

# Sensation and Perception

## AP Objective IV: Sensation and Perception (6-8%)

Everything that organisms know about the world is first encountered when stimuli in the environment activate sensory organs, initiating awareness of the external world. Perception involves the interpretation of the sensory inputs as a cognitive process.

**AP Objective:** Discuss basic principles of sensory transduction, including absolute threshold, difference threshold, signal detection, and sensory adaptation.

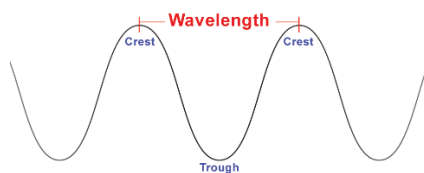
- **Sensation:** the detection of external stimuli via the five senses, and the transmission of this information to the brain.
  - **Bottom-up processing:** sensory receptors register information about the external environment and send it up to the brain for interpretation.
- **Perception** is the process of organizing and interpreting sensory information so that it makes sense.
  - **Top-down processing:** information processing guided by higher-level mental processes; constructs perceptions based on experience and expectations.
- **Transduction:** conversion of one form of energy into another that the brain can use.
  - Sensory receptors in the eyes, ears, nose, tongue, and skin detect sensory information.
  - That sensory information is transformed into neural impulses.
  - The neural impulses are sent to the brain for processing.
- **Psychophysics:** the study of the relationships between physical characteristics of stimuli, such as their intensity, and our psychological experience of them.
- **Absolute Threshold:** the minimum stimulation needed to detect a particular stimulus 50 percent of the time.
  - **Example:** to test your absolute threshold for sound, a hearing specialist would expose each of your ears to varying sound levels. For each tone, the test would define where half the time you could detect the sound and half the time you could not. That 50-50 point would define your absolute threshold.
  - Studied and labeled by German scientist and philosopher **Gustav Fechner** (1801-1887).
- **Signal detection theory:** a theory predicting how and when we detect the presence of a faint stimulus (signal) amid background distractions. Assumes there is no single absolute threshold and that detection depends partly on a person's experience, expectations, motivation, and alertness.
  - Signal detection theorists seek to understand why people respond differently to the same stimuli, and why the same person's reactions vary as circumstances change.
    - Exhausted parents will notice the faintest whimper from a newborn's cradle while failing to notice louder, unimportant sounds.
- **Subliminal:** below one's absolute threshold for conscious awareness.
  - Under certain conditions you can be affected by stimuli so weak that you don't consciously notice them.
    - **Priming:** when the exposure to one stimulus influences the response to another stimulus.

- Priming thirsty people with the subliminal word “thirst” can, for a moment, make a thirst-quenching beverage ad more persuasive, but “subliminal messaging” does not have a powerful, enduring effect on behavior.
- **Difference threshold (just noticeable difference):** the minimum difference a person can detect between any two stimuli 50 percent of the time.
  - The difference threshold increases with the size of the stimulus.
  - **Weber’s law:** states that for an average person to perceive a difference, two stimuli must differ by a constant *proportion*, not a constant *amount*.
    - If you had 1 ounce to a 10-ounce weight, you will detect the difference; add 1 ounce to a 100-ounce weight and you probably will not.
- **Sensory adaptation:** diminished sensitivity as a consequence of constant stimulation.
  - When we are constantly exposed to a stimulus that does not change, we become less aware of it because our nerve cells fire less frequently.
    - The only exception is with vision because, unnoticed by us, our eyes are constantly moving. This continual flitting from one spot to another ensures that stimulation on the eyes’ receptors continually changes.
  - Gives us freedom to focus on informative changes in our environment without being distracted by background noise.
  - Helps explain television’s attention-grabbing power. Cuts, edits, zooms, pans, sudden noises—all demand attention and keep viewers engaged.

**AP Objective:** Describe sensory processes (e.g., hearing, vision, touch, taste, smell, vestibular, kinesthesia, pain), including the specific nature of energy transduction, relevant anatomical structures, and specialized pathways in the brain for each of the senses.

**VISION:** our eyes receive light energy and transduce (transform) it into neural messages that our brain then processes into what we consciously see.

