**Sensation & Perception**

Review 2

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Ch 4-7

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**PET, MRI**

- Subjects carry out some psychological tasks (e.g., visual perception)
- Trace neural activities of the brain (blood flow)
- Identify the brain location in which the psychological function takes place.
- Bridge psychological functions and their brain locations.

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**Visual pathway: revised**

- **Retinotopic map** → preserving the spatial layout of a stimulus
- LGN and V1 (primary visual cortex) show a retinotopic map.

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**Representing spatial layout**

Lateral Geniculate Nucleus

Image courtesy of Dr. Paul Wellman
Cortical magnification factor

- Fovea accounts for .01% of retina
- Signals from fovea account for 8% to 10% of the visual cortex

Retina | V1 (primary visual cortex)
--|------------------

Striate cortex (V1)

Ocular dominance columns

Visual information from different eyes is stored in separate columns in an alternate manner
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).

Question: what happen after that?

• Neurons in higher cortical areas respond complex visual attributes

Functional segregation

• The brain is segregated into a number of areas.
• These segregated brain areas process different types of functional information.

Two visual pathways (what & where/how systems)

Object discrimination task

The monkey had to select the correct object to get the food reward

Landmark discrimination task

The monkey had to select the food well close to the cylinder.

Object discrimination task

Can’t do the object discrimination task but can do the landmark discrimination task

Landmark discrimination task

Can’t do the landmark discrimination task but can do the object discrimination task
Double dissociation

Two visual pathways (how & what systems)

Patient D. F had damage to the ventral path.

Modularity: Structures for Faces, Places, and Bodies

- Module - a brain structure that processes information about specific stimuli
  - Inferotemporal (IT) cortex in monkeys
    - One part responds best to faces while another responds best to heads
    - Results have led to proposal that IT cortex is a form perception module
  - Temporal lobe damage in humans results in prosopagnosia
Prosopagnosia

Dr. P. was a musician of distinction, well-known for many years as a singer, and then, at the first School of Music, as a teacher. He was here, in relation to his students, that certain strange problems were first observed. Sometimes a student would present himself, and Dr. P. would not recognize him, or, specifically, would not recognize his face. The reason for the student, quite, he would be recognized by his voice. Such incidents multiplied, causing embarrassment, perplexity, fear—and sometimes, mania. For not only did Dr. P. occasionally fail to see faces, but he saw faces when they were no faces to see generally, Magik-like, where in the street he might spot the hand of a friend's hand or a parking meter, taking these to be the heads of all children; he would similarly address called bros on the Furniture and be answered when they did not speak. At first these odd emotions were laughed off as jokes, not least by Dr. P. himself. Had he not always had a quirk of humor and been given to Zen-like parodies and jests? His manual dexterity was destroying as ever; he did not feel ill—improved, he had never felt better, and the mistakes were so illogical; and so ingenious—that they could hardly be serious or because anything.

I helped him on with his shoe (his foot), to avoid further complication. Dr. P. himself seemed untroubled, indifferent, maybe amused. I resumed my examination. His visual acuity was good: he had no difficulty seeing a pin on the floor, though sometimes he missed it if it was placed to his left.

He saw all right, but what did he see? I opened out a copy of the National Geographic Magazine and asked him to describe some pictures in it.

His responses were very curious. His eyes would dart from one thing to another, picking up tiny features, individual features, as they had done with my face. A striking brightness, a colour, a shape would arrest his attention and elicit comment—but in no case did he get the scene as a whole. He failed to see the whole, seeing only details, which he spotted like blips on a radar screen. He never entered into relation with the picture as a whole—never

The Challenge of Object Perception - continued

- Objects look different from different viewpoints
  - Viewpoint invariance: the ability to recognize an object regardless of the viewpoint
- The reasons for changes in lightness and darkness in the environment can be unclear

Object recognition and inverse projection problem

Figure 5.3 The principle behind the inverse projection problem. The small square stimulus creates a square image on the retina. However, this image could also have been created by the other two shapes and many other stimuli. This is why we say that the image on the retina is ambiguous.

The man who mistook his wife for a hat

He had no sense of whatever of a landscape in terms. I showed him the scene, an unknown opaque of Sahara dunes. Who do you see here? I asked. Not a scene, my wife for a hat. A little girl beside her with a face, the dunes. People are driving out on the dunes. I saw colored patches and hues. They were looking at it, I was looking at it, right off the coast into midland and contrasting a pleasant fantasy, as if the absence of features in the actual part of the dunes had shown him to imagine the dunes and the face and the colored patches.

