

Ch 5. Perception and Encoding

Cognitive Neuroscience: The Biology of the Mind, 2nd Ed.,
M. S. Gazzaniga, R. B. Ivry, and G. R. Mangun, Norton, 2002.

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Disorders of Perception: A Case Study



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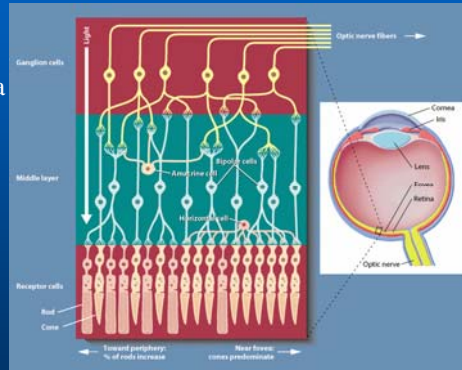
- Overview of Neural Pathways
- Parallel Processing in the Visual System
- Cortical Visual Areas
- Deficits in Feature Perception
- Independent or Convergent Pathways
- Dissociations of Cortical and Subcortical Visual Pathways
- Auditory Perception
- Summary

Overview of Neural Pathways

Overview of Neural Pathways

● The Eye, Retina, and Receptors

- ◆ As light passes through the lens of eye, the image is inverted and focus on the retina
- ◆ Rods are sensitive to low levels of **light** stimulation at night
- ◆ Cones are most active during daytime vision and essential for **color**
- ◆ Rods and Cones have differential distribution

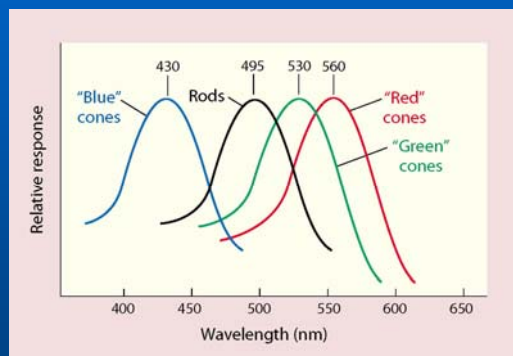


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Overview of Neural Pathways

● The Eye, Retina, and Receptors



- ◆ Spectral sensitivity functions for rods and the three types of cone

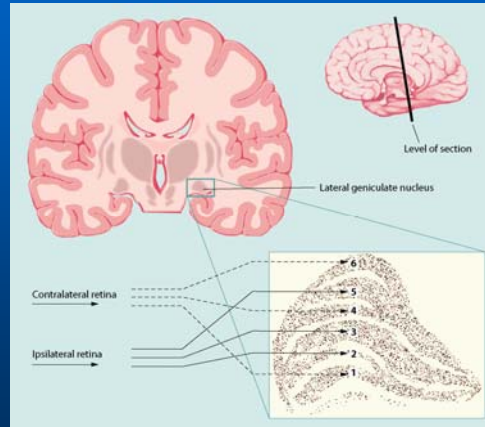
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Parallel Processing in the Visual System

- Organization of the Lateral Geniculate Nucleus (LGN)

- ◆ The LGN contains six well-defined layers
- ◆ Three of the layers receive input from one retina while the other three receive input from the other retina
- ◆ The multilayered system is not simply redundant



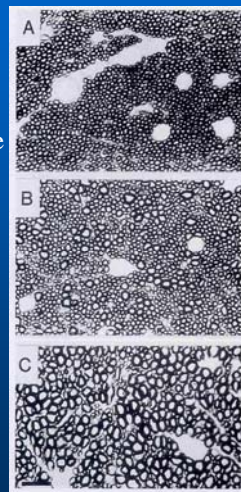
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Parallel Processing in the Visual System

- Organization of the Lateral Geniculate Nucleus (LGN)

- ◆ The bottom two layers are referred to as the magnocellular system (M system)
- ◆ Smaller cells in the upper four layers constitute the parvocellular system (P System)
- ◆ 80% of the LGN neurons are part of the P system