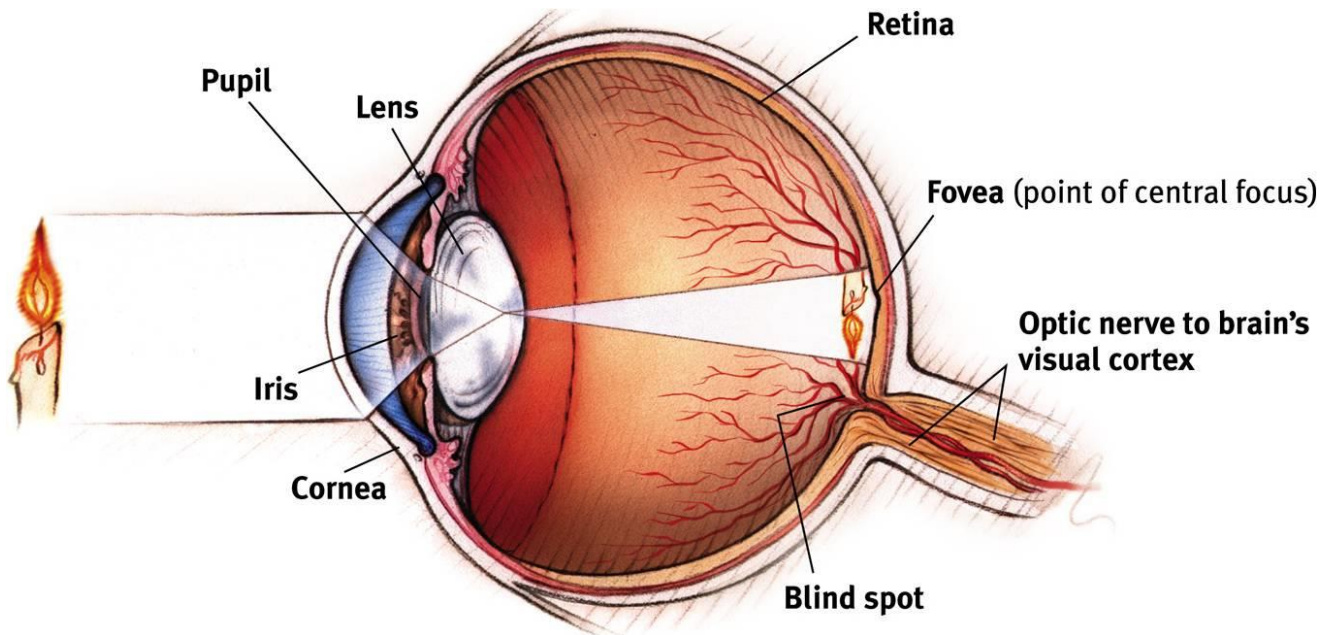
- When you look at a bright red tulip, what strikes your eyes is not particles of the color red but pulses of electromagnetic energy that your visual system perceives as red.
  - **Wavelength:** the distance from one wave peak to the next.
    - Determines **hue** (color).



- **Amplitude:** the wave’s height.
  - Determines brightness/**intensity**.

## VISION PROCESS

1. Light enters the eye through the **cornea**, which protects the eye and bends light to provide focus.
2. The light then passes through the **pupil**, a small adjustable opening.
3. Surrounding the pupil and controlling its size is the **iris**, a colored muscle that dilates or constricts in response to light intensity and even to inner emotions.
  - Each iris is so distinctive that an iris-scanning machine can confirm your identity.
4. The **lens**, behind the pupil, focuses incoming light rays and projects them onto the **retina**, the thin inner surface of the back of the eyeball.
  - **Accommodation:** the process by which the eye's lens changes shape to focus near or far objects on the retina.
5. Receptor cells gather sensory information from the light and activate neighboring cells in the **optic nerve** which then sends the information to the brain for processing.



## RETINAL ANATOMY

- **Bipolar cells:** specialized cells that connect and transmit information from the eye's receptor cells (rods and cones) to the ganglion cells that make up the optic nerve.
- **Ganglion cells:** receives information from bipolar cells and transmits it to the brain for processing.
- **Cones:** receptors in the retina that detect fine detail and color.
  - Clustered in the **fovea**, a small depression in the center of the retina where visual acuity is highest.
  - Each cone transmits information to a single bipolar cell that helps relay the cone's individual message to the visual cortex, which devotes a large area to input from the fovea.
    - These direct connections preserve the cones' precise information, making them better able to detect fine detail.
  - Approximately 6 million per retina
- **Rods:** receptors in the retina that enable black and white vision; they detect black, white, and gray.
  - Located predominantly in the outer regions of the retina.

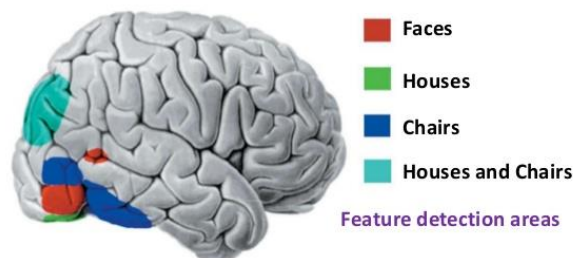
- Necessary for peripheral and twilight vision.
- They remain sensitive in dim light.
- Unlike cones, rods share bipolar cells with other rods, sending combined messages to the cortex.
  - This results in less sensitivity to detail.
- Approximately 120 million per retina
- **Optic nerve:** the nerve that carries neural impulses from the eye to the brain.
  - Made up of the axons of ganglion cells.
  - **Blind spot:** the point at which the optic nerve leaves the eye, creating a “blind” spot because no receptor cells are located there.
    - The brain normally fills in this gap automatically, so you assume the world continues and are not aware that a blind spot exists in the middle of your field of vision.

