CHAPTER 6

Sensation and Perception

Chapter Preview

Sensation is the process by which we detect stimulus energy from our environment and transmit it to our brain. Perception is the process of organizing and interpreting sensory information, enabling us to recognize meaningful objects and events. Clear evidence that perception is influenced by our experience comes from the many demonstrations of perceptual set and context effects.

The task of each sense is to receive stimulus energy, transform it into neural signals, and send those neural messages to the brain. In vision, light waves are converted into neural impulses by the retina; after being coded, these impulses travel up the optic nerve to the brain's cortex, where they are interpreted.

In organizing sensory data into whole perceptions, our first task is to discriminate figure from ground. We then organize the figure into meaningful form by following certain rules for grouping stimuli. We transform two-dimensional retinal images into three-dimensional perceptions by using binocular cues, such as retinal disparity, and monocular cues, such as the relative sizes of objects. The perceptual constancies enable us to perceive objects as enduring in color, shape, and size regardless of viewing angle, distance, and illumination. The constancies explain several well-known illusions.

Both nature and nurture shape our perceptions. For example, when cataracts are removed from adults who have been blind from birth, these persons can distinguish figure and ground and can perceive color but are unable to distinguish shapes and forms. At the same time, human vision is remarkably adaptable. Given glasses that turn the world upside down, people manage to adapt and move about with ease.

In hearing, sound waves are transmitted to the fluid-filled cochlea, where they are converted to neural messages and sent to the brain. We locate sounds by differences in the timing and loudness of the sounds received by each ear.

Our other senses include touch, taste, smell, and body position and movement. The sense of touch is actually four senses—pressure, warmth, cold, and pain—that combine to produce other sensations such as "hot." Taste, a chemical sense, is a composite of sweet, sour, salty, bitter, and umami sensations. Smell, also a chemical sense, does not have basic sensations as there are for touch and taste. Our effective functioning also requires a kinesthetic sense and a vestibular sense, which together enable us to detect body position and movement.

Our senses are not totally separate information channels. In interpreting the world, our brain blends their input. Thus, for example, the smell of food may influence its taste.

Although parapsychologists have tried to document ESP, most research psychologists remain skeptical, particularly because the results of experiments have not been reproducible.

Chapter Guide

Introductory Exercise: Fact or Falsehood?

The correct answers to Handout 6–1 are as follows: 1. F 2. T 3. F 4. F 5. T 6. T 7. T 8. T 9. T 10. F

- ▶ Podcast/Lecture: Person Perception (p. 305)
- ▶ Worth Video Anthology: *The Man Who Cannot Recognize Faces*

Basic Principles of Sensation and Perception

- ▶ Lectures: Sensation Versus Perception (p. 306); Top-Down Processing (p. 307); Sensory Processing Disorder (p. 308); "Thin-Slicing" (p. 309)
- ▶ Exercises: A Scale to Assess Sensory-Processing Sensitivity (p. 308); Human Senses Demonstration Kits (p. 309)
- ▶ Exercise/Project: The Wundt-Jastrow Illusion (p. 306)

6-1. *Contrast sensation and perception, and explain the difference between bottom-up and top-down processing.*

Sensation is the process by which our sensory receptors and nervous system receive and represent stimulus energies from our environment. ***Bottom-up processing*** is analysis that begins with the sense receptors and works up to the brain's integration of sensory information. ***Perception*** is the process of organizing and interpreting sensory information, enabling us to recognize meaningful objects and events. ***Top-down processing*** is information processing guided by our experience and expectations.

6-2. *Identify the three steps that are basic to all our sensory systems.*

All our senses perform three basic steps: They receive sensory stimulation, transform that stimulation into neural impulses, and deliver the neural information to our brain. The process of converting one form of energy into another that our brain can use is called ***transduction.***

- ▶ Lectures: Subliminal Smells (p. 311); Subliminal Persuasion (p. 311); Applying Weber's Law (p. 312)
- ▶ Projects: The Variability of the Absolute Threshold (p. 310); Understanding Weber's Law (p. 312)

6-3. *Distinguish between* absolute *and* difference thresholds, *and discuss whether we can sense and be affected by stimuli below the absolute threshold.*

In studying our awareness of faint stimuli, Gustav Fechner identified an ***absolute threshold*** as the minimum stimulation needed to detect a particular stimulus 50 percent of the time. ***Signal detection theory*** predicts how and when we detect the presence of a faint stimulus, assuming that our individual absolute thresholds vary with our experiences, expectations, motivation, and level of alertness.

