CHAPTER 3 OUTLINE
SENSING AND PERCEIVING

I. SENSING AND PERCEIVING THE WORLD

*What is the difference between sensation and **perception**?*

A **sense** is a system that translates outside information into activity in the nervous system. Messages from the senses are called **sensations**. Perception is the process of using information and your understanding of the world, so that sensations become meaningful experiences.

II. SENSORY SYSTEMS

How does information from my eyes and ears get to my brain?

Each sensory system detects a specific form of environmental energy (e.g., sound, light, heat, physical pressure), and encodes this energy into neural activity, and relays these signals to the brain.

1. **Accessory structures** modify the incoming stimulus.

   Transduction is the process of converting incoming energy into neural activity.

   Receptors are specialized cells that detect certain forms of energy.

   a. Sensory systems respond best to *changes* in energy. **Adaptation** is a decreasing responsiveness to constant stimulation over time.

   b. *Sensory nerves* carry information from the receptors to the brain. For all senses except smell the information goes to the thalamus then to the cerebral cortex.

A. CODING SENSATIONS: DID YOU FEEL THAT?

1. **Coding** translates the physical properties of a stimulus into patterns of neural activity.

B. ABSOLUTE THRESHOLDS: IS SOMETHING OUT THERE?

1. The **absolute threshold** is the minimum detectable amount of physical energy a sensory system can detect.

2. *Psychophysics* focuses on the relationship between physical energy in the environment and the psychological experience of that energy.

   a. Psychophysics has redefined absolute threshold as the smallest amount of energy that can be detect 50 percent of the time.

3. The absolute threshold varies over time and between people according to two factors.

    a. **Internal noise**, the spontaneous random firing of neurons, gives a background "noise." If the amount of internal noise is high at a moment, it may be mistakenly interpreted as a stimulus.

    b. **Response criterion** is a person's willingness or reluctance (bias) to respond to a stimulus. It is the amount of energy needed for a person to justify saying that a signal has occurred. It reflects both motivation and expectancies.

4. The signal-detection theory is a mathematical model of how personal sensitivity and response criterion combine to determine your decision about whether or not a near-threshold stimulus has occurred.

    a. **Sensitivity** is a person's ability to discriminate a stimulus from it's background.

    b. The response criterion is the internal rule used in deciding whether to report a signal.

C. JUDGING DIFFERENCES BETWEEN STIMULI

1. **Weber's law** states that the smallest detectable difference in stimulus energy (the *difference threshold*, or the **just-noticeable difference, JND**) is a constant fraction of the intensity of the stimulus.

D. SENSORY ENERGY: The sensory energies of light and sound vibrate as waves passing through space.

2. **Wavelength** is the distance from one peak of the wave to the next.

3. *Wave frequency* is the number of complete waves or cycles that pass a given point per unit of time.

4. **Amplitude** is the height of the wave from baseline to peak.

III. SEEING

Why do some people need eyeglasses?

Light is a form of energy known as *electromagnetic radiation*. Most electromagnetic radiation passes through space undetected by the human eye.

1. **Visible light** is electromagnetic radiation with wavelengths between 400 and 750 nanometers. Light can be referred to as either light waves or light rays.

2. Sensations of light depend on the intensity and wavelength of light waves.

    a. **Light intensity** refers to how much energy the light contains; it determines the *brightness* of light.

    b. **Light wavelengths** create the sensation of color.

A. FOCUSING LIGHT

1. Accessory structures of the eye focus light rays into a sharp image.

2. Light waves enter the eyeball through a curved, protective transparent membrane, the **cornea**.

3. Light then passes through the pupil, an opening in a circular muscle called the **iris**.

4. The iris adjusts the amount of entering light by constricting to reduce the size of the pupil or relaxing to enlarge it.

5. The curved **lens**, behind the pupil, bends and focuses light waves onto the **retina** at the back of the eye. (Light rays from the top of an object are focused at the bottom of the image on the retinal surface and those from the right side of the object end up on the left side of the retinal image. The brain then rearranges this upside-down and reversed image.)

    a. In **accommodation**, the lens changes shape to focus images at different distances onto the retina. This ability declines with age as the lens loses flexibility.

