

Chapter in Review

1. Sensing is the process by which our sense organs receive raw physical or chemical energy from the natural world; perception occurs when our brains organize and interpret transduced sensory signals. Psychophysicists study the relationship between physical stimuli and how they are perceived through the senses.
2. An absolute threshold of stimulus intensity must be reached in order for the stimulus to be detected by the appropriate sense organ. The just-noticeable difference (JND) is the smallest difference between two stimuli that can be detected by the appropriate sense organ. For any given stimulus, the JND is always directly proportionate to the level of the standard (the original stimulus). Gustav Fechner expressed this mathematically, calling it Weber's law after the discoverer of JND.
3. Human judgment and bias can influence the detection of stimuli, as recognized in signal detection theory. Signal detection theorists propose that noise and response bias in particular interfere with detection of stimuli. Sensory adaptation also influences stimulus detection. Subliminal perception is the unconscious, or implicit, perception of a stimulus. Subliminal perception does have effects, but there is no evidence that it can persuade a person to buy a product through subliminal advertising, or boost a person's self-esteem through the use of subliminal self-improvement tapes.
4. Light is a form of electromagnetic radiation. It travels around the world in waves separated measured in wavelengths. Visible light exists in a narrow spectrum of wavelengths. In addition to varying by wavelength, light also varies by amplitude, a measure of the intensity of a light source. Eyes allow light to be focused upon the retina, where rods and cones (photoreceptors) initiate the processes of transducing images into electrical signals to be conveyed through the thalamus to the visual cortex and associated visual areas where they are perceived as visual images. Rods are specialized to allow us to see at night. They respond in low light but are not good at capturing fine detail, and their peak sensitivities for responding to light do not correspond to those necessary for color perception. Cones are specialized for daylight vision and color vision.
5. The color we perceive varies according to the wavelength of light reflected from objects, but the color does not exist in these light waves. Color is not a physical property of an object—it is created by the brain of the animal perceiving the object and is therefore a psychological property. The trichromatic theory of color states that any color can be created if the light waves associated with blue, green, and red are combined at various intensities and in various combinations—a process known as additive color mixture. The opponent process theory states that colors are mixed in color vision in three opposing pairs: blue *or* yellow, red *or* green, and black *or* white. According to this idea, certain color combinations cannot exist in color vision—say, mixing red and green to get a reddish green.
6. Audition is the hearing sense. Sound is vibration that causes pressure changes in the air (or water) known as sound waves. Sound waves vary in amplitude (intensity of source) and frequency (speed of vibration). The ear collects, amplifies, and transduces sound waves into electrical signals. When the signals

- pass through the thalamus and reach the auditory cortex they are perceived as sound. Both ears are needed to determine the location of a sound source.
7. Olfaction is the sense of smell. The nose detects odors when molecular particles of odorants from a source pass from the air into the nasal cavity and contact the olfactory epithelium. There, olfactory receptors transduce the chemical signals to electrical impulses and relay the information through the thalamus to the frontal cortex where they are perceived as aromas. The nose also detects odorless human pheromones—hormone-like compounds that act as chemical communications. Evidence is strong for the existence of human primer pheromones (a pheromone that affects hormonal activity in another person) and modulator pheromones (that alter moods or other psychological states). However, evidence is weakest for the existence of releasing pheromones—pheromones that alter the behavior of another person.
  8. Gustation is the sense of taste. Taste sensations are received by the tongue after food molecules are dissolved in saliva during chewing and passed over taste buds. Taste buds contain taste receptors that transduce taste signals and send the information along cranial nerves through the thalamus, where they are relayed to the frontal lobe and interpreted as taste. There are four established tastes: sweet, salty, sour, and bitter. Two other tastes, fatty and umami, have been proposed by researchers but not accepted by all. Taste is not the same as flavor. Flavor is what happens when food molecules are released into the air inside the mouth, travel up the retronasal passage, and are sensed by receptors in the olfactory epithelium. This is why tasting flavor is very difficult when your nose is stuffed.
  9. Touch is the skin's principal sense. It can be broken down into subdivisions of tactition (touching), thermoception (heat and cold), and nociception (pain). The muscles, tendons, and joints primarily contribute to the kinesthetic sense—our awareness of where our limbs are and how we are moving. Touch is perhaps the most important of all senses. The loss of sense of touch would be life-threatening. Tactile sensations are converted into neural signals by mechanoreceptors and then carried along trunks of nerves directly to the spinal column instead of the brain. The signals then travel up the spinal column to the thalamus, and from there to the somatosensory area of the cerebral cortex where they are perceived as touch.
  10. Pain is a psychological experience as much as a physiological event. Beliefs, emotions, motivations, prior experiences, and observations of other people's behavior affect the experience of pain. There are no specific pain receptors. Any free nerve ending in the body can serve as a receptor for pain sensations. First pain is the initial sharp sensation one experiences at the moment of painful stimulus. Second pain is slower to arrive, but tends to be more unpleasant, in part because by the time these sensations arrive we have had time to respond emotionally and cognitively to the pain. Gate control theory has been highly influential in pain research, although it does not explain everything important about pain.
  11. Gestalt theorists propose that human beings have an innate tendency to perceive meaningful visual “wholes” out of what are inherently meaningless and fragmented sensory impressions. The most important contributions of Gestalt theory are the idea of figure-ground relationships, and an explanation for the way

