Sensation and Perception

Chapter

KEY CONTENT REVIEW

I. INTRODUCTION

A. SENSATION

1. The process by which our sensory receptors respond to light, sound, odor, textures, and taste and transmit that information to the brain.
2. Our eyes, ears, nose, tongue, and skin comprise an elaborate sensory system that receives and processes information from the environment.
3. Each sense organ contains specialized cells called receptors which detect and then convert light waves, sound waves, chemical molecules, and pressure into neural impulses that are transmitted to the brain.
4. When adults are totally deprived of sensory input for long periods of time, they experience hallucinations and impaired efficiency in all areas of intellectual functioning.

B. PERCEPTION

1. The process by which the brain actively selects, organizes, and assigns meaning to incoming neural messages sent from sensory receptors.
2. For example, from a sensory point of view, the American flag is a mass of red, white, and blue colors and horizontal and vertical lines. Perception is the process by which you interpret these splotches of color and array of lines as the American flag.

II. BASIC PRINCIPLES OF SENSATION

A. TRANSDUCTION

1. The process by which sensory receptors convert the incoming physical energy of stimuli such as light waves into neural impulses that the brain can understand.
2. As noted by psychologist Philip Zimbardo, the transduction "process seems so immediate and direct that it fools us into assuming that the sensation of redness is characteristic of a tomato or the sensation of cold is characteristic of ice cream." In reality, sensations such as "red" and "cold" occur only when the neural impulses reach the brain.

B. THRESHOLDS

1. Absolute threshold
    - *The minimum amount of a stimulus that an observer can reliably detect at least 50 percent of the time.*
    - *For example, the human visual system can barely detect a candle flame at a distance of about 30 miles on a clear, dark night.*
2. Difference Threshold
    - *The minimal difference needed to notice a stimulus change.*
    - *The difference threshold is also called the "just noticeable difference" or JND.*
    - *For example, Ben is trying to study for an AP Psychology test on sensation and perception. However, he can't concentrate because his sister is watching Gossip Girl and has the volume turned at full blast. Ben asks Charlotte to "please turn the volume down so I can study!" Charlotte responds by lowering the volume by one notch. If Ben notices this minimal amount of change, it qualifies as a just noticeable difference. Needless to say, Ben will probably not be satisfied with a just noticeable difference and will soon demand that Charlotte turn the TV volume down some more.*
3. Weber's law
    - *The German psychologist Ernst Weber (1795–1878) observed that the just noticeable difference will vary depending on its relation to the original stimulus.*

- *According to Weber's law, the size of the just noticeable difference is proportional to the strength of the original stimulus. For example, for the average person to perceive their difference, two objects must differ in weight by 2 percent.*
- *For example, a weight lifter who is bench pressing 50 pounds would notice the addition of a 5-pound weight. However, the same weight lifter would not notice the extra 5 pounds if he were bench pressing 500 pounds.*

C. SIGNAL DETECTION THEORY

1. A problem with traditional thresholds
   - *The traditional theory of thresholds assumed that if a signal were intense enough to exceed one's absolute threshold, it would be sensed. If the same signal were below our threshold, it would be missed.*
   - *The traditional theory of thresholds did not take into account the characteristics of the perceiver. For example, Ben noticed the change in volume when Charlotte turned her TV down one notch because he was trying to concentrate and was focused on the TV's distracting noise. Had Ben been playing a video game with a friend, he would not have noticed the change in volume.*
2. A new theory
   - *Signal detection theory assumes that there is no single absolute threshold. Instead, a detection depends upon a combination of stimulus intensity, background noise, and a person's physical condition, biases, and level of motivation. For example, a sentry in wartime will likely detect fainter stimuli than the same sentry in peacetime.*
   - *When they are applying signal detection theory to experiments, psychologists sort the trials into one of four categories. If the signal is present, the person can decide that it is present or absent. These outcomes are called hits or misses. If the signal is absent, the person can still decide that the signal is either present or absent. These are called false alarms or correct rejections.*

D. SENSORY ADAPTATION

1. Sensory adaptation occurs when a constant stimulus is presented for a length of time. When this happens receptors fire less frequently and the sensation often fades or disappears.
2. Examples
   - *When a jogger first puts on a new pair of running shoes, he or she immediately notices that the new shoes have a different feel from the old shoes. However, after going for a jog, he or she no longer notices the new shoes.*
   - *When a swimmer first dives into a pool, he or she immediately notices that the water is chilly. However, after swimming a few laps, he or she no longer notices the water temperature.*
3. It is interesting to note that sensory adaptation does not affect our vision. The reason is because our eyes constantly shift from one location to another. This ensures that receptor cells in the eyes always receive continuously changing stimuli.