The ***priming*** effect, as shown in experiments, reveals that we *can* process some information from stimuli too weak to recognize, indicating that much of our information processing occurs automatically, unconsciously. But the effect is too fleeting to enable advertisers to exploit us with ***subliminal*** messages.

A ***difference threshold*** is the minimum difference between two stimuli that a person can detect 50 percent of the time. In humans, difference thresholds (experienced as a *just noticeable difference* [*jnd*]) increase in proportion to the size of the stimulus—a principle known as ***Weber's law***.

- ▶ Exercise: Eye Movements (p. 313)
- ▶ Project: Sensory Adaptation (p. 312)
- ▶ Exercise/Lecture Break: Sensory Adaptation in the Marketplace (p. 313)

6-4. *Explain the function of sensory adaptation.*

Sensory adaptation refers to diminished sensitivity as a consequence of constant stimulation. Constant, unchanging images on the eye's inner surface fade and then reappear. The phenomenon of sensory adaptation enables us to focus our attention on informative changes in our environment without being distracted by uninformative background stimulation.

- ▶ Exercises: Discovering Personal Bias (p. 313); Perceptual Set (p. 314); Perceptual Set and Gender Stereotypes (p. 316); Context and Perception (p. 317)
- ▶ Exercise/Lecture Break: The Role of Experience in Visual Perception (p. 315)

6-5. *Explain how our expectations, contexts, emotions, and motivation influence our perceptions.*

Clear evidence that perception is influenced by our experiences—our learned assumptions and beliefs—as well as by sensory input comes from the many demonstrations of ***perceptual set,*** a mental predisposition to perceive one thing and not another.

Through experience, we also form concepts, or *schemas,* which organize and interpret unfamiliar information, a fact that helps explain why some of us "see" monsters, faces, and UFOs that others do not.

A given stimulus may trigger radically different perceptions, partly because of our different schemas, but also because of the immediate context. For example, we discern whether a speaker said "morning" or "mourning" or "dye" or "die" from the surrounding words.

Perceptions are influenced, top-down, not only by our expectations and by the context but also by our motivations and emotions.

Vision

- ▶ Exercise: The Hermann Grid (p. 318)
- ▶ Exercise/Project: Physiology of the Eye—A CD-ROM for Teaching Sensation and Perception (p. 318)
- ▶ Project: Locating the Retinal Blood Vessels (p. 318)
- ▶ Projects/Exercises: Rods, Cones, and Color Vision (p. 318); Locating the Blind Spot (p. 319)
- ▶ Worth Video Anthology: *Vision: How We See*

6-6. *Describe the characteristics of the energy we see as visible light.*

The energies we experience as visible light are a thin slice from the broad spectrum of electromagnetic energy. Our sensory experience of light is determined largely by the light energy's ***wavelength,*** which determines the ***hue*** of a color, and its ***intensity*** (determined by a wave's *amplitude,* or height), which influences brightness.

- ▶ Exercise: Movement Aftereffects (p. 319)
- ▶ Worth Video Anthology: *Visual Information Processing: Elementary Concepts*

6-7. *Describe how the eye transforms light energy into neural messages, and how the eye and brain process that information.*

After light enters the eye through the *cornea,* it passes through the *pupil,* whose size is regulated by the *iris.* A cameralike *lens* then focuses the rays by changing its curvature, a process called ***accommodation,*** on the ***retina.*** This light-sensitive surface contains receptors that begin the processing of visual information.

The retina's ***rods*** and ***cones*** (most of which are clustered around the ***fovea***) transform the light energy into neural signals. These signals activate the neighboring *bipolar cells,* which in turn activate the neighboring *ganglion cells*, whose axons converge to form the ***optic nerve*** that carries information via the thalamus to the brain. Where the optic nerve leaves the eye, there are no receptor cells—creating a ***blind spot.*** The cones enable vision of color and fine detail. The rods enable black-and-white vision, remain sensitive in dim light, and are necessary for peripheral vision.

