**Thresholds**

Sensory sensitivity can be measured by the **absolute threshold**, the weakest level of a **stimulus** that can be correctly detected at least half the time. Measured in studies by Galanter about 50 years ago, our absolute threshold for sight/vision is a candle flame seen at 30 miles on a dark, clear night; for hearing/audition, the tick of a watch under quiet conditions at 20 feet; for taste/gustation, 1 teaspoon of sugar in 2 gallons of water; for smell/olfaction, 1 drop of perfume diffused in a three-room apartment; for touch, the wing of a bee falling on your cheek from a distance of 1 centimeter. Have you noticed that dental or medical procedures feel more painful when you feel tired? It's not your imagination! According to **signal detection theory**, there is no actual absolute threshold because the threshold changes with a variety of factors, including fatigue, attention, expectations, motivation, and emotional distress. It also varies from one person to another. In a signal-detection experiment, a person needs to decide whether a signal is present or not. If the signal is present and the person thinks it is present, it is a hit. If the signal is present and the person thinks it is absent, it is a miss. If the signal is absent and the person thinks it is present, it is a false alarm. If the signal is absent and the person thinks it is absent, it is a correct rejection. Clearly, you want an air controller in front of a radar screen with the ability to score both hits and correct rejections.

**Subliminal stimulation** is the receipt of messages that are below one's absolute threshold for conscious awareness. Subliminal messages can have a momentary, subtle effect on thinking. Such stimuli can evoke a feeling, though not a conscious awareness of the stimulus. When you are just barely aware of a change in stimulus, such as an increase in volume of a CD or brightness on your computer screen, the **difference threshold**—the minimum difference between any two stimuli that a person can detect 50% of the time—has been reached. In order to survive, organisms must have difference thresholds low enough to detect minute changes in important stimuli. You experience the difference threshold as what Ernst Weber called the **just noticeable difference (jnd)**. If you add one BB to a container with 10 BBs in it, you're more likely to notice a difference than if you add one BB
to a container holding 100 BBs. According to Weber's law, which was quantified by Gustav Fechner, difference thresholds increase in proportion to the size of the stimulus. When stimulation is unchanging, you become less sensitive to the stimulus. This sensory adaptation permits you to focus your attention on informative changes in your environment without being distracted by irrelevant data such as odors or background noises.

Transmission of Sensory Information

Sensory information of stimuli comes from millions of sensory receptors in your eyes, ears, nose, tongue, skin, muscles, joints, and tendons. Different receptors detect different types of physical energy, such as light waves, mechanical energy, chemical energy, and heat energy. Receptors transduce energy from one form into another. In sensation, transduction refers to the transformation of stimulus energy to the electrochemical energy of neural impulses. Except for impulses for olfaction/smell transmitted directly to the olfactory bulbs on the underside of the cortex, impulses from sense organs are transmitted to the thalamus before the cortex. The cerebral cortex puts all the sensory information together and acts on it. Different areas of the cortex translate neural impulses into different psychological experiences, such as odor or touch. Visual information is first processed in the occipital lobes in the back of the cortex, hearing in the temporal lobes, body senses in the parietal lobes, taste at the junction of temporal and parietal lobes, and smell in the lower portion of the frontal lobes. These primary sensory centers then project the results of their activity to other areas in the cortex, the association areas, where more abstract information processing takes place and where you connect new information with old information stored in your memory. Perception is the process of selecting, organizing, and interpreting sensations, enabling you to recognize meaningful objects and events.

Vision

While psychologists study all sensory processes, a major focus is visual perception because most of us depend so much on sight. Initial visual sensation and perception take place in three areas: in the cones and rods of the retina located at the back inner surface of your eye; in the pathways through your brain; and in your occipital lobes, also called the visual cortex.
The image formed on your retina is upside down and incomplete. Your brain fills in information and straightens out the upside down image almost immediately.

**Visual Pathway**

Millions of rods and cones are the photoreceptors that convert light energy to electrochemical neural impulses. Your eyeball is protected by an outer membrane composed of the sclera, tough, white, connective tissue that contains the opaque white of the eye, and the cornea, the transparent tissue in the front of your eye.