## VISUAL INFORMATION PROCESSING

- **Optic chiasm:** the point in the brain where the optic nerve fibers from each eye cross over each other.
  - The visual information originating in the right halves of the two retinas is transmitted to the left side of the occipital lobe for processing.
  - The visual information in the left halves of the two retinas is transmitted to the right side of the occipital lobe for processing.
- **Thalamus:** most sensory information first goes to the thalamus where it is then routed to the appropriate area of the cortex for processing.
  - Smell is the exception.
- **Visual cortex:** located in the occipital lobe, it is the part of the cerebral cortex involved in vision.
  - Most information travels to the **primary visual cortex** where it is processed before moving to other visual areas for further analysis.
- **Feature detectors:** neurons in the brain that respond to specific features of the stimulus, such as shape, angle, or movement.
  - Example: the brain’s face-perception occurs separately from its object-perception.
  - Brain activity is so specific that, with the help of brain scans, “we can tell if a person is looking at a shoe, a chair, or a face, based on the pattern of their brain activity.”

### Turning Neural Signals into Images

- In the visual cortex are neurons called **feature detectors:** they respond to certain visual aspects of the environment.
- These cells in turn send information to neural networks (*supercell clusters*) that can perform tasks such as recognizing individual faces.



- **Parallel processing:** the processing of many aspects of a stimulus simultaneously.
  - To analyze a visual scene, the brain divides it into subdimensions—color, motion, form, depth—and works on each aspect simultaneously.
  - We then construct our perceptions by integrating the separate but parallel work of these different visual teams.
  - One theory suggests that visual areas beyond the primary visual cortex form two parallel processing streams or pathways
    - **Ventral stream** (“what” stream): specialized for the perception and recognition of objects, such as determining their colors and shapes.
    - **Dorsal stream** (“where” stream): specialized for spatial perception—determining where an object is and relating it to other objects in a scene.
- **Facial perception:** the brain has specific cortical areas and even neurons that specialize in perceiving faces.
  - The **fusiform gyrus** in the right temporal lobe specializes in perceiving faces and responds most strongly to upright faces.
    - People have a surprisingly hard time recognizing faces, especially unknown faces, that are upside down.
  - To recognize a face, the brain integrates information projected by the retinas to several visual cortex areas, compares it to stored information, and enables you to recognize the face.
    - The whole facial recognition process requires tremendous brain power—30 percent of the cortex (10 times the brain area devoted to hearing).
    - **Prosopagnosia:** the inability to recognize faces, but not objects.

## **COLOR VISION**

Our difference threshold for colors is so low that we can discriminate more than 1 million different color variations. At least, most of us can. For about 1 person in 50, vision is color deficient—and that person is usually male, because the defect is genetically sex linked.

- **Trichromatic theory:** the theory that the retina contains three different color receptors—one most sensitive to red, one to green, and one to blue—which, when stimulated in combination, can produce the perception of any color.
  - **Example:** there are no receptors especially sensitive to yellow. We see yellow when mixing red and green light, which stimulates both red-sensitive and green-sensitive cones.
  - Most people with color-deficient vision are not actually “colorblind.” They simply lack functioning red or green sensitive cones, or sometimes both.
- **Opponent-process theory:** the theory that opposing retinal processes (red-green, yellow-blue, white-black) enable color vision.
  - In the retina and in the thalamus (where impulses from the retina are relayed en route to the visual cortex), some neurons are turned “on” by red but turned “off” by green. Others are turned on by green but off by red.
    - Like red and green marbles sent down a narrow tube, “red” and “green” messages cannot both travel at once. Thus, we do not experience reddish green because red and green are opponents.
    - Red and blue travel in separate channels, so we *can* see a reddish-blue magenta.
  - **Afterimages:** stare at a green square for a while and then look at a white sheet of paper, and you will see red, green’s opponent color.

- By staring at green, we tire our green response. When we then stare at white, only the red part of the green-red pairing will fire normally.

Color processing occurs in two stages. The retina's red, green, and blue cones respond in varying degrees to different color stimuli, as the trichromatic theory suggested. Their signals are then processed by the nervous system's opponent-process cells.