We process information at progressively more abstract levels. The information from the retina's rods and cones is received and transmitted by the ganglion cells whose axons make up the optic nerve. When individual ganglion cells register information in their region of the visual field, they send signals to the occipital lobe's visual cortex. In the cortex, individual neurons (***feature detectors***) respond to specific features of a visual stimulus. The visual cortex passes this information along to other areas of the cortex where teams of cells *(supercell clusters)* respond to more complex patterns.

- ▶ Lecture: Blindsight (p. 320)

Subdimensions of vision (color, movement, depth, and form) are processed by neural teams working separately and simultaneously, illustrating our brain's capacity for ***parallel processing.*** Other teams collaborate in integrating the results, comparing them with stored information and enabling perceptions. Some people who have lost part of their visual cortex experience *blindsight*.

- ▶ PsychSim 5: Colorful World (p. 320)
- ▶ Exercises: The Color Vision Screening Inventory and Color Blindness (p. 320); Subjective Colors (p. 320)

6-8. *Discuss the theories that help us understand color vision.*

The ***Young-Helmholtz trichromatic (three-color) theory*** states that the retina has three types of color receptors, each especially sensitive to red, green, or blue. When we stimulate combinations of these cones, we see other colors. For example, when both red- and green-sensitive cones are stimulated, we see yellow.

Hering's ***opponent-process theory*** states that there are two additional color processes, one responsible for red versus green perception and one for yellow versus blue plus a third black versus white process. These opponent processes help explain *afterimages.*

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

- ▶ Lectures: Object Recognition (p. 322); Visual Agnosia (p. 323)
- ▶ Exercises: Perceptual Illusions and Principles (p. 321); Visual Organization (p. 324); An Auditory Analogue of the Visual Reversible Figure (p. 324); The Ganzfeld (p. 325)
- ▶ Projects: Playing Cards and Illusions (p. 323); Instant Object Recognition (p. 323)
- ▶ PsychSim 5: Visual Illusions (p. 321)
- ▶ Worth Video Anthology: A Variety of Visual Illusions

6-9. *Describe Gestalt psychologists' understanding of perception, and explain how figure-ground and grouping principles contribute to our perceptions.*

Gestalt psychologists described principles by which we organize our sensations into perceptions. They provided many compelling demonstrations of how, given a cluster of sensations, the human perceiver organizes them into a ***gestalt,*** a German word meaning a "form" or a "whole." They further demonstrated that the whole may differ from the sum of its parts. Clearly, our brains do more than merely register information about the world. We are always filtering sensory information and inferring perceptions in ways that make sense to us.

Our first task in perception is to perceive any object, called the ***figure,*** as distinct from its surroundings, called the ***ground.*** We must also organize the figure into a meaningful form. Gestalt principles for ***grouping*** that describe this process include *proximity* (we group nearby figures together), *continuity* (we perceive smooth, continuous patterns rather than discontinuous ones), and *closure* (we fill in gaps to create a whole object).

- ▶ Lecture: Autostereograms (p. 326)
- ▶ Exercises: Binocular Vision (p. 325)
- ▶ Exercise/Lecture Break: Identifying Cues to Depth and Distance (p. 326)
- ▶ Exercise/Project: Binocular Vision Versus Monocular Vision (p. 325)
- ▶ Worth Video Anthology: *The Visual Cliff*

6-10. *Explain how we use binocular and monocular cues to perceive the world in three dimensions.*

Depth perception is the ability to see objects in three dimensions, although the images that strike the eye are two-dimensional. It enables us to judge distance. Research on the ***visual cliff*** (a miniature cliff with a drop-off covered by sturdy glass) reveals that depth perception is, in part, innate. Many species perceive the world in three dimensions at, or very soon after, birth.

Binocular cues require information from both eyes. In the ***retinal disparity*** cue, the brain computes the relative distance of an object by comparing the slightly different images an object casts on our two retinas. The greater the difference, the greater the distance.

Monocular cues enable us to judge depth using information from only one eye. The monocular cues include *relative size* (the smaller image of two objects of the same size appears more distant), *interposition* (nearby objects partially obstruct our view of more distant objects), *relative height* (higher objects are farther away), *relative motion* (as we move, objects at different distances change their relative positions in our visual image, with those closest moving most), *linear perspective* (the converging of parallel lines indicates greater distance), and *light and shadow* (dimmer objects seem more distant).

