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

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

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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.
Anatomy of the Ear

**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**

<table>
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<tr>
<th>Example</th>
<th>P (in sound-pressure units)</th>
<th>Log P</th>
<th>Decibels</th>
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<tr>
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<tr>
<td>Soft whisper</td>
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<td>1</td>
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<tr>
<td>Quiet neighborhood</td>
<td>100</td>
<td>2</td>
<td>40</td>
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<tr>
<td>Average conversation</td>
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<td>3</td>
<td>60</td>
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<td>Loud music from a radio</td>
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<td>4</td>
<td>80</td>
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<td>Heavy automobile traffic</td>
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<td>5</td>
<td>100</td>
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<tr>
<td>Very loud thunder</td>
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<td>Jet airplane taking off</td>
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<td>140</td>
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<tr>
<td>Loudest rock band on record</td>
<td>100,000,000</td>
<td>8</td>
<td>160</td>
</tr>
<tr>
<td>Spacecraft launch from 150 ft.</td>
<td>1,000,000,000</td>
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<td>180</td>
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</table>

**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

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
- Nocireceptors—receptors for pain found in skin, muscles, and internal organs

Pain Systems

- Two types of nocireceptors—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 known as binocular disparity.

Stereogram

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

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.

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.

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