B. CONVERTING LIGHT INTO IMAGES

1. Conversion of light energy into neural activity takes place in the *retina* in specialized cells called **photoreceptors**.

2. Photoreceptors, **rods** and **cones**, contain chemicals that are light-sensitive.

3. **Dark adaptation** is the increasing ability to see in the dark over time. *Rods* are more sensitive to light than cones and allow you to see in dim light. There are no rods in the fovea but a large proportion in the periphery of the retina.

4. *Cones* allow you to see color. Most cones are packed in the **fovea**, the center of the retina. The density of cones accounts for differences in visual *acuity* or the ability to see details. Cones do not work well in low light.

5. Signals generated by the rods and cones go back toward the surface of the retina making connections with *bipolar* and *ganglion cells*. This allows the eye to begin analyzing visual information in the retina.

6. The axons of *ganglion cells* form the **optic nerve** which then goes to the brain. Since there are no photoreceptors where the optic nerve exits the eyeball, point, a **blind spot**, insensitive to light, is created.

7. About half of the optic nerve fibers from each eye cross to the opposite side of the brain at the *optic chiasm*. Fibers from the inside half of each eye, nearest to the nose, cross over. Fibers from the outside half of each eye do not. All visual information from the left half of the visual world goes to the right hemisphere of the brain and vice versa.

8. The optic chiasm is part of the bottom of the brain. The fibers extend into the brain, with most ganglion cells forming synapses in the thalamus. Then visual input is sent to the primary visual cortex in the occipital lobe at the back of the brain, and to many association areas of the brain for processing.

9. Certain cells in the brain's cerebral cortex are called **feature detectors** because they respond to specific characteristics of objects in the visual field.

C. SEEING COLOR

1. The sensation produced by a *mixture* of different wavelengths of light is not the same as the sensations produced by separate wavelengths. Three separate aspects of the sensation of color are hue, saturation and brightness. They are the *psychological* dimensions.

    a. **Hue**, the essential "color" you see, is determined by a light mixture's dominant wavelength.

    b. **Saturation** is the "purity" of a color. A color is more saturated (more pure) if a single wavelength is more intense (contains more energy) than others. Pastels are colors that have been desaturated by the addition of whiteness.

    c. **Brightness** reflects the intensity of the light.

2. *Additive color mixing* occurs when two lights of different colors are mixed. White is the eventual result of adding different colored lights.

a. *Subtractive color mixing* occurs when two colors absorb (subtract) more wavelengths of light than either one does alone. Mixing paints is an example.

D. THEORIES OF COLOR VISION

1. The **trichromatic theory** was proposed by Thomas Young and Hermann von Helmholz. They proved that by mixing pure version of blue, green, and red light in different rations, they could produce *any* color.

   a. There are three types of cones, each most sensitive to a different wavelength.

      i. Short-wavelength cones respond most to light in the blue range.

      ii. Medium-wavelength cones respond most to light in the green range.

      iii. Long-wavelength cones respond most to light in the yellow range, although by tradition these are known as the red cones.

   b. The ratio of the three cone types' activities determines the color sensation. This theory was applied to the creation of color television screens.

2. The **opponent-process theory** of color vision, proposed by Ewald Hering holds that each of the three color-sensitive elements are organized as pairs, with the pair members opposing, or inhibiting, each other.

   a. The three pairs are red-green, blue-yellow, and black-white. Each element signals one color or the other, but never both.

3. Both the trichromatic and opponent-process theories are needed to explain what is known about color vision.

   a. There are three types of cones, as the trichromatic theory predicts. And any color can be produced by mixing three pure wavelengths of light.

   b. The cones connect to ganglion cells containing pairs of opposing elements that respond to different colors and inhibit each other. This explains after-images.

E. COLORBLINDNESS

People with *colorblindness* discriminate fewer colors because they are missing one or more of the

three color-sensitive pigments in cones. The result is loss of one or more of the three-opponent-process color elements, most often the red-green system. Colorblindness is more common in men than in women.

IV. HEARING

How would my voice sound on the moon?