Rays of light entering your eye are bent first by the curved transparent cornea, pass through the liquid aqueous humor and the hole through your muscular iris called the pupil, are further bent by the lens, and pass through your transparent vitreous humor before focusing on the rods and cones in the back of your eye (see Figure 8.1).

You are said to be near-sighted if too much curvature of the cornea and/or lens focuses an image in front of the retina so nearby objects are seen more clearly than distant objects. You are said to be far-sighted if too little curvature of the cornea and/or lens focuses the image behind the retina so distant objects are seen more clearly than nearby ones. Astigmatism is caused by an irregularity in the shape of the cornea and/or the lens. This distorts and blurs the image at the retina.
The more abundant rods have a lower threshold than cones and are sensitive to light and dark, as well as movement. Three different kinds of cones are each most sensitive to a different range of wavelengths of light, which provides the basis for color vision. When it suddenly becomes dark, your gradual increase in sensitivity to the low level of light, called dark adaptation, results from a shift from predominantly cone vision to predominantly rod vision. Rods and cones both synapse with a second layer of neurons in front of them in your retina, called bipolar cells. More rods synapse with one bipolar cell than do cones. Small amounts of stimulation from each rod to a bipolar cell can enable it to fire in low light. In bright light, just one cone can stimulate a bipolar cell sufficiently to fire, providing greater visual acuity or resolution. Bipolar cells transmit impulses to another layer of neurons in front of them in your retina, the ganglion cells. Axons of these cells converge to form the optic nerve of each eye. Where the optic nerve exits the retina, there aren't any rods or cones, so the part of an image that falls on your retina in that area is missing—the blind spot. At the optic chiasm on the underside of your brain, half the axons of the optic nerve from each eye criss-cross, sending impulses from the left half of each retina to the left side of your brain and from the right half of each retina to the right side of your brain. The thalamus then routes information to the primary visual cortex of your brain, where specific neurons called feature detectors respond only to specific features of visual stimuli, for
example a line in a particular orientation. Many different feature detectors can process the different elements of visual information, such as color, contours, orientation, etc., simultaneously. Simultaneous processing of stimulus elements is called parallel processing. David Hubel and Torsten Weisel (1979) won a Nobel prize for the discovery that most cells of the visual cortex respond only to particular features, such as the edge of a surface. More complex features trigger other detector cells, which respond only to complex patterns.

**Color Vision**

The colors of objects you see depend on the wavelengths of light reflected from those objects to your eyes. Light is the visible portion of the electromagnetic spectrum. Do you remember ROYGBIV? The letters stand for the colors red, orange, yellow, green, blue, indigo, and violet, which combine to produce white light. The colors vary in wavelength from the longest (red) to the shortest (violet). A wavelength is the distance from the top of one wave to the top of the next wave. The sun and most electric light bulbs essentially give off white light. When light hits an object, different wavelengths of light can be reflected, transmitted, or absorbed. Generally, the more lightwaves your eyes receive (the higher the amplitude of the wave), the brighter an object appears. The wavelengths of light that reach your eye from the object determine the color, or hue, the object appears to be. If an object absorbs all of the wavelengths, then none reach your eyes and the object appears black. If the object reflects all of the wavelengths, then all reach your eyes and the object appears white. If it absorbs some of the wavelengths and reflects others, the color you see results from the color(s) of the waves reflected. For example, a rose appears red when it absorbs orange, yellow, green, blue, indigo, and violet wavelengths and reflects the longer red wavelengths to your eyes.