- ▶ Lecture: Auditory Organization (p. 328)
- ▶ Exercises: Brightness Contrast (p. 326);Variation in the Size of the Retinal Image (p. 327); Perceived Distance and Perceived Size (p. 327); Binocular Disparity and Size Constancy (p. 328)
- ▶ Exercise/Project: Perceived Lunar Size (p. 328)
- ▶ Project: Visual Capture (for entire section on vision) (p. 329)
- ▶ Worth Video Anthology: *Depth Cues; Müller-Lyer Illusion*

6-11. *Explain how perceptual constancies help us organize our sensations into meaningful perceptions.*

Perceptual constancy is necessary to recognize an object. It enables us to see an object as unchanging (having consistent shape, size, brightness, and color) even as illumination and retinal images change.

Color constancy refers to our perceiving familiar objects as having consistent color, even if changing illumination alters the wavelengths reflected by the object. We see color as a result of our brain's computations of the light reflected by any object relative to the objects surrounding it.

Brightness constancy (also called *lightness constancy*) enables us to perceive an object as having a constant brightness even when its illumination changes. Perceived brightness depends on *relative luminance,* which is the amount of light an object reflects relative to its surroundings.

Shape constancy is our ability to perceive familiar objects (for example, an opening door) as unchanging in shape, and *size constancy* is perceiving objects as unchanging in size, despite the changing images they cast on our retinas.

Given the perceived distance of an object, we instantly and unconsciously infer the object's size. The perceived relationship between distance and size is generally valid but, under special circumstances, can lead us astray. For example, one reason for the Moon illusion is that cues to objects' distances at the horizon make the Moon behind them seem farther away. Thus, the Moon on the horizon seems larger. In the distorted (trapezoidal) room designed by Adelbert Ames, we perceive both corners as being the same distance away. Thus, anything in the near corner appears disproportionately large compared with anything in the far corner.

- ▶ Lecture: Cases of Restored Vision (p. 329)
- ▶ Feature Film: *At First Sight* (p. 330)

6-12. *Describe what research on restored vision, sensory restriction, and perceptual adaptation reveals about the effects of experience on perception.*

In the classic version of the nature–nurture debate, the German philosopher Immanuel Kant maintained that knowledge comes from our *inborn* ways of organizing sensory experiences. On the other side, the British philosopher John Locke argued that we *learn* to perceive the world through our experiences of it. It's now clear that different aspects of perception depend more or less on nature's endowments and on the experiences that influence what we make of our sensations.

When cataracts are removed from adults who have been blind from birth, these people remain unable to perceive the world normally. Generally, they can distinguish figure from ground and perceive colors, but they are unable to recognize objects that were familiar by touch. In controlled experiments, infant kittens and monkeys have been reared with severely restricted visual input. When their visual exposure is returned to normal, they, too, suffer enduring visual handicaps. For many species, infancy is a *critical period* during which experience must activate the brain's innate visual mechanisms.

- ▶ Exercise: Displacement Glasses (p. 330)
- ▶ Worth Video Anthology: *Seeing the World Upside Down*

Human perception is remarkably ***adaptable***. Given glasses that shift the world slightly to the left or right, or even turn it upside down, people manage to adapt their movements and, with practice, to move about with ease.

Hearing

- ▶ Lecture: Recognizing Our Own Voice (p. 331)
- ▶ PsychSim 5: The Auditory System (p. 331)
- ▶ Worth Video Anthology: *Hearing: From Vibration to Sound*

6-13. *Describe the characteristics of air pressure waves that we hear as sound, and explain the process by which the ear transforms sound energy into neural messages.*

Audition, or hearing, is highly adaptive. The pressure waves we experience as sound vary in *amplitude* and ***frequency*** and correspondingly in perceived *loudness* and ***pitch.*** *Decibels* are the measuring unit for sound energy.