Sound is a repetitive vibration in the pressure of a substance, such as air. Since the moon has almost no atmosphere or air pressure, sound cannot exits there.

A. SOUND

1. Vibration of an object produce the fluctuations in pressure that make *sound*. A wave is a repetitive change in pressure that spread out in 3 dimensions.

2. Physical characteristics of sound waves determine psychological dimensions of sound.

    a. **Loudness**, measured in *decibels (dB)*, is determined by wave amplitude. 0 decibels is the minimum detectable sound for normal hearing.

    b. A sound's wavelength is the distance from one wave peak to the next. The *frequency* is the number of complete waves that pass a point in one second. Once cycle per second is 1 *Hertz* (*Hz*). **Pitch** is how low or high a tone's sound increases or decreases with the frequency of waves. Humans can hear sounds ranging from about 20 to 20,000 Hz.

    c. **Timbre** is a sound's quality. It is caused by complex wave patterns that are added to the lowest, or *fundamental*, frequency of a sound.

B. THE EAR: The human ear converts sound energy into neural activity.

1. The **pinna** is the crumpled, oddly shaped *external ear* on the side of the head that collects sound waves in the outer ear and funnels them into the *ear canal*.

    a. At the end of the ear canal, sound waves strike the tightly stretched *tympanic membrane* (**eardrum**) of the *middle ear*.

    b. Tympanic membrane movements shake a chain of three tiny bones: *the malleus (hammer), incus (anvil)*, and *stapes (stirrup)*. These bones amplify the vibrations and directs them onto a smaller membrane called the *oval window*.

2. Auditory transduction occurs in the **cochlea** of the *inner ear*.

    a. The cochlea is a fluid-filled "tube" coiled into a spiral that begins at the oval window. Within this tube, the **basilar membrane** forms the floor of a long duct.

    b. When a sound wave passes through the fluid in the tube it moves the basilar membrane, which in turn deforms *hair cells* on the membrane.

        i. *Hair cells* make connections with fibers from the **auditory nerve**, a bundle of axons that go into the brain.

3. There are two basic forms of deafness.

    a. *Conduction deafness* occurs when the middle ear's bones fuse so that they cannot properly amplify vibrations. Treatment includes hearing aids, which amplify the signals reaching the inner ear or surgery to break the bones apart or replacing the natural bones with plastic ones.

    b. *Nerve deafness* follows damage to the auditory nerve or the hair cells. High-intensity sound can actually rip off the hair cells of the inner ear. Scientists are working on regenerating hair cells. Artificial *cochlear implants* are being developed to stimulate the auditory nerve.

4. The auditory nerve carries input to the thalamus. The information is then relayed to the *primary auditory cortex* of the temporal lobe. Each neuron in the auditory nerve has a "favorite" or characteristic frequency.

C. CODING SOUNDS: The more intense the sound, the more rapid the firing of given neurons.

1. The place on the basilar membrane where the wave peaks depends on the sound frequency. High-frequency sounds peak at the beginning of the basilar membrane, lower-frequency sounds peak farther down. According to **place theory**, the greatest response by hair cells occurs at the peak of the wave.

    a. When cells with a particular *characteristic frequency* fire, we sense a sound of that frequency.

2. *Frequency-matching* or **volley theory** says that the firing rate of auditory nerve neurons matches the frequency of a sound wave. This explains the encoding of very low frequencies.

V. THE CHEMICAL SENSES: SMELL AND TASTE

Why can't I taste anything when I have a cold?

A. SMELL, TASTE, AND FLAVOR

1. A food's flavor depends on both smell and taste. Both tastes and odors prompt strong emotional responses. Humans learn aversions to odors more readily than to tastes.

2. Variations in our nutritional state also affect our experience of taste and flavor, as well as our motivation.

3. Warm foods taste sweeter, and the aroma of warm food can create more flavor sensations.

4. Spicy "hot" food actually stimulate pain fibers in the mouth because they contain a substance called *capsaicin*.

B. OUR SENSE OF SMELL

1. *Olfaction* (smell) detects chemicals that are airborne using receptors in the upper nose. People sense odors in the upper part of the nose. Receptors detect molecules that pass into the moisture lining of the nose. Odor molecules bind to receptors on the dendrites of olfactory neurons causing a biochemical change. The leads to a change in the firing rates and the axons of these olfactory neurons combine to form the olfactory nerve.

