Chapter 3:
Sensation and
Perception

The 6 Major Senses

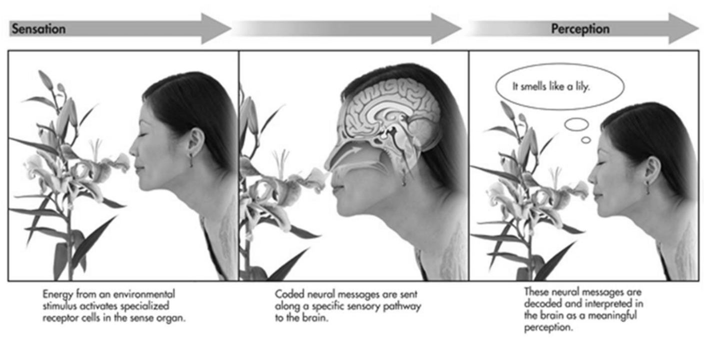
- vision
- hearing
- touch
- taste
- pain
- smell

Sensation

The process of detecting a physical stimulus such as light, sound, heat, or pressure

Perception

The process of integrating, organizing, and interpreting sensations



Principles of Sensation

- Transduction—physical energy to neural signal
- Absolute threshold—smallest strength of a stimulus that can be detected
- Difference threshold—(just noticeable difference) smallest difference that can be detected
- Sensory receptors—specialized cells unique to each sense organ that respond to stimulation
- Sensory adaptation—the decline in sensitivity to constant stimulus

Principles of Sensation

- Subliminal perception—detection of stimuli just below conscious awareness
- Mere exposure effect—repeated exposure to a stimulus increases a person's preference for it
- Weber's law—for each sense the size of a just noticeable difference is a constant proportion of the size of the initial stimulus

Vision

Purpose of the Visual System

- transform light energy into an electrochemical neural response
- represent characteristics of objects in our environment such as size, color, shape, and location

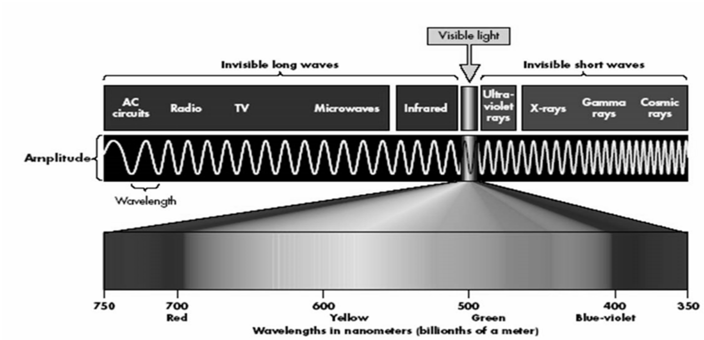
Vision Key Terms

- Cornea—clear membrane that covers the front of the eye, helps gather and direct incoming light
- Pupil—the opening in the middle of the iris that changes size to let in different amounts of light
- Iris—the colored part of the eye; the muscle that controls the size of the pupil

Vision Key Terms

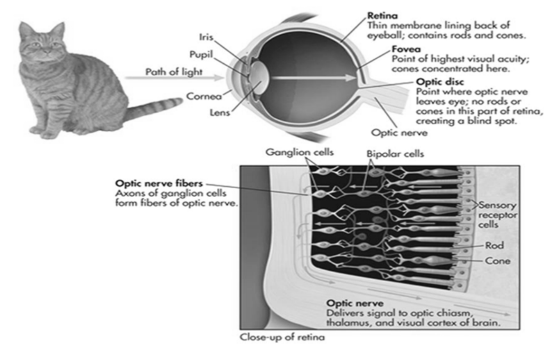
- Lens—a transparent structure behind the pupil; bends light as it enters the eye
- Retina—a thin, light-sensitive membrane located at the back of the eye that contains sensory receptors for vision
- Accommodation—the process by which the lens changes shape to focus incoming light so that it falls on the retina