The man who mistook his wife for a hat

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Perceptual organization

Gestalt psychology
- “Gestalt” means “whole.”
- Organizational principles:
  - Similarity
  - Proximity
  - Continuity
    • And more (see the textbook)

Law of similarity
Similar things are put together

Law of proximity
• Things that are close to each other are put together.
Law of good continuity

We tend to put things together when they show nice continuity.

Figure-ground segregation

The figure represents “some thing.”
The contours belong to the figure rather than to the ground.

Which one if the figure and which is the ground?
This is easy.
The figure tends to have solid and continuous surface.

Object recognition

Symmetric items tend to be seen as a figure.
Biederman’s Recognition by Components (RBC)

- Objects are described and stored by simple geometric components (geons).
- There are about 36 geons.
- To represent objects, we use geons and their arrangements.

Combinations of geons

Combining 4 geons can yield more than 1 million objects.

(36x36x36x36)
The intelligence of human object perception

- Why are humans much better than computers in object perception?

- Theory of unconscious inference
  - Human object perception is like problem solving.
  - We make an unconscious inference.
  - Likelihood principle
    - objects are perceived based on what is most likely to have caused the pattern.
  - Humans have a vast array of knowledge (intelligence) that can disambiguate ambiguous stimuli.
Visual attention

Selecting information

- The retina receives so much visual information.

Attention helps us select information.
- We can focus on relevant information.
- This is necessarily because of the way the eye is structured.
  - Most of the cones reside at the fovea.
  - To get detailed information about a scene, we need to pick up particular parts of a scene according to what we want.

Attention helps integrating information

- Binding problem
- Feature integration theory

Binding problem
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

• Attention is the “glue” that combines the information from the what and where systems.

Illusionary conjunctions

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

• Some brain damaged patients (parietal lobe) show illusionary conjunctions even when the patients were allowed to view the stimuli for 10 seconds.

Visual search experiments

• Looking for the target
  
  • Feature search
    – This is easy because you find the target by looking for a single feature.
    – You don’t need attention
  
  • Conjunction search
    – For this you need to combine two or more features (color and orientation)
    – You need attention

• Conjunction search
  – For this you need to combine two or more features (color and orientation)
  – You need attention
  – Because you can attend an item one at a time, the difficulty in the conjunction search increases proportional to the number of items in the stimulus frame.
  – This is not the case in the feature search.
Find
Which is more difficult?

Visual search experiments

- Looking for the target

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<th>Orientation</th>
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<tr>
<td>D: green</td>
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<td>D1: green</td>
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<tr>
<td>D2: red</td>
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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.

Perceiving color

- Separate neurons respond to color (green, blue, white), contours (orientations), textures, so on.
- Synchrony hypothesis:
  - When the features come from the same object (i.e., the woman), these neurons fire at the same time in the same manner.
  - When the neurons fire at the same time and in the same manner, we perceive “binding” of features.
- Attention is likely to increase synchrony
• 2 complementary theories

• What are they?

3 types of cones

• There are three types cones that are selectively tuned to three different lengths of electromagnetic waves (Short, Medium, and Long)

Color perception is produced by combinations of these 3 types of cones:

Different objects reflect light in a different manners.

Some objects (tomato) absorb short waves while reflect long waves → create a red surface.

Absorb short waves but reflect long waves

Color perception is produced by combinations of these 3 types of cones:

More Phenomenological Observations

• Visualize something red (apple, fire engine)
  – Now reddish-yellow
  – Now reddish-green

• Visualize something blue
  – Now cyan

• Visualize something yellow
  – Now orange
Assign % of green, blue, yellow, and red

Trichromatic \(\rightarrow\) Opponent-process

Trichromatic stage:
3 kinds of cone receptors (S, M, L)

Opponent process
At the bipolar or ganglionic cells, the difference between S and (M+L) (Circuit 1) and the difference between M and L (Circuit 2) is assessed.
The first circuit (Circuit 1) processes the blue-yellow difference.
The second circuit (Circuit 2) processes the red-green difference.

After-images:
Red \(\rightarrow\) Green
Green \(\rightarrow\) Red
Blue \(\rightarrow\) Yellow
Yellow \(\rightarrow\) Blue

Color perception
After image adaptation

Opponent-process theory

Why is this process efficient?

• Distinguishing the two wavelengths, 1 and 2 is very hard using just the M and L receptors.

• Opponent process create two categorical responses $\rightarrow +$ or $-$