The visible *outer ear* channels the sound waves through the *auditory canal* to the *eardrum,* a tight membrane that vibrates with the waves. Transmitted via the bones of the ***middle ear*** (the *hammer*, *anvil*, and *stirrup*) to the fluid-filled ***cochlea*** in the ***inner ear,*** these vibrations cause the *oval window* to vibrate, causing ripples in the *basilar membrane,* which bends the *hair cells* that line its surface. This movement triggers neural messages to be sent (via the thalamus) to the temporal lobe's *auditory cortex.*

- ▶ Lectures: Hearing Loss (p. 331); A Quiet World—Living With Hearing Loss (p. 331)

Problems with the mechanical system that conducts sound waves to the cochlea cause ***conduction hearing loss***. Damage to the cochlea's hair cell receptors or their associated nerves can cause the more common ***sensorineural hearing loss*** *(nerve deafness).* Disease, biological changes linked with aging, or prolonged exposure to ear-splitting noise or music may cause sensorineural hearing loss.

The only way to restore hearing for people with nerve deafness is a ***cochlear implant,*** which is wired into various sites on the auditory nerve, allowing them to transmit electrical impulses to the brain. It helps children to become proficient in oral communication. The latest cochlear implants also can help restore hearing for most adults.

We detect loudness according to the *number* of activated hair cells, not the intensity of a hair cell's response.

6-14. *Discuss the theories that help us understand pitch perception.*

Place theory presumes that we hear different pitches because different sound waves trigger activity at different places along the cochlea's basilar membrane. Thus, the brain can determine a sound's pitch by recognizing the place on the membrane from which it receives neural signals.

Frequency theory states that the rate of nerve impulses traveling up the auditory nerve matches the frequency of a tone, thus enabling us to sense its pitch. The *volley principle* explains hearing sounds with frequencies above 1000 waves per second.

Place theory best explains how we sense high-pitched sounds, and frequency theory best explains how we sense low-pitched sounds. Some combination of the two theories explains sounds in between.

- ▶ Exercise: Locating Sounds (p. 331)

6-15. *Describe how we locate sounds.*

Sound waves strike one ear sooner and more intensely than the other ear. We localize sounds by detecting the minute differences in the intensity and timing of the sounds received by each ear.

The Other Senses

- ▶ Lectures: The Amazing Capabilities of Touch (p. 331); The Remarkable Case of Ian Waterman (p. 333)
- ▶ Exercises: Two-Point Thresholds (p. 332); Touch Localization (p. 333)
- ▶ Exercise/Project: Warm Plus Cold Equals Hot (p. 332)
- ▶ Worth Video Anthology: *Losing One's Touch: Living Without Proprioception*

6-16. *Describe the sense of touch.*

Our sense of touch is actually four senses—pressure, warmth, cold, and pain—that combine to produce other sensations, such as "hot." Touch sensations involve more than tactile stimulation, however. A self-produced tickle produces less somatosensory cortex activation than does the same tickle from something or someone else.

- ▶ Lectures: Cultural Differences in Pain (p. 335); Pain Control (p. 336)
- ▶ Lecture/Critical Thinking Break: "Amputating" a Phantom Limb (p. 335)
- ▶ Exercise: The Revised Reducer–Augmenter Scale (p. 334)
- ▶ Worth Video Anthology: *Phantom Limb Sensations; Pickpockets, Placebos, and Pain: The Role of Expectations; Coping With Pain*

6-17. *Describe how we best understand and control pain.*

Pain is an alarm system that draws our attention to some physical problem. Without the ability to experience pain, people may die before early adulthood. There is no one type of stimulus that triggers pain, and there are no special receptors for pain. Instead there are different *nociceptors*—sensory receptors that detect hurtful temperatures, pressure, or chemicals. The ***gate-control theory*** of pain is that small fibers in the spinal cord open a "gate" to permit pain signals to travel up to the brain, or large fibers close the "gate" to prevent their passage.

The biopsychosocial approach views pain not only as a product of biological influences, for example, of injured nerves sending impulses to the brain, but also as a result of psychological influences such as our expectations, and social influences such as the presence of others. We can be distracted from pain (a psychological influence) and soothed by *endorphins* (a biological influence). Our brain can also create pain, as in *phantom limb sensations.* Pain is controlled through a combination of medical and psychological treatments.