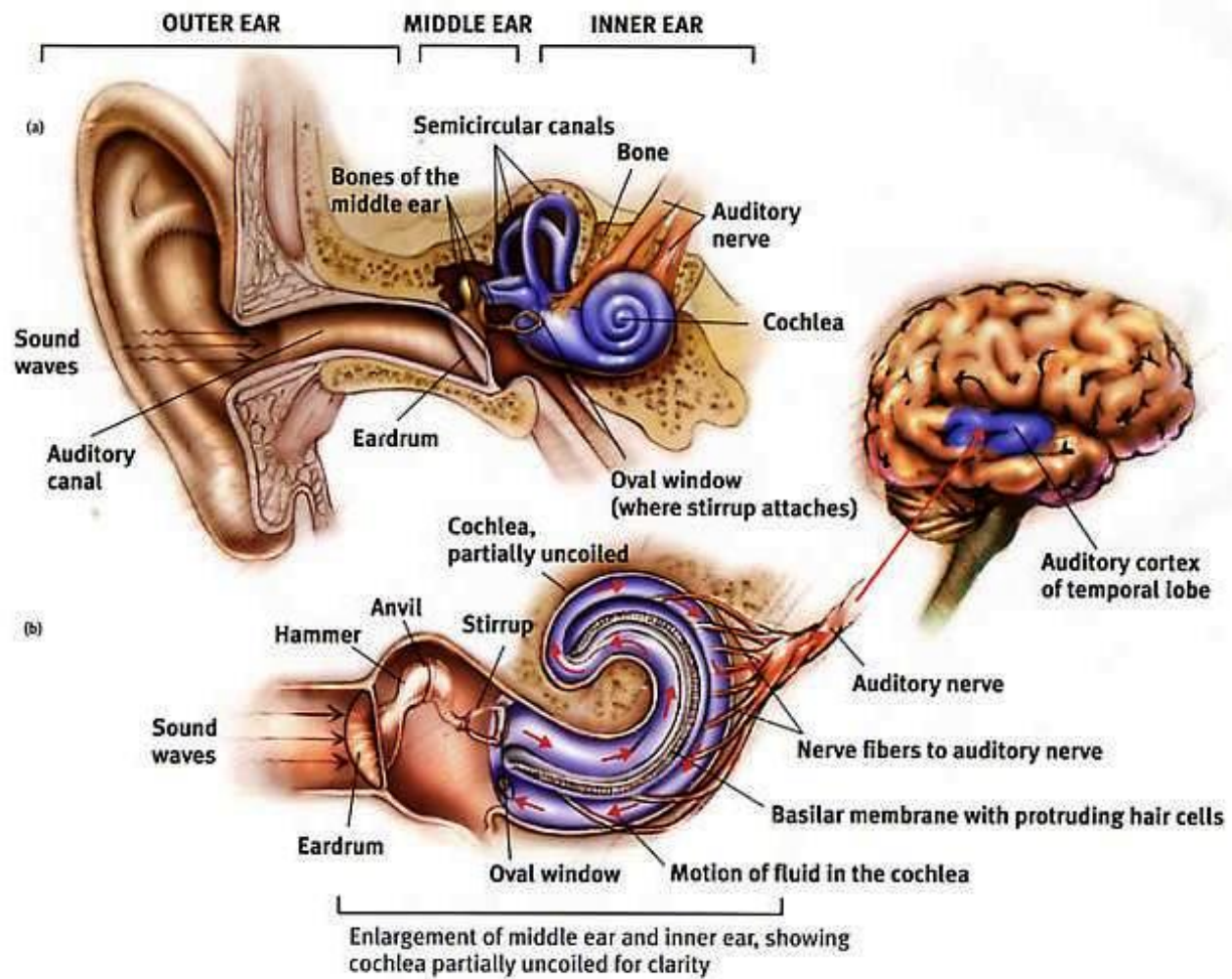
**AUDITION (HEARING)**: hearing is highly adaptive. We hear a wide range of sounds, but the ones we hear best are those sounds with frequencies in a range corresponding to that of the human voice.

- **Amplitude** (height) of sound waves determines their **loudness**.
- **Frequency**: the number of complete wavelengths that pass a point in a given time (for example, per second).
  - Frequency determines a tone's **pitch**, the experienced highness or lowness.

**HEARING PROCESS**: the intricate process that transforms vibrating air into nerve impulses, which our brain decodes as sounds, begins when sound waves enter the outer ear.

1. An intricate mechanical chain reaction begins as the visible outer ear channels the waves through the auditory canal to the **eardrum**, a tight membrane, causing it to vibrate.
2. In the **middle ear**, the chamber between the eardrum and the cochlea, a piston made of three tiny bones, the **hammer**, **anvil**, and **stirrup**, picks up the vibrations and transmits them to the **cochlea**, a snail-shaped tube in the **inner ear**.
3. The incoming vibrations cause the cochlea's membrane to vibrate, jostling the fluid that fills the tube. This motion causes ripples in the cochlea's basilar membrane, bending the **hair cells** lining its surface, not unlike the wind bending a wheat field.
4. Hair cell movement triggers impulses in the adjacent nerve cells. Axons of those cells converge to form the **auditory nerve** which sends neural messages (via the thalamus) to the **auditory cortex** in the brain's temporal lobe.





**PERCEIVING LOUDNESS:** we do not detect loudness from the intensity of a hair cell's response. Rather, a soft, pure tone activates only the few hair cells attuned to its frequency. Given louder sounds, neighboring hair cells also respond. Thus, the brain can interpret loudness from the number of activated hair cells.

- If a hair loses sensitivity to soft sounds, it may still respond to loud sounds.

## **PERCEIVING PITCH**

- **Place theory:** presumes that we hear different pitches because different sound waves trigger activity at different places along the cochlea's basilar membrane.
  - The brain determines a sound's pitch by recognizing the specific place on the membrane that is generating the neural signal.
  - A problem remains: place theory can explain how we hear high-pitched sounds, but not low-pitched sounds.
    - The neural signals generated by low-pitched sounds are not so neatly localized on the basilar membrane.
- **Frequency theory:** suggests that the brain reads pitch by monitoring the frequency of neural impulses traveling up the auditory nerve.

