
MODULE 18

Vision

Module Preview

The task of each sense is to receive stimulus energy, transduce it into neural signals, and send those neural messages to the brain. In vision, light waves are converted into neural impulses by the retina; after being coded, these impulses travel up the optic nerve to the brain's cortex, where they are interpreted. The Young-Helmholtz and opponent-process theories together help explain color vision.

Module Guide

Stimulus Input: Light Energy and The Eye

- ▶ Exercise: The Hermann Grid
- ▶ Exercise/Project: Physiology of the Eye—A CD-ROM for Teaching Vision
- ▶ Project: Locating the Retinal Blood Vessels
- ▶ Projects/Exercises: Rods, Cones, and Color Vision; Locating the Blind Spot
- ▶ Video: Segment 9 of the Scientific American *Frontiers* series, 2nd ed.: *Smart Glasses*

18-1. *Describe the characteristics of visible light, and explain the process by which the eye converts light energy into neural messages.*

The energies we experience as visible light are a thin slice from the broad spectrum of *electromagnetic* energy. Our sensory experience of light is determined largely by the light energy's **wavelength**, which determines the **hue** of a color, and its **intensity**, which influences brightness.

After light enters the eye through the *pupil*, whose size is regulated by the *iris*, a cameralike *lens* focuses the rays by changing its curvature, a process called **accommodation**, on the **retina**. This light-sensitive surface contains receptors that begin the processing of visual information.

The retina's **rods** and **cones** (most of which are clustered around the **fovea**) transform the light energy into neural signals. These signals activate the neighboring *bipolar cells*, which in turn activate the neighboring *ganglion cells*, whose axons converge to form the **optic nerve** that carries information via the thalamus to the brain. Where the optic nerve leaves the eye, there are no receptor cells—creating a **blind spot**. The cones enable vision of color and fine detail. The rods enable black-and-white vision, remain sensitive in dim light, and are necessary for peripheral vision.

Visual Information Processing

► Exercise: Movement Aftereffects

- 18-2. *Discuss the different levels of processing that occur as information travels from the retina to the brain's cortex.*

We process information at progressively more abstract levels. The information from the retina's 130 million rods and cones travels to our bipolar cells, then to our million or so ganglion cells whose axons make up the optic nerve. When individual ganglion cells register information in their region of the visual field, they send signals to the occipital lobe's visual cortex. In the cortex, individual neurons (*feature detectors*) respond to specific features of a visual stimulus. The visual cortex passes this information along to other areas of the cortex where teams of cells (*supercell clusters*) respond to more complex patterns.

► Lecture: Blindsight

► Videos: Program 11 of *Moving Images: Exploring Psychology Through Film: Nonconscious Processing: Blindsight*; Modules 8 and 9 of *The Brain*, 2nd ed.: *Visual Information Processing: Elementary Concepts* and *Visual Information Processing: Perception*

- 18-3. *Define parallel processing, and discuss its role in visual information processing.*

Subdimensions of vision (color, movement, depth, and form) are processed by neural teams working separately and simultaneously, illustrating our brain's capacity for **parallel processing**. Other teams collaborate in integrating the results, comparing them with stored information and enabling perceptions. This contrasts sharply with the step-by-step serial processing of most computers and of conscious problem solving. Some people who have lost part of their visual cortex experience *blindsight*.

Color Vision

► PsychSim 5: Colorful World

► Exercises: The Color Vision Screening Inventory and Color Blindness; Subjective Colors

- 18-4. *Explain how the Young-Helmholtz and opponent-process theories help us understand color vision.*

The **Young-Helmholtz trichromatic (three-color) theory** states that the retina has three types of color receptors, each especially sensitive to red, green, or blue. When we stimulate combinations of these cones, we see other colors. For example, when both red- and green-sensitive cones are stimulated, we see yellow.

Hering's **opponent-process theory** states that there are two additional color processes, one responsible for red versus green perception and one for yellow versus blue plus a third black versus white process. Subsequent research has confirmed that after leaving the receptor cells, visual information is analyzed in terms of the opponent colors red and green, blue and yellow, and also black and white. Thus, in the retina and in the thalamus, some neurons are turned "on" by red, but turned "off" by green. Others are turned on by green but off by red. These opponent processes help explain *afterimages*.