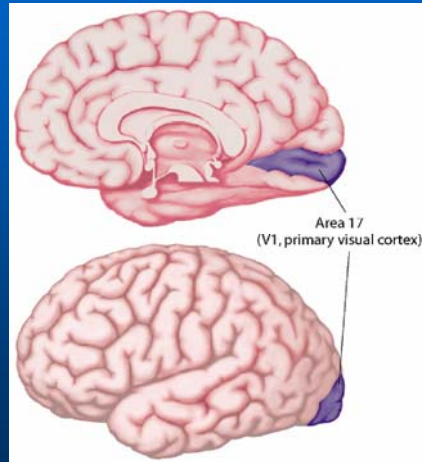
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Parallel Processing in the Visual System

- Multiple Pathways in the Visual Cortex

- ◆ Primary visual cortex (or Striate Cortex)
- ◆ It is located medially and buried below the superficial surface of the cortex along the calcarine sulcus



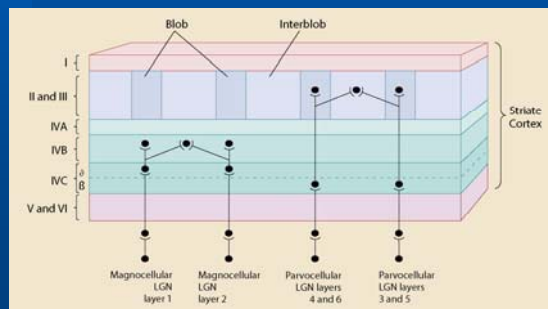
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Parallel Processing in the Visual System

- Multiple Pathways in the Visual Cortex

- ◆ The segregation of M and P pathways is maintained in the cortex
- ◆ Axons from both regions terminate in layer 4 of the striate cortex
- ◆ While all of the inputs terminate in layer 4, the parvocellular inputs synapse on intracortical neurons that terminate in layers 2 and 3

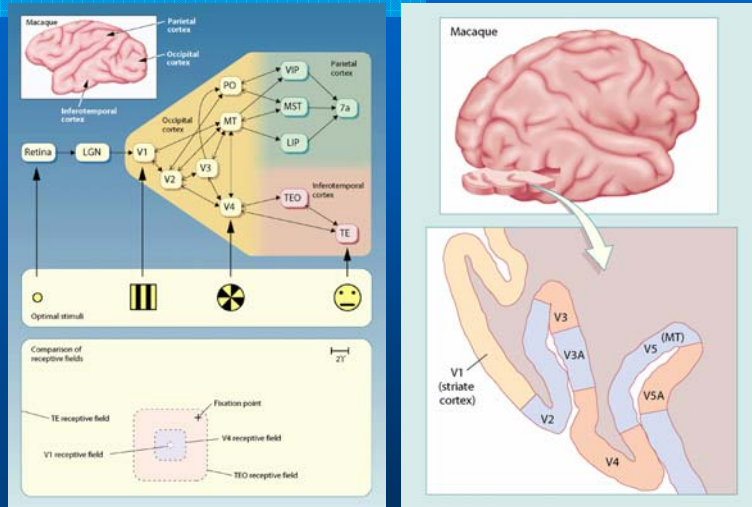


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Cortical Visual Areas

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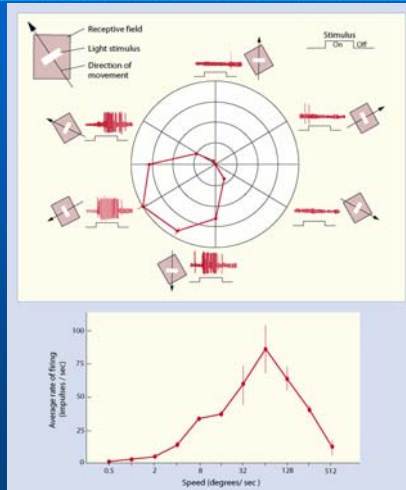
Cortical Visual Areas



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Cortical Visual Areas



- ◆ Directional and speed tuning of a neuron from area MT
- ◆ Top: A rectangle was moved through the receptive field of this cell in various directions
- ◆ Bottom: The graph shows speed tuning for a cell in MT

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Cortical Visual Areas

● Cellular Correlates of Visual Features

- ◆ This table summarizes stimulus variations used in neurophysiological studies to identify the representational characteristics of cells in the M, P-blob, and P-interblob pathways
- ◆ Neurons in the M pathway are movement sensitive and color insensitive
- ◆ In contrast, neurons in the P-blob pathway are highly selective to color and are minimally responsive to movement or changes in orientation