- The whole basilar membrane vibrates with the incoming sound wave, triggering neural impulses to the brain at the same rate as the sound wave.
  - If the sound wave has a frequency of 100 waves per second, then 100 pulses per second travel up the auditory nerve.
- A problem remains: an individual neuron cannot fire faster than 1000 times per second. How, then, can we sense sounds with frequencies above 1000 waves per second?
- **Volley principle:** like soldiers who alternate firing so that some can shoot while others reload, neural cells can alternate firing. By firing in rapid succession, they can achieve a combined frequency above 1000 waves per second.
- **Place theory best explains how we sense high pitches, frequency theory best explains how we sense low pitches, and some combination of the two seems to handle the pitches in the intermediate range.**

**LOCATING SOUNDS:** as the placement of our eyes allows us to sense visual depth, so the placement of our two ears allows us to enjoy stereophonic (multidirectional) hearing.

- Two ears are better than one for at least two reasons.
  - If a car to the right honks, your right ear receives a more intense sound, and it receives sound slightly sooner than your left ear.
    - Our supersensitive auditory system can detect such minute differences.

**TOUCH:** our sense of touch is actually a mix of distinct skin sense for **pressure, warmth, cold, and pain**. Touching various spots on the skin with a soft hair, a warm or cool wire, and the point of a pin reveals that some spots are especially sensitive to pressure, others to warmth, others to cold, and still others to pain. Other skin sensations are variations of the basic four.

- Stroking adjacent pressure spots creates a **tickle**.
- Repeated gentle stroking of a pain spot creates an itching sensation.
- Touching adjacent cold and pressure spots triggers a sense of **wetness**, which you can experience by touching dry, cold metal.
- Stimulating nearby cold and warm spots produces the sensation of hot.

A self-produced tickle produces less somatosensory cortex activation than does the same tickle from something or someone else. The brain is wise enough to be most sensitive to unexpected stimulation.

**PAIN:** your body's way of telling you something has gone wrong. Pain orders you to change your behavior. Without the discomfort that makes us occasionally shift position, joints fail from excess strain, and without the warnings of pain, the effects of unchecked infections and injuries accumulate.

- Individual pain sensitivity varies depending on genes, physiology, experience, attention, and surrounding culture.
  - Feeling pain reflects both bottom-up sensations and top-down processes.



- **Nociceptors:** sensory receptors than detect hurtful temperatures, pressure, or chemicals.
  - They send an impulse to the spinal cord, which passes the message to the brain, which interprets the signal as pain.
- **Gate-control theory:** the theory that the spinal cord contains a neurological “gate” that blocks pain signals or allows them to pass on to the brain.
  - The “gate” is opened by the activity of pain signals traveling up small nerve fibers and is closed by activity in larger fibers or by information coming from the brain.
    - When tissue is injured, the small fibers activate and open the gate, and you feel pain.
    - Large-fiber activity closes the gate, blocking pain signals and preventing them from reaching the brain.
      - One way to treat chronic pain is to stimulate (by massage, electrical stimulation, or acupuncture) “gate-closing” activity in the large neural fibers.
  - Brain to spinal cord messages can also close the gate.
    - When we are distracted from pain and soothed by the release of our naturally painkilling endorphins, our experience of pain diminishes.

## **TASTE:**

- Like our sense of touch, taste involves several basic sensations.
  - Sweet
  - Salty
  - Sour
  - Bitter
  - Umami (savory meaty taste)
- Taste exists for more than our pleasure.
  - Appealing tastes attracted our ancestors to energy or protein rich foods that enabled their survival.
  - Aversive tastes deterred them from new foods that might be toxic.
- Taste is a chemical sense. Inside each little bump on the top and sides of your tongue are 200 or more **taste buds**, each containing a pore that catches food chemicals.
  - Into each taste bud pore, 50 to 100 taste receptor cells project antennalike hairs that sense food molecules.
    - Some receptors respond mostly to sweet-tasting molecules, other to salty, sour, umami, or bitter tasting ones.
    - Taste receptors reproduce themselves every week or two, so if you burn your tongue with hot food it hardly matters.
    - As you grow older, the number of taste buds decreases, as does taste sensitivity.
      - Smoking and alcohol use accelerate these declines.
  - Neural impulses are sent to the temporal lobe for processing.
- Expectations can influence taste.

## **OLFACTION (SMELL):** you inhale something of whatever it is you smell.

- We smell something when molecules of a substance carried in the air reach a tiny cluster of 5 million or more receptor cells at the top of each nasal cavity.
  - These olfactory receptor cells, waving like sea anemones on a reef, respond selectively to different smells as instantly alert the brain through their axon fibers.
  - Odor molecules come in many shapes and sizes—so many, in fact, that it takes many different receptors to detect them.
    - There are 350 or so receptor proteins that recognize particular odor molecules.
      - As a key slips into a lock, so odor molecules slip into these receptors.
      - We don't seem to have a distinct receptor for each detectable odor.
        - Some odors trigger a combination of receptors, in patterns that are interpreted by the olfactory cortex.
          - This produces the 10,000 odors we can detect.
  - Though it's difficult to recall odors by name, we have a remarkable capacity to recognize long-forgotten odors and their associated memories.
    - A hotline runs between the brain area receiving information from the nose and the brain's ancient limbic centers associated with memory and emotion.