What enables you to perceive color? In the 1800s, Thomas Young and Hermann von Helmholtz accounted for color vision with the **trichromatic theory** that three different types of photoreceptors are each most sensitive to a different range of wavelengths. People with three different types of cones are called trichromats; with two different types, dichromats; and with only one, monochromats. Cones are maximally sensitive to red, green,
or blue. Each color you see results from a specific ratio of activation among the three types of receptors. For example, yellow results from stimulation of red and green cones. People who are colorblind lack a chemical usually produced by one or more types of cones. The most common type of color blindness is red–green color blindness resulting from a defective gene on the X-chromosome, for a green cone chemical, or, less often, for a red cone chemical. Because it is a sex-linked recessive trait, males more frequently have this inability to distinguish colors in the red–orange–green range. Blue–yellow color blindness and total color blindness are rarer. Although trichromatic theory successfully accounts for how you can see any color in the spectrum, it cannot explain how mixing complementary colors produces the sensation of white, or why after staring at a red image, if you look at a white surface, you see green (a negative afterimage). According to Ewald Hering's opponent-process theory, certain neurons can be either excited or inhibited, depending on the wavelength of light, and complementary wavelengths have opposite effects. For example, the ability to see reds and greens is mediated by red–green opponent cells, which are excited by wavelengths in the red area of the spectrum and inhibited by wavelengths in the green area of the spectrum, or vice versa. The ability to see blues and yellows is similar. Black–white opponent cells determine overall brightness. This explains why mixing complementary colors red and green or blue and yellow produces the perception of white, and the appearance of negative afterimages. Colors in afterimages are the complements of those in the original images. Recent physiological research essentially confirms both the trichromatic and opponent-process theories. Three different types of cones produce different photochemicals, then cones stimulate ganglion cells in a pattern that translates the trichromatic code into an opponent-process code further processed in the thalamus.

**Hearing (Audition)**

In the dark, without visual stimuli that capture your attention, you can appreciate your sense of hearing, or **audition**. Evolutionarily, being able to hear approaching predators or prey in the dark, or behind one’s back, helped increase chances of survival. Hearing is the primary sensory modality for human language. How do you hear? Sound waves result from the mechanical vibration of molecules from a sound source such as your vocal cords or the strings of a musical instrument. The vibrations move in a
medium, such as air, outward from the source, first compressing molecules, then letting them move apart. This compression and expansion is called one cycle of a sound wave. The greater the compression, the larger the \textbf{amplitude} or height of the sound wave and the louder the sound. The amplitude is measured in logarithmic units of pressure called decibels (dB). Established by Fechner, every increase of 10 dB corresponds to a 10-fold increase in volume. The absolute threshold for hearing is 0 dB. Normal conversations measure about 60 dB. Differences in the \textbf{frequency} of the cycles, the number of complete wavelengths that pass a point in a second (hertz or Hz), determine the highness or lowness of the sound called the pitch. The shorter the wavelength, the higher the frequency and the higher the pitch. The longer the wavelength, the lower the frequency and the lower the pitch. People are sensitive to frequencies between about 20 and 20,000 Hz. You are best able to hear sounds with frequencies within the range that corresponds to the human voice. You can tell the difference between the notes of the same pitch and loudness played on a flute and on a violin because of a difference in the purity of the wave form or mixture of the sound waves, a difference in \textbf{timbre}.

\textbf{Parts of the Ear}

Your ear is well adapted for converting sound waves of vocalizations to the neural impulses you perceive as language (see Figure 8.2). Your outer ear consists of the pinna, which is the visible portion of the ear; the auditory canal, which is the opening into the head; and the eardrum or tympanum. Your outer ear channels sound waves to the eardrum that vibrates with the sound waves. This causes the three tiny bones called the ossicles (the hammer, anvil, and stirrup) of your middle ear to vibrate. The vibrating stirrup pushes against the oval window of the cochlea in the inner ear. Inside the cochlea is a basilar membrane with hair cells that are bent by the vibrations and transduce this mechanical energy to the electrochemical energy of neural impulses. Hair cells synapse with auditory neurons whose axons form the auditory nerve. The auditory nerve transmits sound messages through your medulla, pons, and thalamus to the auditory cortex of the temporal lobes. Crossing of most auditory nerve fibers occurs in the medulla and pons so that your auditory cortex receives input from both ears, but contralateral input dominates.
Locating Sounds

How do you know where a sound is coming from? With ears on both sides of your head, you can locate a sound source. The process by which you determine the location of a sound is called **sound localization**. If your friend calls to you from your left side, your left ear hears a louder sound than your right ear. Using parallel processing, your brain processes both intensity differences and timing differences to determine where your friend is. The location of a sound source directly in front, behind, above, or below you is harder for you to pinpoint by hearing alone because both of your ears hear the sound simultaneously at the same intensity. You need to move your head to cause a slight offset in the sound message to your brain from each ear.