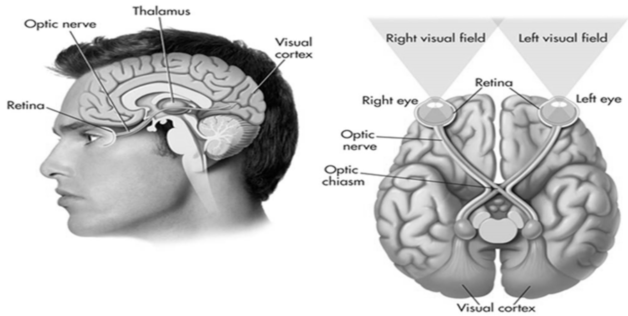
Light: The Visual Stimulus



Light: The Visual Stimulus

- Light can be described as both a particle and a wave.
- The wavelength of a light is the distance of one complete cycle of the wave.
- Visible light has wavelengths from ~400nm to 700nm.
- The wavelength of light is related to its perceived color.





Distribution of Rods and Cones

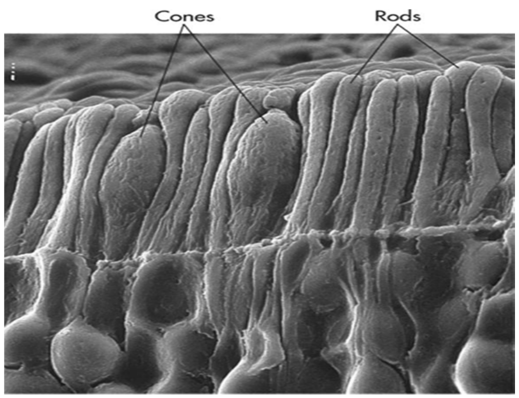
- Cones—concentrated in center of eye (fovea)
  - ~6 million
- Rods—concentrated in periphery
  - ~120 million
- Blind spot—region with no rods or cones

Differences Between Rods and Cones

- Cones
  - allow us to see in bright light
  - allow us to see fine spatial detail
  - allow us to see different colors
- Rods
  - allow us to see in dim light
  - can not see fine spatial detail
  - can not see different colors

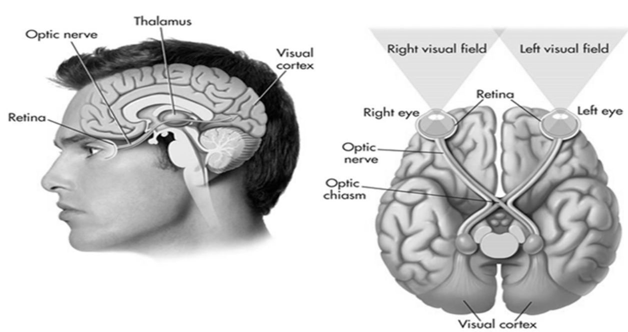
Rod Vs Cone Visual Acuity

- Cones—one cone often synapses onto only a single ganglion cell
- Rods—the axons of many rods synapse onto one ganglion cell
- This allows rods to be more sensitive in dim light, but it also reduces visual acuity.



Processing Visual Information

- Ganglion cells—neurons that connect to the bipolar cells; their axons form the optic nerve
- Bipolar cells—neurons that connect rods and cones to the ganglion cells
- Optic chiasm—point in the brain where the optic nerves from each eye meet and partly crossover to opposite sides of the brain



Color Vision

- Our visual system interprets differences in the wavelength of light as color
- Rods are color blind, but the cones allow us to see different colors
- This difference occurs because we have only one type of rod but three types of cones

Properties of Color

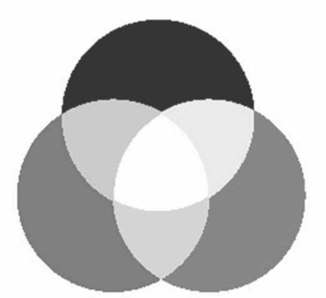
- Hue—property of wavelengths of light known as color; different wavelengths correspond to our subjective experience of color (hue)
- Saturation—property of color that corresponds to the purity of the light wave
- Brightness—perceived intensity of a color, corresponds to amplitude of the light wave

Color Mixing

- Two basic types of color mixing
  - subtractive color mixture
    - example: combining different color paints
  - additive color mixture
    - example: combining different color lights

Additive Color Mixture

- By combining lights of different wavelengths we can create the perception of new colors.
- Examples:
  - red + green = yellow
  - red + blue = purple
  - green + blue = cyan



Trichromatic Theory of Color Vision

- Researchers found that by mixing only three primary lights (usually red, green, and blue), they could create the perceptual experience of all possible colors.
- This lead Young and Helmholtz to propose that we have three different types of photoreceptors, each most sensitive to a different range of wavelengths.