2. Any particular odor is sensed as a particular *pattern* of responses by the *odorant receptors*.

3. Olfaction is the only sense in which neurons do not synapse in the thalamus. Olfactory axons extend directly into the brain to synapse in the **olfactory bulb**.

    a. The olfactory bulb's connections to the *amygdala*, which plays important roles in emotion and memory, may underlie the special relationship between smells and emotions or memories.

4. Some animals release **pheromones** , chemicals that other animals detect and respond to behaviorally and physiologically. In humans, pheromones released by women can influence other women's menstrual cycles, so that women living together eventually menstruate at about the same time.

C. OUR SENSE OF TASTE

1. *Gustation* (taste) detects chemicals in solution. Gustatory receptors are in *taste buds*, grouped together as **papillae** in the mouth and throat.

2. The human taste system detects only four basic sensations: *sweet, sour, bitter*, and *salty*. A possible fifth taste, *unami*, may be triggered by monosodium glutamate (MSG).

3. About 25% of the population are "supertasters" individuals whose genes have given them a large number of papillae on their tongues and who are more sensitive to bitterness.

VI. SENSING YOUR BODY

Which is the largest organ in my body?

The **somatic senses**, or *somatosensory systems*, are located throughout the body rather than in a localized, specific organ.

A. TOUCH AND TEMPERATURE

1. The stimulus for touch is the mechanical deformation of the skin, by direct pressure or by bending hairs on the skin

2. The sense of touch codes information about an object's intensity and location.

3. The somatosensory system responds best to *changes* in touch. Constant input leads to *adaptation*.

4. Many of the fibers that respond to temperature also respond to touch so these sensations sometimes interact. "Warm fibers" and "cold fibers" respond to specific temperature changes only.

B. PAIN

1. The receptors for pain are free nerve endings, which come from the spinal cord, enter the skin, and then end. Two types of nerve fibers carry pain signals to the spinal cord; one for sharp, pricking pain; the other for chronic, dull aches and burning sensations.

2. There are specific pathways that carry the emotional component of a painful stimulus to areas of the hindbrain, reticular formation, and cortex via the thalamus and other parts of the brain. However, cognition affects emotional responses to pain. Knowing about the nature of pain and when to expect it makes the same stimuli less unpleasant.

3. The **gate control theory** says that there is a "gate" in the spinal cord that either allows pain signals to reach the brain or prevents their passage.

a. Input from other skin senses may "take over" pathways that pain impulses would have used. This may explain why rubbing eases pain and scratching relieves itching (which is low-level pain).

b. The brain can close the gate with descending signals into the spinal cord. The result is **analgesia**, an absence of pain sensation following a normally painful stimulus.

4. The body can relieve pain using its own *natural analgesics*.

a. *Serotonin* and *endorphins*, released as neurotransmitters, can block several levels of pain pathways into and within the brain.

i. Endorphins are also released as hormones by the adrenal and pituitary glands.

b. Endorphins operate during late pregnancy, perhaps to reduce labor pains, and also when people merely believe they are receiving a real drug even if they are receiving only a placebo. An endorphin system is activated during any period of real or imagined stress.

c. People can no longer tolerate "hot" foods when they receive *naloxone*, a drug that blocks endorphin actions.

D. SENSING BODY POSITION

1. **Proprioception** refers to sensory information about one's body, as opposed to sensory information about the external environment.

2. **Kinesthesia** is sensory information about where your body parts are relative to each other.

a. The brain depends on kinesthetic inputs to guide movements.

b. The primary source of kinesthetic inputs are from receptors in muscles and skeletal joints. Kinesthetic inputs eventually reach the *somatosensory cortex* and the *cerebellum*.