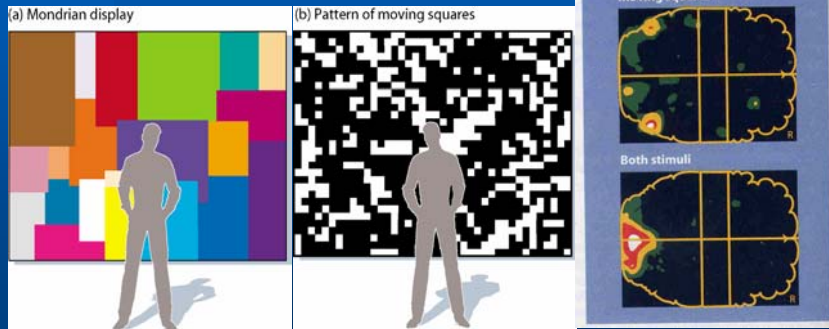
Parallel Pathways in Visual Perception			
Neural Structure	Cell Types		
	Magnocellular	Parvocellular	
Thalamus (LGN)		Blobs	Interblobs
Area 17 (V1)	Layer 4b		
Area 18 (V2)	Thick stripes	Thin stripes	Interstripes
Cellular Correlates			
Contrast (brightness)	high	high	low
Location	low	low	high
Motion	high	low	middle
Color	low	high	middle
Orientation	middle	low	high

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Cortical Visual Areas

- Imaging Visual Areas in Humans
 - ◆ Positron Emission Tomography (PET)

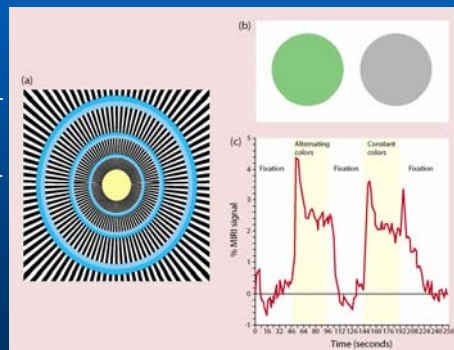


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Cortical Visual Areas

- Imaging Visual Areas in Humans
 - ◆ The neural basis of visual illusions
 - ◆ (a) Illusory motion is perceived when one is viewing the Enigma pattern, and activation is observed in area MT
 - ◆ (b) Color aftereffects are produced after staring at the bright green patch
 - ◆ (c) Activation in a visual region anterior to V4 is shown graphically



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Cortical Visual Areas

- Analysis and Representation of Visual Features

 - ◆ Visual Search

The diagrams illustrate two types of visual search tasks:

- Feature search:** Shows a search area with a target 'T' (green) and distractors 'X' (red). Below, a larger search area shows multiple 'T's and 'X's, with the target 'T' highlighted in green.
- Conjunction search:** Shows a search area with a target 'T' (red) and a distractor 'X' (green). Below, a larger search area shows multiple 'T's and 'X's, with the target 'T' highlighted in red.

Additional examples of visual search are shown in a separate set of panels:

- (a) Search for a cube among other cubes.
- (b) Search for a sphere among other spheres.
- (c) Search for an 'L' among other 'L's and 'T's.

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Cortical Visual Areas

- Analysis and Representation of Visual Features

 - ◆ Illusions and Feature Independence

The diagrams illustrate visual illusions and feature independence:

- (a) A diagram showing a triangle with a horizontal base. The top vertex is formed by two lines meeting at a point. The base is a horizontal line. The diagram is shown in three different orientations: Time 1 (horizontal), Time 2 (vertical), and Time 3 (vertical).
- (b) Two diagrams showing the same triangle as in (a), but with different colors for the lines. The first diagram has red lines on a green background. The second diagram has red lines on a red background.

Graph (b) shows Perceived speed versus Actual speed. The graph compares the perceived speed of black and white stripes (a straight line) and isoluminant stripes (a curve below the straight line).