## **BODY POSITION AND MOVEMENT:**

- **Kinesthesia:** the system for sensing the position and movement of individual body parts.
  - Enabled by important sensors in the joints, tendons, bones, and ears, and skin.
- **Vestibular sense:** monitors the head's (and thus the body's) position and movement.
  - The biological gyroscopes for this sense of equilibrium are in the inner ear.
    - The **semicircular canals**, which look like a three-dimensional pretzel, and **vestibular sacs**, which connect the canals with the cochlea, contain fluid that moves when your head rotates or tilts.
      - This movement stimulates hair-like receptors, which send messages to the cerebellum at the back of the brain, thus enabling you to sense your body position and to maintain your balance.
      - If you twirl around and then come to an abrupt halt, neither the fluid in your semicircular canals nor your kinesthetic receptors will immediately return to their neutral state. The dizzy aftereffect fools your brain with the sensation that you're still spinning.

## **SENSORY INTERACTION**

- **Sensory interaction:** the principle that one sense may influence another, as when the smell of food influences its taste.
  - To savor a taste, we normally breathe the aroma through our nose.
  - Smell plus texture plus taste equals flavor.
  - Our senses—tasting, smelling, hearing, seeing, touching—are not totally separate information channels. In interpreting the world, our brain blends their inputs.

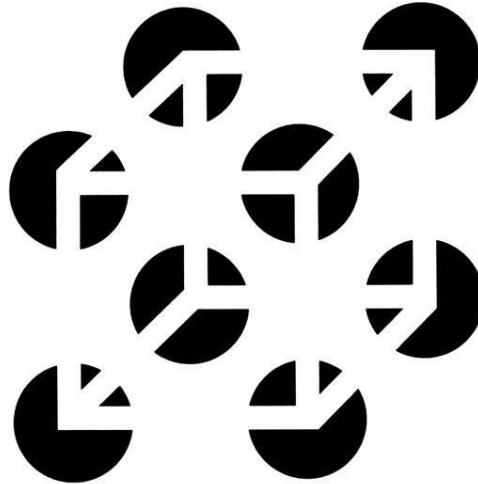
- **McGurk effect:** a perceptual phenomenon that demonstrates an interaction between hearing and vision in speech perception. The illusion occurs when the auditory component of one sound is paired with the visual component of another sound, leading to the perception of a third sound.
  - Seeing the mouth movements for *ga* while hearing *ba*, we may perceive *da*.
- **Embodied cognition:** the influence of bodily sensations, gestures, and other states on cognitive preferences and judgments.
  - After holding a warm drink rather than a cold one, people are more likely to rate someone more warmly, feel closer to them, and behave more generously.

**AP Objective:** Explain common sensory disorders (e.g., visual and hearing impairments).

- **Phantom limb sensations:** the experience of sensation or pain in nonexistent limbs (most commonly as a result of amputation).
  - Occurs when the brain misinterprets the spontaneous central nervous system activity that occurs in the absence of normal sensory input.
- **Tinnitus:** a chronic ringing in the ears.
  - The most common cause of tinnitus is damage and loss of the tiny sensory hair cells in the cochlea of the inner ear.
  - This tends to happen as people age, and it can also result from prolonged exposure to excessively loud noise.
- **Sensorineural hearing loss** (nerve deafness): hearing loss caused by damage to the cochlea's receptor cells or to the auditory nerves.
  - **Cochlear implant:** a device for converting sounds into electrical signals and stimulating the auditory nerve through electrodes threaded into the cochlea.
    - Can help restore hearing for people with sensorineural hearing loss.
- **Conduction hearing loss:** caused by damage to the mechanical system that conducts sound waves through the outer and middle ear to the cochlea.
- **Glaucoma:** a disease that damages the optic nerve.
  - It usually happens when fluid builds up in the front part of your eye. That extra fluid increases the pressure in your eye, damaging the optic nerve.
- **Synaesthesia:** where one sort of sensation (such as hearing sound) produces another (such as seeing color).
  - Hearing music or seeing a specific number may activate color-sensitive cortex regions and trigger a sensation of color.
  - Seeing the number 3 more evoke a taste sensation.
  - An odor can evoke a sensation of taste.

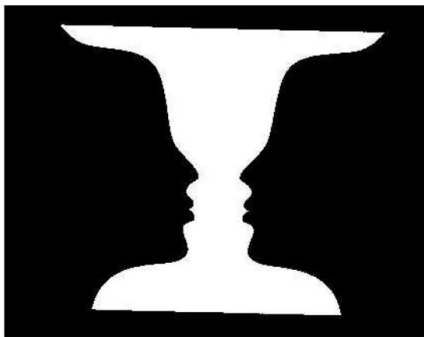
**AP Objective:** Describe general principles of organizing and integrating sensation to promote stable awareness of the external world (e.g., Gestalt principles, depth perception).

- **Gestalt**: an organized whole. Gestalt psychologists emphasized our tendency to integrate pieces of information into meaningful wholes.
  - The individual elements of the Necker cube in the image below are really nothing but eight circles, each containing three converging white lines. When we view these elements all together, however, we see a cube that sometimes reverses direction.

