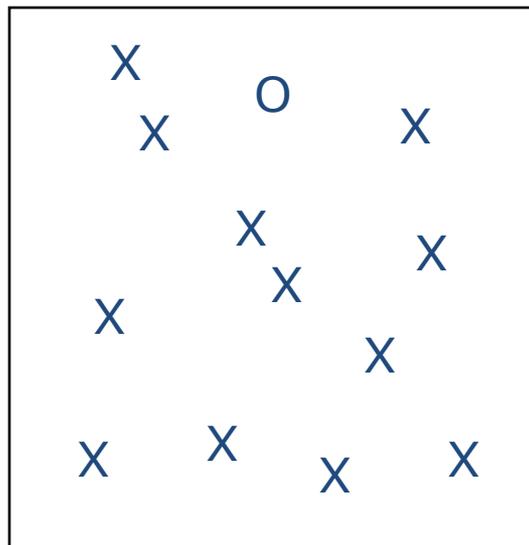
- “Pre-attentive” low-level features computed in parallel across the image
 - E.g. color, edge orientations, motion
- In visual search, attention can jump to locations based on pre-attentive features (“pop-out”)
- Conjunctions of features or complex features require sequential search
- Implicitly assumes attention is like a spotlight

Feature Integration Theory (II)

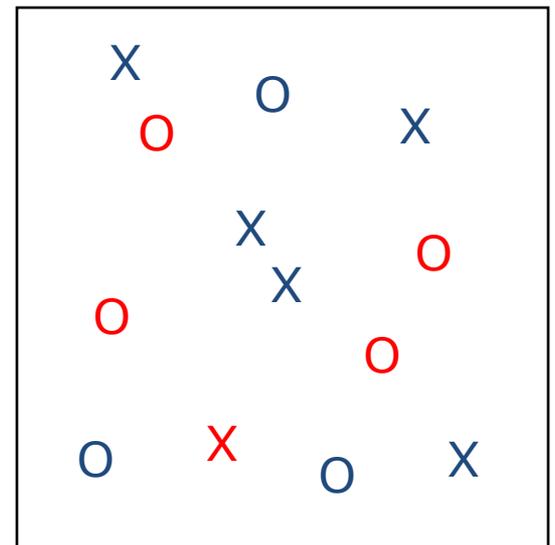
Find the red target



Find the round target



Find the red 'X' target



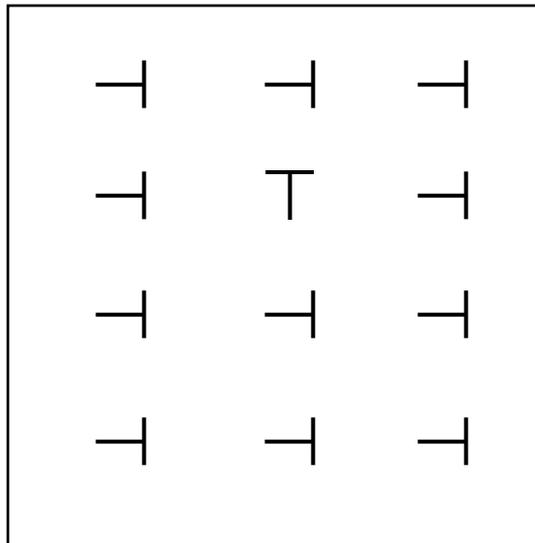
3 Models (II)

2. Integrated Competition Hypothesis⁶

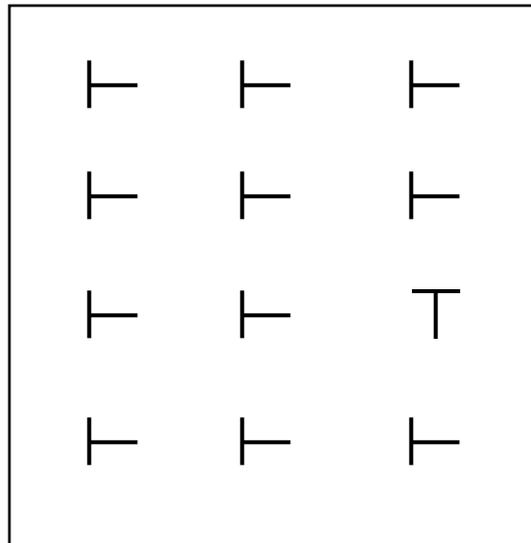
- “Pop-out” effect depends on:
 - Homogeneity of distractors
 - Homogeneity of targets (seq. pres.)
- Primary role of attention is *segmentation* (or grouping)
- Low-level features important as the basis of segmentation

Integrated Competition Hypothesis (II)

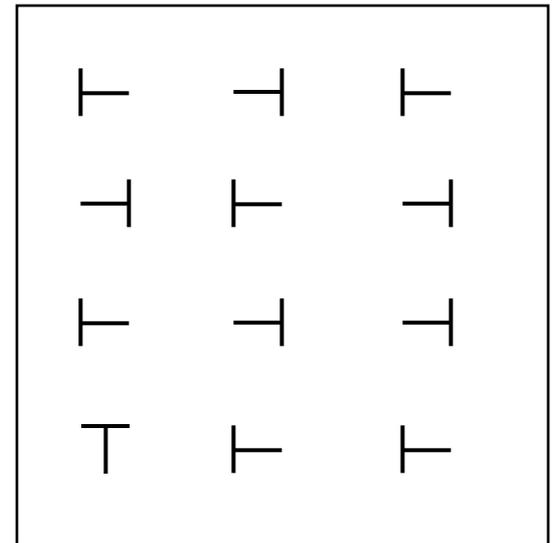
Find the upright T



Find the upright T



Find the upright T



Theory #3

Task: Which Line is Longer?