Actual speed	Perceived speed (Black and white stripes)	Perceived speed (Isoluminant stripes)
0	0	0
1	1	0.8
2	2	1.5
3	3	2.2
4	4	2.8
5	5	3.5

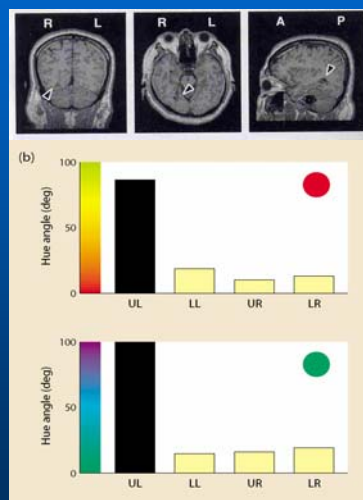
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Deficits in Feature Perception

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Deficits in Feature Perception

- Deficits in Color Perception: Achromatopsia
 - ◆ Achromatopsia are disorders of color perception that arise from disturbances of the central nervous system
 - ◆ MRI scans showing a small lesion encompassing V4
 - ◆ Color perception thresholds in each visual quadrant

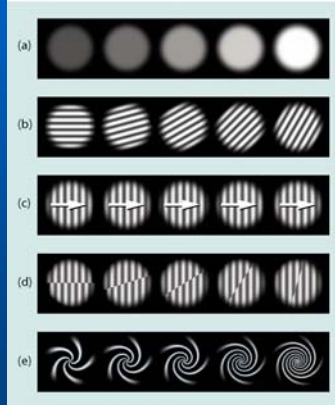


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Deficits in Feature Perception

● Deficits in Color Perception: Achromatopsia



- ◆ Stimuli used to assess form perception in the patient with damage to area V4.
- ◆ On basic tests of luminance (a), orientation (b), and motion (c), the patient's perceptual threshold was similar in all four quadrants.
- ◆ Thresholds for illusory contours (d), and complex shapes (e) were elevated in the upper left quadrant.

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Independent or Convergent Pathways

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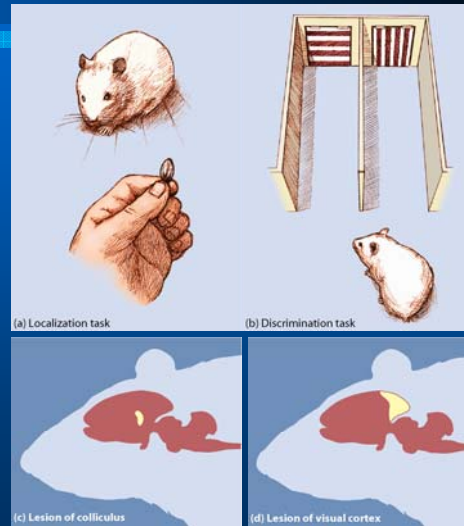
Independent or Convergent Pathways

- The visual system contains multiple pathways, each specialized to abstract specific information.
- Yet the outputs from these systems are designed to complement each other.
- Lesion studies of animals have brought into question the notion that the processing of feature like depth, color, and orientation depends solely on a single pathway.
- Prefer the term **concurrent processing**

Dissociations of Cortical and Subcortical Visual Pathways

Dissociations of Cortical and Subcortical Visual Pathways

- Spatial Orientation and Object Perception in the Hamster
 - ◆ To turn their head in the direction of a sunflower seed and to run down a maze and to enter the door behind which a sunflower seed was hidden
 - ◆ This study provide compelling evidence for dissociable functions of the hamsters' superior colliculus and visual cortex



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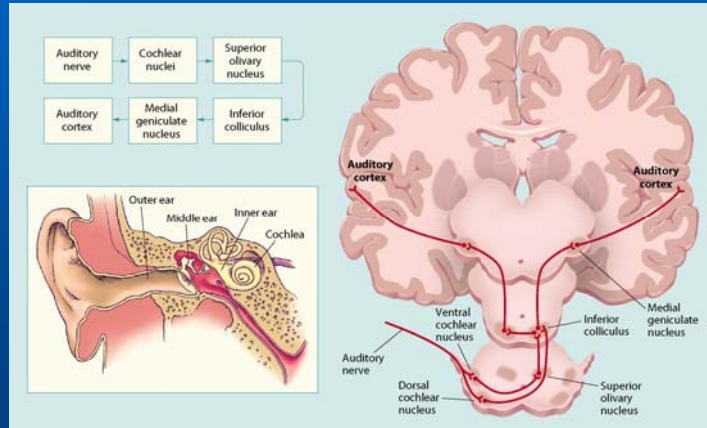
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Auditory Perception