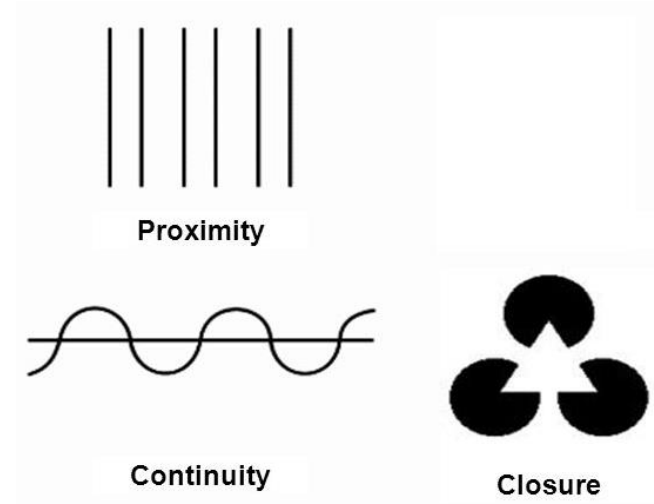


## **FORM PERCEPTION**

- **Figure-ground**: the organization of the visual field into objects (the *figures*) that stand out from their surroundings (the *ground*).
  - Our first task is to perceive any object as distinct from its surroundings.
    - Among the voices you hear at a party, the one you attend to becomes the figure; all others are part of the ground.



- **Grouping**: the perceptual tendency to organize stimuli into coherent groups.
  - Having discriminated figure from ground, we must also organize the figure into a meaningful form.
  - Our minds bring order and form to stimuli by following certain rules for grouping.
    - **Proximity**: we group nearby figures together. In the example below, we see not six separate lines, but three sets of two lines.
    - **Continuity**: we perceive smooth, continuous patterns rather than discontinuous ones. In the example below, the pattern could be a series of alternating semicircles, but we perceive it as two continuous lines—one wavy, one straight.
    - **Closure**: we fill in gaps to create a complete, whole object.



**DEPTH PERCEPTION:** enables us to estimate an object's distance from us. At a glance, we can estimate the distance of an oncoming car or the height of a house.

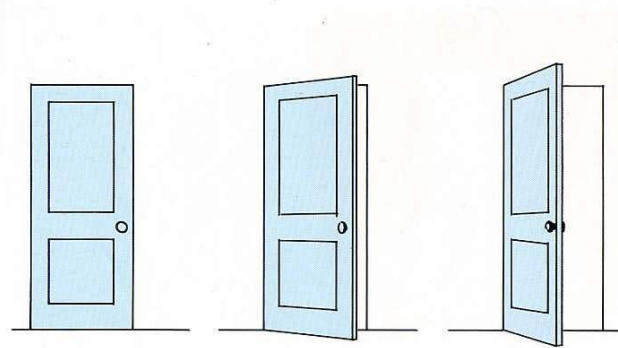
- **Visual cliff:** a laboratory device for testing depth perception in infants and young animals.
  - Helped researchers discover that depth perception is partly innate (inborn).
  - When researcher placed 6-14 month old infants on the edge of a safe canyon and had the infants' mothers coax them to crawl out onto the glass, most infants refused to do so, indicating that they could perceive depth.
- **Binocular cues:** depth cues that depend on the use of both eyes.
  - Because your eyes are about 2½ inches apart, your retinas receive slightly different images of the world. By comparing these two images, your brain can judge how close an object is to you.
    - **Retinal disparity:** a binocular cue for perceiving depth: by comparing images from the retinas in the two eyes, the brain computes distance—the greater the disparity (difference) between the two images, the closer the object.
- **Monocular cues:** depth cues available to either eye alone.
  - **Relative height:** we perceive objects higher in our field of vision as further away.
  - **Relative motion:** as we move, objects that are actually stable may appear to move (like when driving).
  - **Relative size:** if we assume two objects are similar in size, most people perceive the one that casts the smaller retinal image as further away.
  - **Linear perspective:** parallel lines appear to meet in the distance. The sharper the angle of convergence, the greater the perceived distance.
  - **Interposition:** if one object partially blocks our view of another, we perceive it as closer.
  - **Texture gradient:** as a uniformly textured surface recedes, its texture continuously becomes less sharp.

**MOTION PERCEPTION:** normally your brain computes motion based partly on its assumption that shrinking objects are retreating (not getting smaller) and enlarging objects are approaching (not getting bigger).

- Large objects, such as trains, appear to move more slowly than smaller objects, such as cars moving at the same speed.

**PERCEPTUAL CONSTANCY:** the ability to recognize objects without being deceived by changes in their color, brightness, shape, or size.

- **Color constancy:** perceiving familiar objects as having consistent color, even if changing illumination alters the wavelengths reflected by the object.
  - We see color thanks to our brain's computations of the light reflected by an object *relative to the objects surrounding it*.
    - If you viewed an isolated tomato through a paper tube, its color would seem to change as the light—and thus the wavelengths reflected from its surface—changed. But if you viewed that tomato as one item in a bowl of fresh vegetables, its color would remain roughly constant as the lighting shifts.
- **Shape constancy:** we perceive the form of familiar objects as constant even while our retinas receiving changing images of them.
  - In the image below, the door casts an increasingly trapezoidal image on our retinas as it opens, yet we still perceive it as rectangular.