- human beings group isolated features of objects to form whole perceptions. Among the more important of the original laws of Gestalt perceptual grouping are proximity, similarity, closure, and good continuation.
12. Depth perception is acquired early in infancy. Depth perception relies upon binocular and monocular cues. Binocular cues include retinal disparity and convergence. Monocular cues include relative size, linear perspective, interposition, and position on the horizon.
  13. Perceptual constancy is the ability to perceive an object as “itself” despite changes in angle of view, distance, and illumination. There are four primary categories of perceptual constancy: size constancy, shape constancy, brightness constancy, and color constancy.
  14. Face recognition is the ability to distinguish faces from other objects or body parts and to recognize specific faces. Some researchers believe that human beings have evolved specific visual and cognitive tools and brain regions set aside for the specific task of face recognition. However, even if true, this would not rule out the importance of experience in developing and fine-tuning these mechanisms.
  15. Perception is influenced by experience and expectation. Change blindness is one example of this fact, the Rorschach test is another. Expectations, biases, and predispositions that we bring to the viewing of a scene are known as perceptual set. Some researchers suggest that cultural differences exist between Westerners and East Asians in how visual scenes are perceived, with Far Easterners focusing holistically among objects in context and Westerners focusing analytically on specific qualities of objects.
  16. Many people believe in telepathy, clairvoyance, astrology, ESP, and other paranormal phenomena. However, decades of research has failed to establish the existence of psi, and most scientists have accepted that such phenomena do not exist. However, a few scientists take these ideas seriously and continue to conduct research.

### Section Summaries

#### *What are sensation and perception?*

1. Sensation is the process by which the sense organs receive energy from the natural world and transduce it into neural signals to be sent to the brain. Perception is the process by which the brain organizes and interprets transduced sensory signals.
2. Psychophysics is the scientific study of the relationship between sensation and perception.
3. The absolute threshold is the minimum intensity necessary for a stimulus to be detected at least 50 percent of the time. The just-noticeable difference is the smallest difference between two stimuli that can be detected at least 50 percent of the time. Weber's law demonstrates that the JND for any given type of stimulus is proportionate to the level of the first (standard) stimulus.
4. Signal detection theory acknowledges that in addition to thresholds and JNDs, noise and response bias also affect the perception of stimuli. Noise refers to other competing sensory stimuli and varying psychological states of the perceiver. Response bias acknowledges the fact that a person may be intrinsically biased in favor of or against perceiving a stimulus.
5. Sensory adaptation describes the tendency for sensitivity to stimuli to be lessened over time during exposure.
6. Subliminal perception is the unconscious (implicit) perception of stimuli below the absolute threshold, or of stimuli presented too briefly to reach conscious awareness.

#### *How does the eye work?*

1. Light is electromagnetic radiation that travels in varying wavelengths of varying amplitude. Visible light exists only in a narrow spectrum of wavelengths.
2. Light first passes through the cornea, where it is refracted. It then travels to the pupil, a small opening whose dilation or contraction is controlled by the iris. Light then passes through the lens, which refracts and focuses light on the retina. Before the light reaches the retina, however, it passes through the vitreous humor, which fills 80 percent of the volume of the eye. Light is then finally focused as an image on the retina.
3. Rods are photoreceptors in the cornea specialized for night vision. Cones are photoreceptors specialized for daylight, fine detail, and color vision.
4. Transduced visual signals leave the back of the cornea via the optic disc and travel out into the nervous system along the optic nerve of each eye. The part of the brain that first receives visual signals is the thalamus, but signals are quickly relayed to the visual cortex.
5. Color is not a physical property of objects. It results from an interaction among physical properties and brain mechanisms.
6. The trichromatic theory of color vision proposes that color perception results from stimulation of short-, medium-, and long-wavelength cones and the additive color mixtures which result. The opponent process theory suggests that colors are mixed in three opposing pairs: blue vs. yellow, red vs. green, and black vs. white. Both theories contribute to accurate understanding of color vision.