Determining Pitch

Do you know someone with perfect pitch? Many musicians can hear a melody, then play or sing it. Several theories attempt to explain how you
can discriminate small differences in sound frequency or pitch. According to Georg von Bekesy's place theory, the position on the basilar membrane at which waves reach their peak depends on the frequency of a tone. High frequencies produce waves that peak near the close end and are interpreted as high-pitched sound, while low frequency waves travel farther, peaking at the far end, and are interpreted as low-pitched sound. Place theory accounts well for high-pitched sounds. According to frequency theory, the rate of the neural impulses traveling up the auditory nerve matches the frequency of a tone, enabling you to sense its pitch. Individual neurons can only fire at a maximum of 1,000 times per second. A volley mechanism in which neural cells can alternate firing can achieve a combined frequency of about 4,000 times per second. The brain can read pitch from the frequency of the neural impulses. Frequency theory together with the volley principle explains well how you hear low-pitched sounds of up to 4,000 Hz, but this theory doesn't account for high-pitched sounds. It appears hearing intermediate-range pitches involves some combination of the place and frequency theories.

Hearing Loss

Why do hearing aids only help some deaf people? Conduction deafness and sensorineural or neural deafness have different physiological bases. Conduction deafness is a loss of hearing that results when the eardrum is punctured or any of the ossicles lose their ability to vibrate. People with conduction deafness can hear vibrations when they reach the cochlea by ways other than through the middle ear. A conventional hearing aid may restore hearing by amplifying the vibrations conducted by other facial bones to the cochlea. Nerve (sensorineural) deafness results from damage to the cochlea, hair cells, or auditory neurons. This damage may result from disease, biological changes of aging, or continued exposure to loud noise. For people with deafness caused by hair cell damage, cochlea implants can translate sounds into electrical signals, which are wired into the cochlea's nerves, conveying some information to the brain about incoming sounds.

Touch (Somatosensation)

Just as hearing is sensitivity to pressure on receptors in the cochlea, touch is sensitivity to pressure on the skin. Psychologists often use
**Somatosensation** as a general term for four classes of tactile sensations: touch/pressure, warmth, cold, and pain. Other tactile sensations result from simultaneous stimulation of more than one type of receptor. For example, burning results from stimulation of warmth, cold, and pain receptors. Itching results from repeated gentle stimulation of pain receptors, a tickle results from repeated stimulation of touch receptors, and the sensation of wetness results from simultaneous stimulation of adjacent cold and pressure receptors. Transduction of mechanical energy of pressure/touch and heat energy of warmth and cold occurs at sensory receptors distributed all over the body just below the skin's surface. Neural fibers generally carry the sensory information to your spinal cord. Information about touch usually travels quickly from your spinal cord to your medulla, where nerves criss-cross, to the thalamus, arriving at the opposite sides of your somatosensory cortex in your parietal lobes. Weber used a two-point discrimination test to determine that regions such as your lips and fingertips have a greater concentration of sensory receptors than your back. The amount of cortex devoted to each area of the body is related to the sensitivity of that area. Touch is necessary for normal development and promotes a sense of well-being.

Pathways for temperature and pain are slower and less defined. You probably have a harder time localizing where you sense warmth and pain on your skin than where you sense touch or pressure. Pain is often associated with secretion of substance P, and relief from pain is often associated with secretion of endorphins. Because the experience of pain is so variable, pain requires both a biological and psychological explanation. Ronald Melzack and Patrick Wall's gate-control theory attempts to explain the experience of pain. You experience pain only if the pain messages can pass through a gate in the spinal cord on their route to the brain. The gate is opened by small nerve fibers that carry pain signals. Conditions that keep the gate open are anxiety, depression, and focusing on the pain. The gate is closed by neural activity of larger nerve fibers, which conduct most other sensory signals, or by information coming from the brain. Massage, electrical stimulation, acupuncture, ice, and the natural release of endorphins can influence the closing of the gate. The experience of pain alerts you to injury and often prevents further damage.
Body Senses

The body senses of kinesthesia and the vestibular sense provide information about the position of your body parts and your body movements in your environment. Close your eyes and touch your nose with your index finger. **Kinesthesia** is the system that enables you to sense the position and movement of individual parts of your body. Sensory receptors for kinesthesia are nerve endings in your muscles, tendons, and joints.