- **Size constancy:** we perceive objects as having a constant size, even while our distance from them varies.
  - We assume a car is large enough to carry people, even when we see its tiny image from two blocks away.
  - Perceiving an object's distance gives us cues to its size. Likewise, knowing its general size—that the object is a car—provides us with cues to its distance.

**AP Objective:** Discuss how experience and culture can influence perceptual processes (e.g., perceptual set, context effects).

- **Perceptual set:** a mental predisposition to perceive one thing and not another.
  - Through experience, we come to expect certain results. Those expectations may give us a “set” of mental tendencies and assumptions that greatly affects (top-down) what we perceive.
  - **Example:** Consider the kindly airline pilot who, on a takeoff run, looked over at his depressed co-pilot and said, “Cheer up.” Expecting to hear the usual “Gear up,” the co-pilot promptly raised the wheels—before they left the ground.
  - **Consider the image below:** Show a friend either the left or right image. Then show the center image and ask, “What do you see?” Whether your friend reports seeing a saxophonist or a woman's face may depend on which of the other two drawings was viewed first. In each of those images, the meaning is clear, and it will establish perceptual expectations.



From Shepard, 1990.

- **Context effects:** a given stimulus may trigger radically different perceptions, partly because of our differing set, but also because of the immediate context.
  - Imagine hearing a noise interrupted by the words “eel is on the wagon.” Likely, you would actually perceive the first word as *wheel*. Given “eel is on the orange,” you would likely hear *peel*.
  - This phenomenon suggests that the brain can work backward in time to allow a later stimulus to determine how we perceive an earlier one.

**AP Objective:** Explain the role of top-down processing in producing vulnerability to illusion.

Perceptual illusions (such as size and shape constancy) reinforce a fundamental lesson: perception is not merely a projection of the world onto our brain. Rather, our sensations are disassembled into information bits that our brain then reassembles into its own functional model of the external world. During this reassembly process, our assumptions—such as the usual relationship between distance and size—can lead us astray. Our brain constructs our perceptions.

**AP Objective:** Discuss the role of attention in behavior.

- **Selective attention:** the focusing of conscious awareness on a particular stimulus.
  - By one estimate, your five senses take in 11,000,000 bits of information per second, of which you consciously process about 40.
  - **Cocktail party effect:** your ability to attend to only one voice among many. Let another voice speak your name and your cognitive radar will instantly bring that voice into consciousness.
    - In 2009, two Northwest Airlines pilots, engrossed in conversation, ignored alarmed air traffic controllers’ attempts to reach them as they overflew their Minneapolis destination by 150 miles. If only the controllers had known and spoken the pilots’ names.
  - Talk on the phone or text while driving and your selective attention will shift back and forth between the road and its electronic competition.
    - Multitasking comes at a cost—about 28% of traffic accidents occur when people are texting and driving.
- **Inattention blindness:** failing to see visible objects when our attention is directed elsewhere.
  - At the level of conscious awareness, we are “blind” to all but a tiny sliver of visual stimuli.



- People watching a video in which they are asked to count the number of times a basketball is tossed back and forth are likely to miss the image of a man in a gorilla suit walking across the screen.
- **Change blindness**: failing to notice changes in the environment.
  - Magicians exploit this by distracting the audience. By selectively riveting our attention on their left hand's dramatic act, we fail to notice changes made with their other hand.

**AP Objective:** Challenge common beliefs in parapsychological phenomena.

- **Extrasensory perception (ESP)**: the controversial claim that perception can occur apart from sensory input.
  - **Telepathy**: mind-to-mind communication.
  - **Clairvoyance**: perceiving events beyond normal sensory contact, such as a house on fire in another state.
  - **Precognition**: perceiving future events, such as an unexpected death in the next month.
  - **Psychokinesis**: “mind over matter,” such as levitating a table or influencing the roll of a die.
- **Parapsychology**: the study of paranormal phenomena, including ESP and psychokinesis.
  - Will achieve scientific acceptability only when it provides a positive theory with independently replicable evidence. This has not occurred to date.
- Psychic predictions have almost never come true, and psychics have virtually never anticipated any of the year's headline events.
- The hundreds of psychic visions offered to police departments have been no more accurate than guesses made by others.
- The sheer volume of psychic predictions does increase the odds of an occasional correct guess, which psychics can then report to the media.
- Vague predictions can later be interpreted to match events that have occurred.

**AP Objective:** Identify major historical figures in sensation and perception (e.g., Gustav Fechner, David Hubel, Ernst Weber, Torsten Wiesel).

- **Gustav Fechner**: studied our awareness of faint stimuli and called them our absolute thresholds.
- **David Hubel** and **Torsten Wiesel**: received a Nobel Prize for their work on feature detectors.
- **Ernst Weber**: discovered/proposed Weber's law.