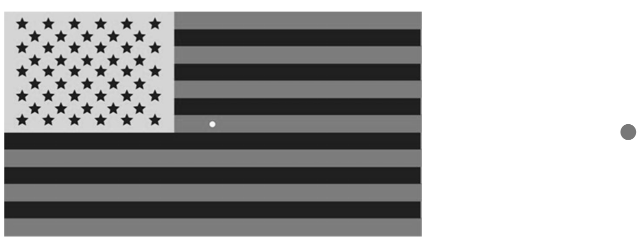
Trichromacy and TV

- All color televisions are based on the fact that normal human color vision is trichromatic.
- Although we perceive the whole range of colors from a TV screen, it only has three colored phosphors (red, green, and blue).
- By varying the relative intensity of the three phosphors, we can fool the visual system into thinking it is seeing many different colors.

Opponent Process Theory of Color Vision

- Some aspects of our color perception are difficult to explain by the trichromatic theory alone.
- Example: afterimages
  - If we view colored stimuli for an extended period, we will see an afterimage in a complementary color.

Complementary Afterimages



Opponent-Process Theory

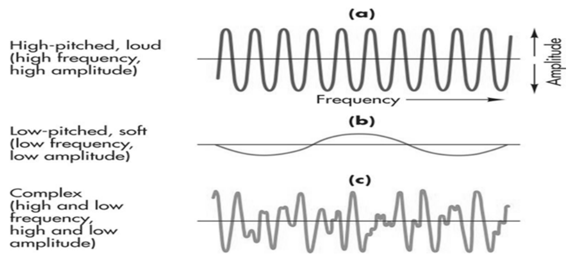
- To account for phenomena like complementary afterimages, Herring proposed that we have two types of color opponent cells.
  - red-green opponent cells
  - blue-yellow opponent cells
- Our current view of color vision is that it is based on both the trichromatic and opponent-process theory.

Overview of Visual System

- The eye is like a camera, but instead of using film to catch the light we have rods and cones.
- Cones allow us to see fine spatial detail and color, but cannot function well in dim light.
- Rods enable us to see in dim light, but at the loss of color and fine spatial detail.
- Our color vision is based on the presence of 3 types of cones, each maximally sensitive to a different range of wavelengths.

Hearing: Sound Waves

- Auditory perception occurs when sound waves interact with the structures of the ear.
- **Sound wave**—changes over time in the pressure of an elastic medium (for example, air or water).
- Without air (or another elastic medium) there can be no sound waves, and thus no sound.



- Frequency of a sound wave is related the pitch of a sound
- Amplitude of a sound wave is related to loudness of a sound

Frequency of Sound Waves

- The frequency of a sound wave is measured as the number of cycles per second (Hertz).
  - 20,000 Hz Highest frequency we can hear
  - 4,186 Hz Highest note on a piano
  - 1,000 Hz Highest pitch of human voice
  - 100 Hz Lowest pitch of human voice
  - 27 Hz Lowest note on a piano

Intensity of Various Sounds

Example	P (in sound-pressure units)	Log *P*	Decibels
Softest detectable sound	1	0	0
Soft whisper	10	1	20
Quiet neighborhood	100	2	40
Average conversation	1000	3	60
Loud music from a radio	10,000	4	80
Heavy automobile traffic	100,000	5	100
Very loud thunder	1,000,000	6	120
Jet airplane taking off	10,000,000	7	140
Loudest rock band on record	100,000,000	8	160
Spacecraft launch from 150 ft.	1,000,000,000	9	180

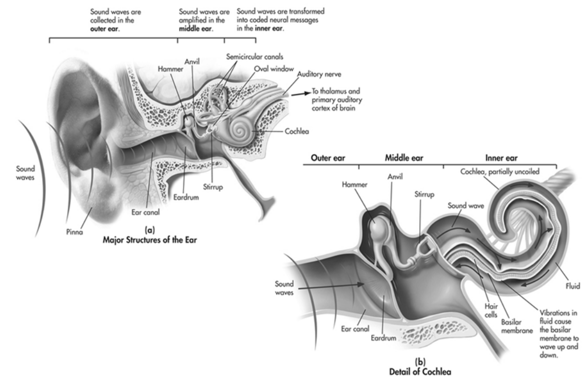
Anatomy of the Ear

Purpose of the structures in the ear:

- Measure the frequency (pitch) of sound waves
- Measure the amplitude (loudness) of sound waves

Major Structures of the Ear

- Outer ear—acts as a funnel to direct sound waves toward inner structures
- Middle ear—consists of three small bones (or ossicles) that amplify the sound
- Inner ear—contains the structures that actually transduce sound into neural response



(a) Major Structures of the Ear

(b) Detail of Cochlea

Transduction of Sounds

- The structures of the ear transform changes in air pressure (sound waves) into vibrations of the basilar membrane.
- As the basilar membrane vibrates it causes the hairs in the hair cells to bend.
- The bending of the hairs leads to a change in the electrical potential within the cell.

Distinguishing Pitch

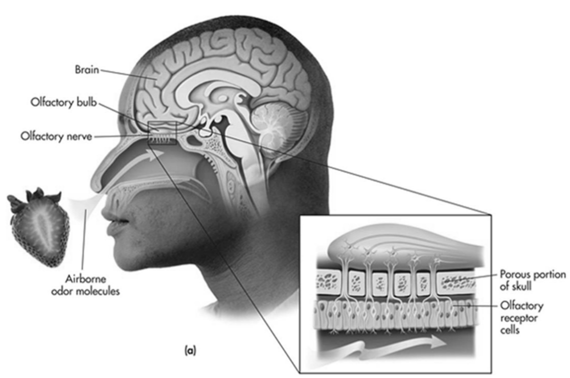
- Frequency theory—basilar membrane vibrates at the same frequency as the sound wave
- Place theory—different frequencies cause larger vibrations at different locations along the basilar membrane

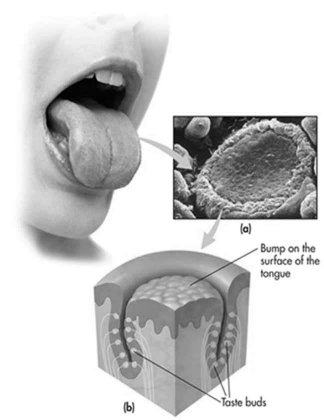
Chemical and Body Senses

- Olfaction (smell)
- Gustation (taste)
- Touch and temperature
- Pain
- Kinesthetic (location of body)
- Vestibular (balance)

Olfactory System

- Olfactory nerves are connected to the olfactory bulb in the brain.
- Olfactory bulb—enlarged ending of the olfactory cortex at the front of the brain where the sensation of smell is registered.
- Olfactory function declines with age.
- Pheromones—chemical signals released by an animal that communicate information and affect the behavior of other animals of the same species.





Taste

- Sweet
- Sour
- Salty
- Bitter
- Umami

Skin and Body Senses

- Pressure—Pacinian corpuscles
- Pain—physical discomfort or suffering with varying degrees of intensity

Specialized Sensory Receptors

- Taste buds—located on tongue and inside of mouth and throat
- Temperature—receptors reactive to cold or warm, simultaneous stimulation produces sensation of hot
- Nociceptors—receptors for pain found in skin, muscles, and internal organs

Pain Systems

- Two types of nociceptors—A-delta fibers (fast pain system) and C fibers (slow pain system)
- Substance P—pain enhancer released by C fibers that stimulates free nerve endings at the site of an injury; increases pain messages at spinal cord

Elements of Pain

- Gate-control theory of pain—pain is a product of both physiological and psychological factors that cause spinal gates to open and relay patterns of intense stimulation to the brain; the brain perceives them as pain.
- Phantom limb pain—when a person continues to experience intense painful sensations in a limb that has been amputated.

Movement, Position, and Balance

- Kinesthetic—sense of location of body parts in relation to one another
- Vestibular—sense of balance, receptors located in the inner ear
- Proprioceptors—receptors in muscles and joints that provide information about body position and movement

Perception

The process of integrating, organizing, and interpreting sensory information.