Your **vestibular sense** is your sense of equilibrium or body orientation. Your inner ear has semicircular canals at right angles to each other. Hair-like receptor cells are stimulated by acceleration caused when you turn your head. The vestibular sacs respond to straightline accelerations with similar receptors. The combined activities of your vestibular sense, kinesthesia, and vision enable you to maintain your balance.

Chemical Senses

**Gustation** (taste) and **olfaction** (smell) are called chemical senses because the stimuli are molecules. Your chemical senses are important systems for warning and attraction. You won't eat rotten eggs or drink sour milk and you can smell smoke before a sensitive household smoke detector. Evolutionarily, these adaptations increased chances of survival.

Taste receptor cells are most concentrated on your tongue in taste buds embedded in tissue called fungiform papillae, but are also on the roof of your mouth and the opening of your throat. Tasters have an average number of taste buds, nontasters have fewer taste buds, and supertasters have the most. You can taste only molecules that dissolve in your saliva or a liquid you drink. Scientists have identified five types of taste receptors for sweet, salty, sour, bitter, and, most recently, umami or glutamate. Babies show a preference for sweet and salty, both necessary for survival; and disgust for bitter and sour, which are characteristic of poisonous and spoiled substances. Supertasters are more sensitive than others to bitter, spicy foods and alcohol, which they find unpleasant. Each receptor is sensitive to specific chemicals that initiate an action potential. The pathway for taste messages passes to the brainstem, thalamus, and primary gustatory cortex. Receptors for different tastes activate different regions of the primary taste cortex. Our tongues also have receptors for touch, pain,
cold, and warmth. The sensory interaction of taste, temperature, texture, and olfaction determine flavor.

Odor molecules reach your moist olfactory epithelium high in your nasal cavity through the nostrils of your nose and the nasal pharynx linking your nose and mouth. Dissolved odor molecules bind to receptor sites of olfactory receptors, triggering an action potential. Research has not uncovered basic odors. Axons of olfactory sensory neurons pass directly into the olfactory bulbs of the brain. Sensory information about smell is transmitted to the hypothalamus and structures in the limbic system associated with memory and emotion as well as the primary cortex for olfaction on the underside of the frontal lobes, but not the thalamus. The primary olfactory cortex is necessary for making fine distinctions among odors and using those distinctions to consciously control behavior.

**Perceptual Processes**

What you perceive is an active construction of reality. Perception results from the interaction of many neuron systems, each performing a simple task. Natural selection favors a perceptual system that is very efficient at picking up information needed for survival in a three-dimensional world in which there are predators, prey, competitors, and limited resources. According to the nativist direct-perception theory of James Gibson, inborn brain mechanisms enable even babies to create perceptions directly from information supplied by the sense organs. For visual perception, your visual cortex transmits information to association areas of your parietal and temporal lobes that integrate all the pieces of information to make an image you recognize. Your brain looks for constancies and simplicity, making a huge number of perceptual decisions, often without your conscious awareness, in essentially two different ways of processing. The particular stimuli you select to process greatly affect your perceptions.