*How does the ear work?*

1. Sound is created when objects vibrate and cause vibrations in surrounding air (or water) molecules. Sound waves vary by amplitude (intensity) and frequency (speed of vibration). Amplitude determines loudness, and frequency determines pitch.
2. The ear consists of an outer ear, middle ear, and inner ear. The pinna is the outer ear structure, which collects sounds. Sounds are conveyed through the ear canal to the tympanic membrane (ear drum) stretched across the end of the canal. Vibrations of the eardrum are transferred to the ossicles of the middle ear, where they are magnified and transmitted to the oval window of the cochlea (the inner ear). The fluid of the cochlea vibrates, causing rippling in the basilar membrane. Hair cells of the basilar membrane are bent by this rippling, and the hair cells fire neurons (transduction) which exit via the auditory nerve to be processed in the auditory cortex of the temporal lobe.
3. The brain uses differences in the speed and intensity with which sound hits the ears to detect the location of sound sources.

*How do the nose and tongue receive chemical signals?*

1. The nose detects odors and chemical signals similar to pheromones. Odors are detected when particles of an odor-producing substance pass through the nasal cavity and contact the olfactory epithelium. Olfactory receptors embedded in the olfactory sensory neurons transduce chemical signals and relay the information via the olfactory nerves to the olfactory bulb of the olfactory cortex.
2. Although human pheromones have not been precisely identified, it is highly likely that modulating and priming human pheromones exist. Releasing pheromones may exist in humans, but there is little evidence of it. Pheromones are probably detected by the specialized sensory neurons in the olfactory epithelium.
3. Taste is perceived when food molecules are dissolved in saliva during chewing and passed over the taste buds which are embedded with taste receptors. These receptors transduce taste signals, sending the information along cranial nerves to the primary and secondary taste cortexes.
4. There is a difference between taste and flavor. There are four basic tastes: salty, sweet, sour, and bitter. There may be two additional basic tastes: umami and fatty. Flavor is experienced when taste and olfaction are combined during chewing.

*How does the skin and body feel?*

1. The sense of touch is subdivided into tactition, thermoception, and nociception. Tactition occurs because mechanoreceptors are embedded in the epidermis, dermis, and subcutaneous fat. Tactile sensations are interpreted in the somatosensory area of the cortex.
2. Thermoreceptors sense warm and cold. There are two types: one for detecting increases in skin temperature and one for detecting decreases.
3. Pain is a cognitive, motivational, and emotional experience as well as a physiological experience. Pain is sensed by free nerve endings throughout the

- body, which act as nociceptors. First pain is conveyed rapidly along A-delta fibers, whereas second pain is conveyed along slower C-fibers.
4. The gate control theory of pain describes the way competing neural messages at the substantia gelatinosa can block pain signals.

*How do we perceive visual images?*

1. Gestalt principles of perceptual organization include the notions of figure and ground and laws of perceptual grouping. When viewing a scene, people choose certain elements on which to focus (figure) and others to relegate to the background (ground). Perceptual grouping laws include proximity, similarity, closure, and good continuation.
2. Depth perception is achieved through binocular and monocular cues. Binocular cues include retinal disparity and convergence. Monocular cues include relative size, linear perspective, interposition, and position on the horizon.
3. Size constancy is the ability to maintain an awareness of the actual size of an object as we move closer to or farther away from it. Shape constancy involves maintaining a single idea about the shape of an object even if we change our angle of viewing the object. Brightness constancy and color constancy refer to our ability to maintain a consistent perception of the brightness and color of an object regardless of the amount or type of illumination. Of all types of constancy, color constancy is the most likely to fail.

*How do evolution, culture, and experience affect perception?*

1. There is some evidence that a cortical region of the right hemisphere (the fusiform face area) may have been “set aside” as a result of evolutionary forces exclusively for face perception. However, face perception and recognition may necessitate particular types of early experiences in order to develop.
2. Change blindness occurs when a person is unable to detect even radical changes in a scene following a moment of distraction. Inattention blindness occurs when a person’s attention is drawn away from being able to perceive an object at which the person is looking directly. Change blindness and inattention blindness are complex phenomena involving vision, memory, expectation, and attention, but they are also part of the larger phenomenon of perceptual set—the expectations, biases, and predispositions that we bring to the perception of a scene.
3. Culture has an effect on the way people perceive visual scenes.

*Does extrasensory perception exist?*

1. Parapsychologists study psi experiences, particularly extrasensory perception (clairvoyance and telepathy) and telekinesis (movement of objects with mental energy).
2. Very little evidence exists in support of the reality of psi, and decades of attempts to find such evidence have ended in failure.