3. Information about the position of the head relative to gravity and about its general movements is supplied by the **vestibular sense**. It is often thought of as the sense of balance.

a. *Vestibular sacs* are inner-ear structures filled with fluid and containing small crystals called *otoliths*, which rest on hair endings.

b. *Semicircular canals* are inner-ear structures whose fluid movements give information independent of gravity.

c. Head movements cause otoliths to shift in vestibular sacs, moving the fluid in the semicircular canals, stimulating hair endings. This activates neurons that travel along the auditory nerve, signaling the brain about the amount and direction of head movement.

d. Vestibular information feeds into three brain areas: the cerebellum, autonomic regions that coordinate digestive activity, and systems that control eye movements. The latter can cause *vestibular-ocular reflexes*, which cause your eyes to move opposite your head movements, thus allowing you to focus on one spot even when your head is moving.

VII. PERCEPTION

How do sensations become perceptions?

VIII. ORGANIZING THE PERCEPTUAL WORLD

What determines how I perceive my world?

A. PRINCIPLES OF PERCEPTUAL ORGANIZATION

1. When faced with complex stimuli, perceptual systems automatically picks out certain features, objects, or sounds to emphasize. **Figure** is the emphasized features and **ground** is the less meaningful background.

2. *Grouping* occurs as certain properties of stimuli lead you to group them together, more or less automatically. *Gestalt* psychologists argue that people perceive sights and sounds as organized wholes.

   The principles that describe how grouping occurs are:

   a. *Proximity*: Objects that are close to each other tend to be grouped together.

   b. *Similarity*: Similar things are perceived to belong to a group.

   c. *Continuity*: Sensations that appear to create a continuous form are perceived as belonging together.

d. *Closure*: People tend to fill in missing information to complete an object.

e. *Texture*: Stimuli that have the same texture (e.g., oriented along the same directions) tend to be grouped together.

f. *Simplicity*: People group stimuli to provide the simplest interpretation of the world.

g. *Common fate*: Objects that are moving in the same direction at the same speed are perceived as a group.

Some additional grouping principles:

h. *Synchrony*. Stimuli that occur at the same time are likely to be perceived as coming from the same source.

i. *Common region*. Stimuli located within some boundary tend to be grouped together.

j. *Connectedness*. Stimuli that are connected by other elements tend to be grouped together.

B. PERCEPTION OF DEPTH AND DISTANCE

Depth perception is the ability to perceive distance.

1. **Depth perception** partly relies on *stimulus cues*, information from the environment .

a. *Relative size*: If two objects are the same size, the object producing a larger retinal image is perceived as closer than the one producing a smaller image.

b. *Height in the visual field*: More distant objects tend to be higher in the visual field.

c. *Interposition*: Closer objects block the view of distant objects.

d. *Linear perspective*: As two lines come closer together, the perceived distance increases.

e. *Reduced clarity*: Greater distances usually yield less clarity.

f. *Light and shadow*: Shading helps contribute to perception of three dimensions.

g. *Textural gradient*: Texture appears finer, less detailed, with increased distance.

2. Depth perception also relies on *properties of the visual system*.

a. In *accommodation*, muscles alter the shape of the lens to focus objects from different depths. Feedback about this muscle activity gives the brain information about an object's distance.

b. Each eyeball rotates inwardly, or *converges*, so that an object's image projects onto each retina. The greater the inward rotation, the closer the object. Thus, feedback from muscles that move the eyeballs gives information about an object's distance.

c. The two eyeballs are in slightly different locations, so they receive slightly different images of the same object. The brain can use this difference between the two retinal images, called *binocular disparity*, to calculate an object's distance.

C. PERCEPTION OF MOTION

1. **Looming** is a rapid expansion in the image size of an object so that it fills the retina. The image is automatically perceived as an approaching stimulus, not an expanding object (recall size constancy).

2. When you are moving, the flow of visual information across the retina combines with information from he vestibular and touch senses to give you the experience of motion. If visual flow is perceived without appropriate sensations from other parts of the body, motion sickness may result.

a. **Stroboscopic motion** occurs because we tend to perceive movement when a series of still images appear, one at a time, in rapid succession.

D. **Perceptual constancy** is the ability to create a consistent perception of an object even as its sensory features change.

1. Visual *size constancy* occurs as objects move closer or farther away. The perceived size of the object is equal to the size of the retinal image multiplied by the perceived distance.