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Auditory Perception

- Overview of the Auditory Pathways



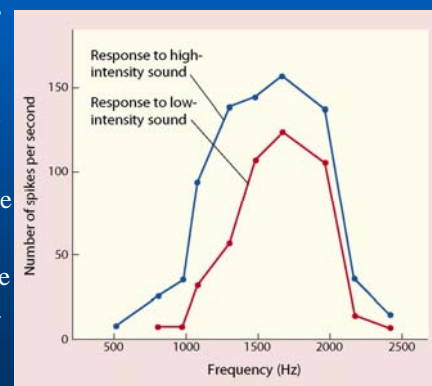
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Auditory Perception

- Overview of the Auditory Pathways

- ◆ Like as photoreceptors, hair cells of the **cochlea** are the primary receptors.
- ◆ Receptive field of hair cells refer to a coding of sound frequency
- ◆ Hair cells at the thick end, or base of the cochlea, are activated by high-frequency sound; cells at the opposite end, or apex, are activated by low-frequency sound



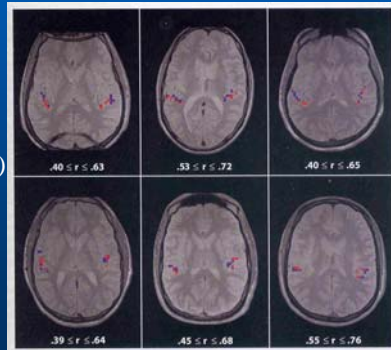
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Auditory Perception

- Overview of the Auditory Pathways

- ◆ Cells in one region of an auditory area will respond to low-frequency stimuli; cells in another region will respond to middle or high-frequencies
- ◆ Tonotopic representation revealed with fMRI
- ◆ In most cases, the region responding to the low tones (blue) is more posterior and medial to the region responding to the high tones (red)



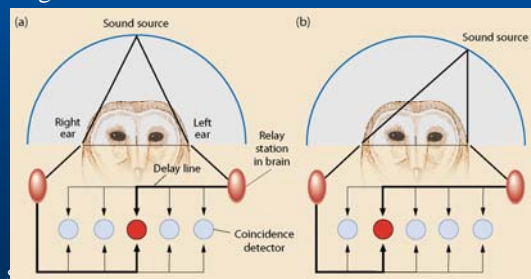
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Auditory Perception

- Concurrent Processing for Sound Localization

- ◆ Barn owls rely on two cues to localize sounds: **interaural time**, and **the difference in the sound's intensity at the two ears**
- ◆ These two cues are processed by independent neural pathways: each cochlear nucleus is composed of two parts, the magnocellular nucleus and the angular nucleus



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Summary

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Summary

- This chapter provided an overview of the organization of the pathways involved in visual and auditory perception.
- A point emphasized in this chapter is that specialized mechanisms for solving different computational problems have evolved in the brain.

Thought Questions

- You watch a short video segment in which a large purple dinosaur appears briefly in the left visual field. Trace the flow of information about this stimulus and its separate features(color, shape, luminance, motion, position) from the eye through the secondary visual areas
- Compare and contrast the functional organization of the visual and auditory systems. What are the computational problems that each system must solve, and how are these solutions achieved in the nervous system?

Thought Questions

- A person arrives at the hospital in a confused state and appears to have some impairments in visual perception. As the attending neurologist, you suspect the person may have had a stroke. How would you go about examining the patient to determine at what level in the visual pathways the damage has occurred? You should emphasize the behavioral tests you would administer, although you should feel free to make predictions about what you expect to see on MRI scans

Thought Questions

- Define the physiological concepts of the receptive field and visual area. How is the receptive field of a cell established? How are the boundaries between visual areas identified? Can either receptive fields or visual areas be studied noninvasively in humans?
- Much of the focus in this chapter has been on salient visual properties such as color, shape, and motion. In looking around the environment, do these properties seem to reflect the most important cues for a highly skilled visual creature? What other sources of information might an adaptive visual system exploit?