**Attention**

Attention is the set of processes by which you choose from among the various stimuli bombarding your senses at any instant, allowing some to be further processed by your senses and brain. You focus your awareness on only a limited aspect of all you are capable of experiencing, which is
selective attention. In data-driven bottom-up processing, your sensory receptors detect external stimulation and send these raw data to the brain for analysis. Hubel and Weisel's feature-detector theory assumes that you construct perceptions of stimuli from activity in neurons of the brain that are sensitive to specific features of those stimuli, such as lines, angles, even a letter or face. In his constructionist theory, Hermann von Helmholtz maintained that we learn through experience to convert sensations into accurate perceptions. Anne Treisman's feature-integration theory proposes that detection of individual features of stimuli and integration into a whole occur sequentially in two different stages. First, detection of features involves bottom-up parallel processing; and second, integration of features involves less automatic, partially top-down serial processing. Concept-driven top-down processing takes what you already know about particular stimulation, what you remember about the context in which it usually appears, and how you label and classify it, to give meaning to your perceptions. Your expectations, previous experiences, interests, and biases give rise to different perceptions. Where you perceive a conflict among senses, vision usually dominates, which is called visual capture. That accounts for why you think the voice is coming from a ventriloquist's wooden pal when the puppet's mouth moves.

Gestalt Organizing Principles of Form Perception

Max Wertheimer, Kurt Koffka, and Wolfgang Kohler studied how the mind organizes sensations into perceptions of meaningful patterns or forms, called a gestalt in German. These Gestalt psychologists concluded that in perception, the whole is different from, and can be greater than, the sum of its parts. Unlike structuralists of the early 1900s, they thought that forms are perceived not as combinations of features, but as wholes.

This is exemplified by the phi phenomenon, which is the illusion of movement created by presenting visual stimuli in rapid succession. Videos consist of slightly different frames projected rapidly one after another, giving the illusion of movement. Gestaltists also noted that we see objects as distinct from their surroundings. The figure is the dominant object, and the ground is the natural and formless setting for the figure. This is called the figure–ground relationship. Gestaltists claimed that the nervous system
is innately predisposed to respond to patterns of stimuli according to rules or principles. Their most general principle was the law of Pragnanz, or good form, which claimed that we tend to organize patterns in the simplest way possible. Other principles of organization include proximity, closure, similarity and continuity or continuation. Consider the following: DEMON DAY BREAK FAST. Looking at the groups of letters, you probably read the four words demon, day, break, and fast, rather than Monday, daybreak, or breakfast. Proximity, the nearness of objects to each other, is an organizing principle. We perceive objects that are close together as parts of the same pattern. Do you know someone who writes letters without quite closing the letter "o" or crossing the "t"? You probably still know what the letter is. The principle of closure states that we tend to fill in gaps in patterns. The closure principle is not limited to vision. For example, if someone started singing, "Happy Birthday to...," you might finish it in your mind. The principle of similarity states that like stimuli tend to be perceived as parts of the same pattern. The principle of continuity or continuation states that we tend to group stimuli into forms that follow continuous lines or patterns.

**Optical or visual illusions** are discrepancies between the appearance of a visual stimulus and its physical reality. Visual illusions, such as reversible figures, illustrate the mind's tendency to separate figure and ground in the absence of sufficient cues for deciding which is which. Illusory contours illustrate the tendency of the perceptual system to fill in missing elements to perceive whole patterns.

**Depth Perception**

Survival in a three-dimensional world requires adaptations for determining the distances of objects around you. **Depth perception** is the ability to judge the distance of objects. You interpret visual cues that tell you how near or far away objects are. Cues are either monocular or binocular. **Monocular cues** are clues about distance based on the image of one eye, whereas **binocular cues** are clues about distance requiring two eyes.

Binocular cues include retinal disparity and convergence. Your principal binocular cue is retinal disparity, which is the slightly different view the two eyes have of the same object because the eyes are a few centimeters apart.
You can experience retinal disparity by extending your arm directly in front of you with your thumb up. Close one eye while looking at your thumb with the other. Then close the open eye and open the closed eye. Your thumb appears to move with respect to the background. If you follow the same procedure with your thumb closer, you'll notice that your thumb appears to move more. The degree of retinal disparity decreases with distance. With both eyes open, your brain fuses the two images, resulting in perception of depth. Convergence is the inward turning of your eyes that occurs when you look at an object that is close to you; the closer an object, the more convergence. You can experience convergence by looking at the tip of your nose with both eyes. Convergence is a less important distance cue than retinal disparity and cannot be used for objects beyond about 8 meters (about 25 feet).