3 Models (III)

- Inattentional Blindness Theory⁷
 - When concentrating on the task, most subjects will not see additional objects
 - Depends on semantics of additional object
 - Additional objects are interpreted
 - Cause priming effects
 - Hypothesis: all objects in visual field are interpreted
 - Attention is a late effect, caused by attentional bottleneck

Gorilla

- Category Example

- Memorable

- Worth knowing



The screenshot shows a web browser window with the URL www.theinvisiblegorilla.com/gorilla_. The page features a large image of a gorilla in a black suit reading a newspaper. To the right of the image is the title "the invisible gorilla" in a serif font, with "gorilla" in red, and the authors' names "Christopher Chabris and Daniel Simons" below it. A horizontal red line separates the header from the main content. On the left side, there is a vertical list of links: "buy the book", "about the book", "about the authors", "press & endorsements", "videos & demos", "blog", "etcetera", and "contact". Below these links are search and social media buttons: "Google Custom Search", "Go", "Follow us" with Facebook, Twitter, and Google+ icons, and "Share this page". At the bottom left, there is a copyright notice: "Entire contents © 2010 by Simons and Chabris All Rights Reserved." On the right side, there is a navigation menu with links: "videos | gorilla experiment | try it | videos from studies | speaking | other". Below the menu is a video player titled "selective attention test" showing a group of people in a hallway. A man on the right is holding a basketball, and a woman in the center has a white circle around her head. The video player includes a progress bar, volume icon, and YouTube logo.

Temple Grandin

Quoting from pages 299-300

That's why autistic savants can make perspective drawings without being taught how. They're drawing what they see, which is all the little changes in size and texture that tell you one object is closer up and another object is farther away. Normal people can't see all those little changes without a lot of training and effort, because their brains process them unconsciously. So normal people are drawing what they "see," which is the finished object, after their brains have put it all together. Normal people don't draw a dog, they draw a concept of a dog. Autistic people draw the dog.

It's ironic that we always say autistic children are in their own little worlds, because if Dr. Snyder is right it's normal people who are living inside their heads. Autistic people are experiencing the actual world much more directly and accurately than normal people, with all their inattentive blindness and their change blindness and their every-other-kind-of-blindness.

Animals in Translation



Using the Mysteries of Autism to Decode Animal Behavior

"Deeply moving and fascinating."
—Oliver Sacks

Temple Grandin and Catherine Johnson
author of *Thinking in Pictures*

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Whose right?

- Most likely explanation: everyone!
- Vision is a multi-stage process
 - Every stage is coarsely parallel
 - Every stage is resource limited
 - Every stage *attends* based on data, task
- There is evidence for attention at the level of:
 - Windows (spatial)⁸
 - Features^{9, 11}
 - Objects^{10, 20}
 - Awareness⁷

Capacity Theory¹²

- Vision is a resource-limited pipeline (or conveyer belt¹³)
- Data and task demands determine where and how attention occurs
 - Psychological support for shifting from spatial to feature-based attention¹⁴
 - ERP support for spatial attention preceding feature-based attention¹⁵

Spatial vs. Feature Attention

O

X

This was a small sample.

Statistically, subjects make more errors when the distracter resembles the ~~non~~-target class. ~~Z~~

Q

Determine if target is 'X' or 'O'; ignore peripheral distracters.

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Spatial vs Feature Attention (II)

Statistically, subjects do better on this task than the previous task. Why? Because spatial attention eliminates the distracter before feature-based attention can be confused

O

Z

Task: Same as before, only now there are additional distracters in a cross around the target

Relation to Human Object Recognition

- Attention occurs at every processing stage
- Human object recognition can be modeled as a four stage pipeline:
 1. Early vision (spatial attention)
 2. Feature extraction (feature attention)
 3. Categorization (object category att.)
 4. Expertise (object attention)
- What do we know about these types of visual attention?

Early Spatial Attention

- Appears as early as LGN⁸
- Manifests as anticipatory rise in baseline activity⁸
 - Both points suggest strong top-down component
- Very fast, even without cueing
 - 80-130 ms post stimulus¹⁵
 - Suggests low-level features (e.g. edges)
 - Above random correlation to NVT²¹
- Probably coarsely parallel
 - Up to 5 objects independently tracked¹⁶
 - Evidence for at least 2 parallel fixations without motion¹⁷
- Probably selects scales as well as positions¹⁸
- Minimum scale for spatial attention¹⁹
 - Larger than minimum scale for visual resolution

Feature-based Attention

- Slower than spatial attention
 - 140-180 ms post stimulus¹⁵
 - Feedback to striate cortex 235 ms ps¹¹
- May itself be several mechanisms
 - Color, shape processed seperately²²
- Feature conjunction tasks require attention; single features do not²³

Object-based Attention

- Object Category Attention
 - Attentional blink is category specific²⁴
- Object Instance Attention
 - Target objects draw attention; distracters do not.²⁰
 - Not as good at it as we think.²⁵

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