Perceptual Processing

- Bottom-up processing—emphasizes the importance of sensory receptors in detecting the basic features of a stimulus; moves from part to whole; also called data-driven processing
- Top-down processing—emphasizes importance of observer's cognitive processes in arriving at meaningful perceptions; moves from whole to part; also called conceptually driven processing

Perceptual Organization

- Some of the best examples of perceptual organization were provided by the Gestalt psychologists.
- Gestalt psychologists hypothesized that "the whole is greater than the sum of the parts."
- They were interested in showing the global nature of our perceptions.

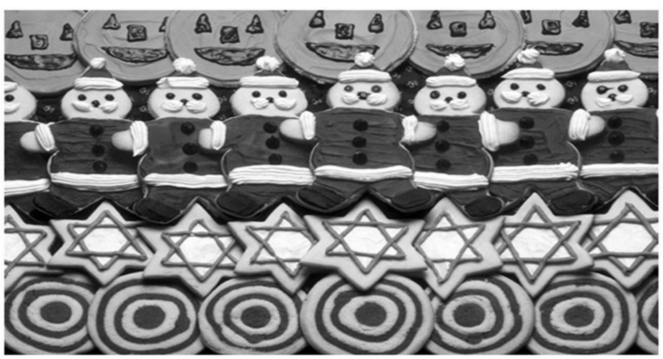
Cultural Differences in Perception

- Research has shown that those from collectivistic cultures tend to focus more on the background of a scene than the foreground object.
- Reflects more “holistic” perceptual style characterizing collectivistic culture.
- Cultural differences seen in brain function: those from individualistic cultures show greater brain activation while making relative judgments.

Gestalt Grouping Principles

Gestalt theorists argued that our perceptual systems automatically organized sensory input based on certain rules.

- Proximity
- Similarity
- Closure
- Good continuation
- Common movement
- Good form



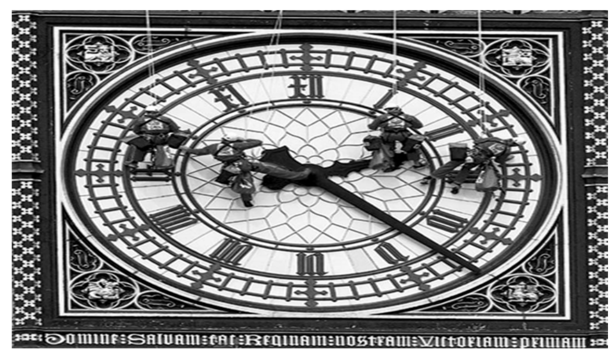
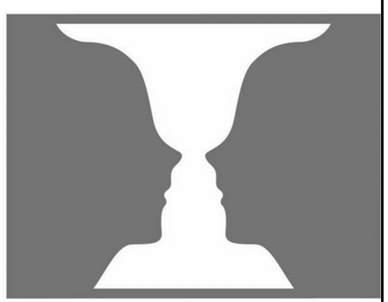


Figure and Ground

Gestalt psychologists also thought an important part of our perception was the organization of a scene into its **figure** (the object of interest) and its **ground** (the background).



ESP: Perception without sensation

- Extrasensory perception (ESP)- perception of information by some other means than a normal process
- Parapsychology-scientific investigation of claims of para-normal phenomena
- Replication is elusive on this topic.

Depth Perception

- One of our more important perceptual abilities involves seeing in three dimensions.
- Depth perception is difficult because we only have access to two-dimensional images.
- How do we see a 3-D world using only the 2-D retinal images?

Depth Perception Cues

- Cue—stimulus characteristics that influence our perceptions
- We are able to see in 3-D because the visual system can use depth cues that appear in the retinal images.

Types of Depth Cues

Depth cues are usually divided into categories; we will consider two types of depth cues

•Monocular—depth cues that appear in the image in either the left or right eye

•Binocular—depth cues that involve comparing the left and right eye images

Monocular Depth Cues

- Relative image size
- Overlap
- Aerial perspective
- Texture gradient
- Linear perspective
- Motion parallax

Binocular Depth Cues

- Monocular depth cues allow us to see in 3-D with the view of only one eye, but our best depth perception occurs if we look through both eyes.
- This is because our right and left eyes see a slightly different view of the world.
- The difference between the image in the two eyes is know as binocular disparity.

