Attention and Scene Perception

Attention: How do we perceive whole scenes?

- Theories of attention
- Techniques for studying scene perception
- Physiological basis of attention
- Attention and single cells
- Disorders of attention
- Scene recognition

Attention: any of a large set of selection processes in the human brain. To deal with the impossibility of handling all the inputs at once, the nervous system has evolved mechanisms able to restrict processing to a subset of things or places or ideas at a time.

William James—“Everyone knows what attention is … It is the taking possession by mind, in clear and vivid form, of one out of what seem several simultaneously possible objects of trains of thought”

Attention: It is impossible to process everything at once

These × Is
letters × it
are × time
big × for
and × a
easy × quick
to × snack
read. × yet?
**Cuing paradigm - Selection in Space**

- reaction time:
  - a measure of the time from the onset of a stimulus to a response.
- cue:
  - stimulus that might indicate where (or what) a subsequent stimulus will be:
    - valid
    - invalid
    - neutral
- stimulus onset synchrony (SOA):
  - the time between the onset of one stimulus and the onset of another.

**Simple probe detection experiment (Posner, 1980)**

- Simple probe detection experiment (Posner, 1980)

  - valid cuing speeds detection performance
    - SOA
      - At 0 ms - no effect
      - improves up to 150 ms and levels off
    - invalid cuing slows detection

**Theories of Attention**

- “spotlight” model (Posner, 1980):
  - attention can move from one point to the next
- “zoom lens” model (Eriksen & Yeh, 1985):
  - attention expands from fixation…grows to fill whole region…shrinks to include just cued location
  - best metaphor not yet clear

**Visual Search**

- visual search task
  - find target in display with “distracting” elements
    - target:
      - item to find in the display (e.g. red circle)
    - distractor:
      - any stimulus other than the target (e.g., green circle)
    - set size:
      - number of items in a visual display
Feature Searches Are Efficient (cont'd)

- efficient searches for features (e.g., color, orientation)
  - parallel:
    - simultaneous processing of multiple stimuli
    - “pop-out”
  - result
    - increase in set size does not affect reaction time
    - slope of the search function 0

Feature Searches Are Inefficient (cont'd)

- inefficient searches
  - serial self-terminating search:
    - items examined in sequence until
    - target is found
    - or... until all items are checked
  - result
    - more distractors -> more time
    - search slope > 0
- limited capacity parallel process:
  - partially parallel- capable of handling many stimuli at once, but processes each item more slowly as set size increases

Conjunction Search

- conjunction search
  - no single feature defines the target
  - target defined by co-occurrence of two or more features
- “lab” conjunction search
  - find red square among red circles and green circles and squares
- “real-world” conjunction search:
  - where is the red station wagon in the following photo?

Visual Search (cont'd)
Conjunction Search (cont’d)

Feature Integration Theory (Treisman and Gelade, 1982):
- theory that holds that a limited set of visual features can be processed in parallel preattentively, but other properties, including the correct binding of features to objects require attention
  1. preattentive stage
  2. attentive stage

Preattentive processing
- primitives, features
  - "words in the language of vision"
  - unbound to location
- tests of preattentive processing
  - "pop-out" for "features"
  - visual search for features (color, etc)
    » parallel with number of distracting items
    » independent access
  - illusory conjunctions
    » red triangle - blue square - green circle

Pop-out

Illusory Conjunction
- illusory conjunction
  - an erroneous combination of two features in a visual scene.
II. Focused Attention

- Attention
  - "glue" with which features are bound into objects
  - bound to location
  - objects = conjunctions of features

- Tests of attentive processing
  - No "pop-out"
  - Visual search for conjunctions of features red square
    - Serial with number of distracting items (RS RT)
    - Co-dependent access

The Binding Problem

- A conjunction search with a binding problem - find red verticals

- Binding problem
  - Problem of binding together different attributes of a visual stimulus (e.g., color, motion, orientation), which are handled by different brain circuits to the appropriate object, so that we can perceive a unified object.