2. As objects change orientation, the shape of their actual retinal images changes, yet *shape constancy* allows you to know that the object's shape is still the same.

3. As the amount of light striking an object changes, *brightness constancy* allows you to perceive the object's brightness as relatively constant. The brightness of an object is perceived in relation to its background.

E. OPTICAL ILLUSIONS

1. Illusions are perceptual mistakes, inaccurate interpretations of sensations.

2. *Optical illusions* are illusions of the visual system.

F. CULTURE, EXPERIENCE, AND PERCEPTION

1. Experience can affect perception and differing experiences can too.

    a. For individuals from cultures in which pictures are seldom seen, it can be very difficult to perceive images in photos or paintings, despite being able to perceive the exact same images in real life.

IX. RECOGNIZING THE PERCEPTUAL WORLD

How do I recognize familiar people?

Your brain analyzes incoming patterns of information and compares that pattern to information stored in memory. If it finds a match, recognition takes place and the stimulus is put into a *perceptual category*.

1. Two general processes occur in recognition.

    a. **Top-down processing** is the use of knowledge, expectations, and other psychological factors.

    b. **Bottom-up processing** relies on specific, detailed information from the sensory receptors, and assembling them into a whole.

A. BOTTOM-UP PROCESSING

1. By a feature-analysis view, sensory *feature detectors* extract *basic features* from a stimulus set, and the brain must try to synthesize a perception by combining these features.

B. TOP-DOWN PROCESSING

2. Top-down processing is the imposition of higher-level cognitive processes (memories, context, expectancy, motivation) onto an incoming stimulus, actively constructing a perception based on more than the raw stimulus per se.

3. Previous experiences help create **schemas**, mental representations of what we know and expect about the world. Schemas guide or bias perception by helping to create a *perceptual set*, a habitual readiness to perceive a stimulus in a certain way.

   Example: It may be easier to recognize your bank teller in the bank than when you are at a grocery store.

4. Motivation also affects perception.

C. TOP-DOWN AND BOTTOM-UP PROCESSING TOGETHER

1. Both top-down and bottom-up processing work together.

   Example: In reading a word, the visual shape of the letters must be sensed (bottom-up processing), yet one can use knowledge, context, and expectancy to figure out the meaning of poorly written or degraded letters (top-down processing).

2. Top-down processing can fill in the gaps between stimuli because the stimulus world is *redundant*—it provides multiple clues about what is going on.

XI. ATTENTION

Can you run out of attention?

Attention is the process of directing and focusing certain psychological resources to enhance perception, performance and mental experience. It helps *direct* sensation and perception, *select* information for analysis, *allocate* computational resources onto that analysis, and *regulate* the mental energy necessary for performing a task or coordinating several tasks at once. Attention has three important characteristics: it improves mental processing, requires effort and has limited resources.

A. THE PROCESS OF ATTENTION

1. *Overt orienting* is shifting attention by physically pointing sensory systems directly onto a to-be-attended-to stimulus, such as when you move your eyes onto something you are viewing.

2. *Covert orienting* is shifting attention without making a physical effort, such as when you think more about some of the images you are seeing without moving your gaze to fall directly upon it.

3. *Parallel processing* is the ability to search rapidly for targets in several locations at once. This early feature analysis is automatic, not requiring volitional effort, and allows quick "pop out" of relevant stimuli.

B. DIVIDING AND FOCUSING ATTENTION

1. Attention is *selective*, focusing on some stimuli more than others.

    a. *Inattentional blindness* occurs when you are so focused on ones aspect of the environment that you fail to perceive changes in other parts of the environment.

2. As covert and overt orienting suggest, attention control can be *voluntary* (goal-directed, purposeful) or *involuntary* (stimulus-driven).

3. *Divided attention* occurs when you simultaneously devote mental resources to more than one thing. In fact, it may sometimes be difficult to focus attention on *only* one thing.

    a. If one task is automatic, it requires less attention, thus making it easier to attend to a second task.

    b. It may be possible to perform two task requiring attention simultaneously, as long as each taps into different kinds of attention.