Sensation & Perception

Ch. 6: Visual Attention

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Main topics

Binding problem
Feature integration theory
Synchrony hypothesis
The physiology of attention
“neuroenhancing drugs”

• http://www.newyorker.com/reporting/2009/04/27/090427fa_fact_talbot
A young man I’ll call Alex recently graduated from Harvard. As a history major, Alex wrote about a dozen papers a semester. He also ran a student organization, for which he often worked more than forty hours a week; when he wasn’t on the job, he had classes. Weeknights were devoted to all the schoolwork that he couldn’t finish during the day, and weekend nights were spent drinking with friends and going to dance parties. “Trite as it sounds,” he told me, it seemed important to “maybe appreciate my own youth.” Since, in essence, this life was impossible, Alex began taking Adderall to make it possible.
Adderall, a stimulant composed of mixed amphetamine salts, is commonly prescribed for children and adults who have been given a diagnosis of attention-deficit hyperactivity disorder. But in recent years Adderall and Ritalin, another stimulant, have been adopted as cognitive enhancers: drugs that high-functioning, overcommitted people take to become higher-functioning and more overcommitted.

During his college years, Alex took fifteen milligrams of Adderall most evenings, usually after dinner, guaranteeing that he would maintain intense focus while losing “any ability to sleep for approximately eight to ten hours.”
• **Change blindness**
  – http://viscog.beckman.illinois.edu/flashmovie/11.php
  – http://viscog.beckman.illinois.edu/flashmovie/12.php
  – http://viscog.beckman.illinois.edu/flashmovie/10.php
What is attention for?

- Selecting information
- Enhancing information

**Combining information**

- What role does attention play in combining/integrating information?
- What physiological mechanism underlie the integrative process?
Selecting information

• The retina receives so much information.
• Attention helps select information.

• This is necessarily because of the way the eye is structured.
  – Most cones reside at the fovea.
  – To get accurate information about a scene, we need to select carefully particular parts of a scene.
Visual Attention

- Visual attention and eye movement
- Eye tracker
- Eye tracking machine and demo
  - http://www.youtube.com/watch?v=lGehsY7pcrc
Attention also enhances perception

• If we don’t attend, we lose information.

• If we attend, we understand better.
Attention helps integrate information

- Binding problem
- Feature integration theory
Binding problem
Two visual pathways (what & where/how systems)

Image from Neuroscience, 2nd Ed. (2000).
Columnar organization

- Neurons that respond to the same orientation are packed in the same column

Image courtesy of Dr. Paul Wellman and Neuroscience, 2nd Ed. (2000).
Distributed coding

- Combinig input

Need more neurons to code these faces

(a) Specificity code

(b) Distributed code
Binding problem

• The modular organization of the brain poses an essential problem.
  – How does the brain combine information?
  – How does it bind features that are processed separately?
• Feature integration theory

  • by Treisman & Gelade

  – Attention plays a central role in solving the binding problem.

  – Attention helps organize information.
Attention and Figure-ground segregation

Depending on where you look at, the figure and the ground switch rapidly.

→ Attention plays some role in determining the figure and the ground.
Attention and 3D structure

Depending on where to look at, you get different kinds of 3D perception.
Damage to the parietal lobe creates binding errors.
Figure 24-4
Clock drawn by a patient with left hemispatial neglect.
(From Dr. Robert Raja with permission.)
Copies of the black (A) and the white (B) vertical contour.

Copies of the black (A) and the white (B) diagonal contour.
• **Attention combines the information from the *what* and *where* systems.**
What can you predict from this theory?

• If you can’t attend, you can’t combine information.

• → Illusionary conjunction
Demonstration

• I will show you a scene quickly.
• Report first the black numbers.
• Report what you see at each of the 4 locations.
• Report first the black numbers.
• Report what you saw at each of the 4 locations.
Illusionary conjunctions

• We tend to put different features from different objects together.

• brain damaged patients (parietal lobe) show illusionary conjunctions even when they view the stimuli for 10 seconds.
Visual search experiments

• Looking for the target

• Feature search
  – You look for a single feature.
  – → you don’t need attention

• Conjunction search
  – You need to combine two or more features (color and orientation)
  – → you need attention
Visual search experiments

• Looking for the target

<table>
<thead>
<tr>
<th>Color</th>
<th>Orientation</th>
</tr>
</thead>
<tbody>
<tr>
<td>T: green</td>
<td>horizontal</td>
</tr>
<tr>
<td>D: green</td>
<td>vertical</td>
</tr>
</tbody>
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<td>D1: green</td>
<td>vertical</td>
</tr>
<tr>
<td>D2: red</td>
<td>horizontal</td>
</tr>
</tbody>
</table>
Find

Which is more difficult?

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36
Find

Which is more difficult?
Feature binding and attention
(Treisman, 1988)

Experiments:

Task:

Given a stimulus frame containing visual items, subjects were asked to indicate whether or not a target item was present in the frame.
Feature search vs. conjunction search

• Feature search
  – The target item has a unique feature.

• Conjunction search
  – Need to combine features \( \rightarrow \) need attention.
  – Because you can attend only one item at a time, the conjunction search becomes more difficult when more items are in the stimulus frame.
Generality of the results:

Feature search

Conjunction search
Experiments:

• Measure accuracy and response times (conjunction cases vs. non-conjunction cases)
Response time

1000 ms

500 ms

# of distractors

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Response time
1000 ms
500 ms

Response time vs. # of distracters
• Patients with damage to the parietal lobe have difficulty with conjunction searches.
  • (Ambridge et al., 1999)
Some problems with FIT

- Distinctiveness of features can also create the pop-out phenomenon.
The physiology of attention

• How do you combine features?
• Synchrony hypothesis
  • When neurons in different parts of the cortex are firing to the same object, the pattern of firing is synchronized (they fire at the same time, and in the same manner).

• So when neurons are firing in synchrony, the corresponding features are bound together.
• Separate neurons respond to color, contours, textures, so on.

• Synchrony hypothesis:
  – When the features come from the same object, these neurons fire at the same time in the same manner.
  – This synchronicity of firing binds features.

• **Attention** increases synchrony
Binding problem and schizophrenia

- People suffering from schizophrenia often experience hallucination.
- An EEG study shows that brain waves of schizophrenic patients are not synchronous compared to normal control subjects.

Attention and Autism

• Impaired social interaction and communication
  – Often fail to understand what other people think.
• Far more autistic boys than autistic girls (4:1)
• Overrepresented in children whose parents / grandparents are engineers
  – (Baron-Cohen et al.; Autism, 1997, 1, 153-163)
• substantial genetic component
• Video clip
  - Invisible wall
  - Autism and symptoms (3:56)
    • http://www.youtube.com/watch?v=FuWWie1DIJY
Attention and Autism

Eye movement: normal (white markers) vs. autistic viewers (black markers)