- Illusory conjunctions: evidence of the elusive nature of binding

Attention in Time: RSVP and the Attentional Blink

- Attention over time:
  - Rapid serial visual processing task (RSVP)
    - Very fast detection of "odd man out"
      - Letter among digits
      - Animal among non-animals

- Attentional Blink
  - Decreased sensitivity *increased time* to detect a second target soon after the first
Attention in Time: RSVP and the Attentional Blink (cont'd)

• Schematic data from an attentional-blink experiment

The Physiological Basis of Attention Overview

Attention performs a variety of tasks

• first stages of cortical processing:
  – influenced by attention

• feedback from later stages of processing

Attentional Selection

• Can you attend to the red items and then, without moving your eyes, can you attend to the blue items?

Examples of Physiological Areas Involved in Attentional Processing

• attention mediates cortical activation
  – fusiform face area
  – parahippocampal place area

• functional fMRI studies:
  – cortical areas activated by faces vs. places

Examples of Physiological Areas Involved in Attentional Processing (cont'd)

• fusiform Face area - FFA
  – Kanwisher, McDermott & Chun (1997)

• parahippocampal place area (PPA)
  – Epstein et al. (1999)
Attention results (O’Craven & Kanwiser, 2000)
- attention to face
  - FFA more active
- attention to house
  - PPA more active

Attention and Single Cells
- ways neuron responses could change with attention
  - response enhancement
    • some evidence, though a weak mechanism
  - sharper tuning
    • no physiological evidence
  - altered tuning
    • physiological evidence in the form of receptive field shrinkage
      - (Moran & Desimone, 1985)

Disorders of Visual Attention
- Most common:
  - visual field defect:
    • a portion of the visual field with no vision or with abnormal vision, typically resulting from damage to the visual nervous system
  - neglect:
    • inability to attend to or respond to stimuli in the contralesional visual field, typically after right parietal damage
Disorders of Visual Attention (cont’d)

• Brain images of neglect patient

8.19 Result you might get if you asked a neglect patient to cross out all the lines on the page.

8.20 This is what can happen when a neglect patient tries to copy a drawing.

Disorders of Visual Attention (cont’d)

• Tipper and Behrmann’s (1996) experiment
  – result - neglect moved with the motion!

Disorders of Visual Attention (cont’d)

• extinction (Driver, 1998)
  – inability to perceive a stimulus in the presence of another stimulus
  
  • attention can be deployed to the contralesional side (bad field) only when there is no competition in the ipsilesional side (good field)

Balint Syndrome

Balint Syndrome (parietal bilateral)

1. reduced spatial localization abilities
2. reduced movement of the eyes
3. inability to perceive more than one object at a time (simultagnosia)
Perceiving and Understanding Scenes

• What does it mean to see more than one object?
• How do we perceive entire visual scenes?
• Understanding scene perception using knowledge from brain damage (Balint Syndrome)

Picture Memory and Change Blindness

• We can very quickly understand scenes…

Picture Memory and Change Blindness (cont’d)

• Picture memory accuracy
  – 612 pictures remembered 1 week later - 90%!
    • Shepard (67)
  – 2500 -> 85% correct
    • Conezio & Haber (70)
  – 10,000 images -> 85% correct
    • Standing (1973)

Picture Memory and Change Blindness (cont’d)

• Picture processing speed
  – rapid scene presentation
    • Potter, (75,76); Intraub (81)
  – scene classification highly accurate
    • 8 images per second (125 ms)
    • Find one “not-an-animal”

Picture Memory and Change Blindness (cont’d)

• change blindness:
  – failure to notice a change between two scenes; perception depends on meaning of change
    • Rensink, O’Reagan & Clark, (1997)
  – Demo -1
Local and Global Approaches to Scene Recognition

- covert attentional shifts:
  - shift of attention without corresponding eye movements
    - process 20–30 objects per second
- overt eye movements:
  - process 3–4 objects per second
- spatial layout:
  - description of the structure of a scene

8.27 A simple visual “scene” composed of two sinusoidal gratings
What Do You Actually See? (Simons and Chabris, 1999)

Attention is so powerful that the gorilla is blocked from entering conscious awareness!

Gradual Changes to scenes

• With abrupt changes in viewpoint
  – few subjects noticed change to objects in real world scenes
  – even when actively searching for change

Person Changes!

• 50% of naïve subjects failed to detect change of person
  • even though person change involved...
    – different appearance
    – different voice
    – different clothes

Person characteristics

• Less often noticed when:
  – Age change between the subject and “foil”
  – “Status” change between the subject and “foil”
So…

- What precisely do we represent about visual events????