- ▶ Lectures: Taste Preferences (p. 339); Taste Preferences—Learned and Genetic (p. 340); Synesthesia (p. 340)
- ▶ Exercises: The Basic Taste Sensations (p. 338); Genetic Effects in Taste (p. 338)
- ▶ Exercise/Project: Taste (p. 340)
- ▶ Project: Mapping Your Tongue (p. 339)
- ▶ Worth Video Anthology: *"Supertasters"; The "Red Hot" Chili-Eating Contest: Sensitivity to Taste; Synesthesia: The Man Who Tastes Words*

6-18. *Describe how we experience taste and smell.*

Taste, a chemical sense, is a composite of sweet, sour, salty, bitter, and umami sensations and of the aromas that interact with information from the taste buds. Taste buds on the top and sides of the tongue contain taste receptor cells, which send information to an area of the brain's temporal lobe. Taste receptors reproduce themselves every week or two. As we grow older, the number of taste buds and taste sensitivity decrease. Expectations can also influence taste.

- ▶ Lectures: Anosmia (p. 341); Odor and Sex Identification (p. 343); Pheromones (p. 343); Fragrance Effects (p. 344)
- ▶ Exercise: Identifying Odors (p. 342)

Smell (*olfaction*) is also a chemical sense, but without any basic sensations. The 5 million or more olfactory receptor cells, with their approximately 350 different receptor proteins, recognize individual odor molecules, with some odors triggering a combination of receptors. The receptor cells send messages to the olfactory lobe, then to the temporal lobe and to parts of the limbic system. An odor's ability to spontaneously evoke memories is due in part to the close connections between brain areas that process smell and those involved in memory storage.

▶ Exercises: Nystagmus (p. 345); Vision and Balance (p. 346)

6-19. *Explain how we sense our body's position and movement.*

Kinesthesis is the system for sensing the position and movement of individual body parts. Sensors in the tendons, joints, and muscles are continually providing our brain with information. A companion ***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 *semicircular canals* and *vestibular sacs* in the inner ear.

Sensory Interaction

6-20. *Describe how our senses interact.*

Sensory interaction refers to the principle that one sense may influence another, as when the smell of food influences its taste. In interpreting the world, our brain circuits blend our bodily sensations with brain circuits responsible for cognition. This ***embodied cognition*** is uniquely illustrated in a few select individuals in whom the senses become joined in a phenomenon called *synaesthesia,* in which one kind of sensation such as hearing sound produces another such as seeing color.

(Thinking Critically) ESP—Perception Without Sensation?

▶ Lecture: Belief in ESP (p. 346)
▶ Exercises: Belief in ESP Scale (p. 346); ESP Tricks (p. 347)
▶ Project: The Psychic Challenge (p. 347)
▶ Project/Exercise: Testing for ESP (p. 350)

6-21. *List the claims of ESP, and discuss the conclusions of most research psychologists after putting these claims to the test.*

Claims are made by ***parapsychologists*** for three varieties of ***extrasensory perception (ESP):*** *telepathy* (mind-to-mind communication), *clairvoyance* (perceiving remote events), and *precognition* (perceiving future events). Closely linked with these are claims of *psychokinesis,* or "mind over matter."

Research psychologists remain skeptical because the forecasts of "leading psychics" reveal meager accuracy, because checks of psychic visions have been no more accurate than guesses made by others, and because sheer chance guarantees that some stunning coincidences are sure to occur. An important reason for their skepticism, however, is the absence of a reproducible ESP result.

HANDOUT 6–1

Fact or Falsehood?

T F	1.	Advertisers can powerfully shape our buying habits through subliminal messages.
T F	2.	If we stare at a green square for a while and then look at a white sheet of paper, we see red.
T F	3.	Infants just learning to crawl do not perceive depth.
T F	4.	Persons who have sight in only one eye are totally unable to gauge distances.
T F	5.	A person who is born blind but gains sight as an adult cannot recognize objects that were familiar by touch.
T F	6.	If required to look through a pair of glasses that turns the world upside down, we soon adapt and coordinate our movements without difficulty.
T F	7.	Touching adjacent cold and pressure spots triggers a sense of wetness.
T F	8.	People who are born without the ability to feel pain may die by early adulthood.
T F	9.	Without their smells, a cold cup of coffee may be hard to distinguish from a glass of red wine.
T F	10.	Laboratory evidence clearly indicates that some people do have ESP.