Stereogram

- Another way to create the illusion of depth through binocular stereopsis is with an stereogram.
- An stereogram is formed by repeating columns of patterns.

Stereogram

Perceptions of Motion

- Induced motion-studied by Karl Duncker-example is illusion of thinking the moon is moving across the sky when it is the clouds behind the move actually moving.
- Stroboscopic motion-studied by Wertheimer-illusion of movement created by two carefully timed flashing lights.

Perceptual Constancy

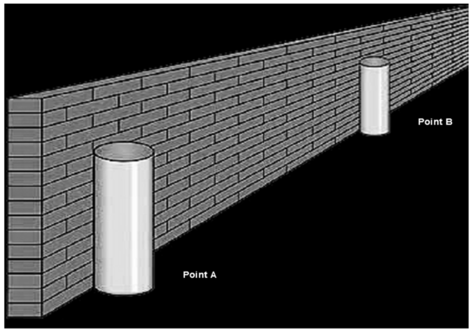
- When viewing conditions change, the retinal image changes even if the objects being viewed remain constant.

Example: As a person walks away from you their retinal image decreases in size.

- Important function of the perceptual system is to represent constancy in our environment even when the retinal image varies.

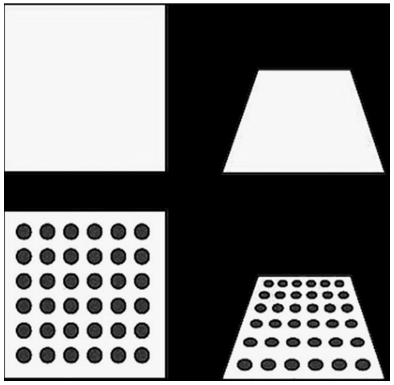
Size Constancy

- The cylinders at positions A and B are the same size even though their image sizes differ.
- The depth cues such as linear perspective and texture help the visual system judge the size accurately.



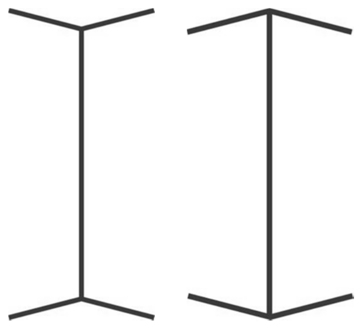
Shape Constancy

- It is hard to tell if the figure on the upper right is a trapezoid or a square slanted backward.
- If we add texture, the texture gradient helps us see that it is actually a square.



Müller-Lyer Illusion

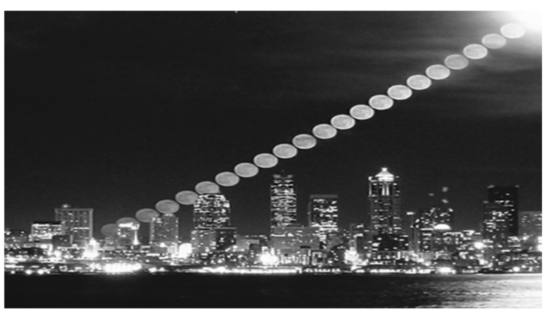
- Perceptual psychologists have hypothesized that the left horizontal line looks longer because it also looks farther away.
- Specifically, the inward pointing arrows signify that the horizontal line is closest to you, and the outward pointing arrows signify the opposite case.



Moon Illusion

- The misperception that the moon is larger when on the horizon than when directly overhead
- Involves a misapplication of the principle of size constancy

Moon Illusion



Perceptual Set

•The influence of prior assumptions and expectations on perceptual interpretations.

•People can actually see faces in ambiguous stimuli (e.g. the face of Jesus in a pirogi, the Virgin Mary on a grilled cheese sandwich).

Strategies to Control Pain

•Self-Administered Strategies: distraction, imagery, relaxation, counter irritation, positive self-talk

•Magnets are an example of an alternative medicine; popular but no empirical data to prove effectiveness

Strategies to Control Pain

•Biofeedback: involves using auditory or visual feedback to learn to exert voluntary control over involuntary body functions like heart rate, blood pressure, and muscle tension

•Acupuncture: procedure involving insertion and manipulation of needles into specific body locations to alleviate pain and treat illness