Monocular cues include motion parallax, accommodation, interposition or overlap, relative size, relative clarity, texture gradient, relative height or elevation, linear perspective, and relative brightness. Motion parallax and accommodation require active use of your eye in viewing, whereas the other monocular cues are pictorial depth cues that can be given in a flat picture. Motion parallax involves images of objects at different distances moving across the retina at different rates. Closer objects appear to move more than distant objects when you move your head. When riding in a moving vehicle, you see very close objects move rapidly in the opposite direction; more distant objects move more slowly past you; extremely far away objects, such as the moon, seem to move with you. Accommodation of the lens increases as an object gets closer.

Look outside your window to notice all of the pictorial cues.

- Interposition or overlap can be seen when a closer object cuts off the view of part or all of a more distant one.
- Relative size of familiar objects provides a cue to their distance when the closer of two same-size objects casts a larger image on your retina than the farther one.
- Relative clarity can be seen when closer objects appear sharper than more distant, hazy objects.
- Texture gradient provides a cue to distance when closer objects have a
coarser, more distinct texture than far away objects that appear more densely packed or smooth.

- Relative height or elevation can be seen when the objects closest to the horizon appear to be the farthest from you. The lowest objects in our field of vision generally seem the closest.
- Linear perspective provides a cue to distance when parallel lines, such as edges of sidewalks, seem to converge in the distance.
- Relative brightness can be seen when the closer of two identical objects reflects more light to your eyes.
- Optical illusions, such as the Muller-Lyer illusion, and the Ponzo illusion, in which two identical horizontal bars seems to differ in length, may occur because distance cues lead one line to be judged as farther away than the other. Similarly, the moon illusion may occur because the moon when near the horizon is judged to be farther away than when it is high in the sky, although in both positions it casts the same image on the retina.

At the San Francisco Exploratorium website, you can see examples of visual illusions and link to other great sites. Go to www.exploratorium.org.

**Perceptual Constancy**

As a car approaches, you know that it's not growing in size, even though the image it casts on your retina gets larger, because you impose stability on the constantly changing sensations you experience. This phenomenon is called **perceptual constancy**. Three perceptual constancies are size constancy, by which an object appears to stay the same size despite changes in the size of the image it casts on the retina as it moves farther away or closer; shape constancy, by which an object appears to maintain its normal shape regardless of the angle from which it is viewed; and brightness constancy, by which an object maintains a particular level of brightness regardless of the amount of light reflected from it. The real shape, orientation, size, brightness, and color are perceived as remaining relatively constant even when there are significant variations in the image it projects. This enables you to identify objects no matter what your viewing angle is, how far away you are, or how dim the lights are.
Perceptual Adaptation and Perceptual Set

Have you ever looked through a periscope or displacement goggles and tried to reach for an object only to find it wasn’t where you thought it was? If you repeated your actions, after a short period of time you were probably able to reach the item easily. You adapted to the changed visual input. Newly sighted people who had been blind from birth are immediately able to distinguish colors and to separate figure from ground, but only gradually become able to visually recognize shapes. Visual perception can also be influenced by cultural factors, assumptions, and beliefs. To make use of the cue of relative size, you need to be familiar with the object and have been exposed to viewing objects in the distance.

Culture and Experience

Your perceptual set or mental predisposition can influence what you perceive when you look at ambiguous stimuli. Your perceptual set is determined by the schemas you form as a result of your experiences. Schemas are concepts or frameworks that organize and interpret information. This can account for people's interpretations of unidentified flying objects (UFOs), the Loch Ness monster, or seeing a cloud of dust in a movie.

Extrasensory Perception

Parapsychologists study evidence for psychological phenomena that are currently inexplicable by science. They try to answer the question "Is there perception without sensation?" ESP (extrasensory perception) is the controversial claim that perception can occur apart from sensory input. Parapsychology, the study of paranormal events, investigates claims of ESP, including

- telepathy: mind-to-mind communication;
- clairvoyance: perception of remote events;
- precognition: perception of future events;
- telekinesis or psychokinesis: moving remote objects through mental processes.
In 1998, a National Research Council investigation on ESP concluded that the best available evidence at that time did not support the contention that these phenomena exist.