Test Tip

The basic processes of sensation generate a significant number of multiple-choice questions. Make sure that you can define and illustrate transduction, absolute threshold, signal detection theory, and sensory adaptation.

III. THE HUMAN VISUAL SYSTEM

A. INTRODUCTION

1. The visual system is our most complex and most important sense.
2. The visual system transduces light waves into neural messages that the brain then processes into what we consciously see.

B. FROM THE CORNEA TO THE RETINA

1. Cornea
   - *Light waves from the outside world first enter the eye through the cornea.*

- *The cornea is a clear membrane covering the visible part of the eye. It protects the eye and helps gather and direct incoming light waves.*

2. Pupil
   - *The small opening in the middle of the iris*
   - *The pupil changes size to let in different amounts of light.*
3. Iris
   - *The colored part of the eye*
   - *The iris is actually a ring of muscle tissue that contracts or expands to control the size of the pupil. The muscles in the eye respond to light and to inner emotions. The pupils constrict when we are in parasympathetic calm and dilate when we are in sympathetic arousal.*
4. Lens
   - *A transparent structure located behind the pupil that actually focuses and bends light as it enters the eye.*
   - *Accommodation is the change in the curvature of the lens that enables the eye to focus on objects at various distances. Nearsightedness is a visual acuity problem that results when the cornea and lens focus on an image in front of the retina. As a result, distant objects appear blurry. Farsightedness is a visual acuity problem that results when the cornea and lens focus an image behind the retina. As a result, objects near the eye appear blurry.*

C. THE ALL-IMPORTANT RETINA

1. The retina is the light-sensitive membrane at the back of the eye. The retina contains millions of sensory receptors for vision. The transduction of light waves into neural messages occurs in the retina.
2. Rods
   - *Photoreceptors in the retina that are especially sensitive to dim light but not to colors.*
   - *Rods allow you to see in poorly lit environments. Cats have better night vision than humans because they have a higher proportion of rods to cones than do humans.*
3. Cones
   - *Photoreceptors in the retina that are especially sensitive to colors and to bright light.*

- *Cones are concentrated in the center of the retina, in a small region called the fovea. Images that do not fall on the fovea tend to be perceived as blurry or indistinct.*

4. Bipolar cells
   - *Specialized neurons that connect the rods and cones with the ganglion cells.*
5. Ganglion cells
   - *Specialized neurons that connect to the bipolar cells. The bundled axons of the ganglion cells form the optic nerve.*
6. Blind spot
   - *The point where the optic nerve leaves the eye and where there are no rods or cones.*
   - *Because there are no rods or cones, we have a tiny hole, or blind spot in our vision. Normally, we are unaware of the blind spot because our eyes are always moving.*

D. THE VISUAL CORTEX

1. The optic nerve carries visual information to the brain's visual cortex.
2. The visual cortex lies in the occipital lobe at the back of the brain.

E. COLOR VISION

1. Introduction
   - *The human visual system can identify approximately 7 million different color combinations. How does normal color vision work?*
   - *Two theories describe how color vision works at different stages of the visual process.*
2. The trichromatic or three-color theory
   - *The trichromatic theory begins with the fact that there are three primary colors—red, green, and blue. Any color can be created by combining the light waves of these three colors.*
   - *In the mid-nineteenth century, the German physicist Hermann von Helmholtz (1821–1894) proposed that the eye must have color receptors that correspond to the three primary colors.*

- *Years later, researchers confirmed that the retina does have cones especially sensitive to the three primary colors.*

3. The opponent-process theory
   - *The trichromatic theory explains how color processing works in the cones. However, it does not explain what happens in the ganglion cells and the rest of the visual system.*
   - *According to the opponent-process theory, the ganglion cells process color in opposing pairs of red or green, black or white, and blue or yellow colors. The visual cortex also encodes color in terms of these three opponent pairs.*
   - *The opponent-process theory explains a phenomena known as afterimages. An afterimage is the visual experience that occurs after the original source of stimulation is no longer present. For example, if you stare at a green, black, and yellow flag, you will soon tire your neural response to these colors. If you then look at a white sheet of paper, you will see an afterimage composed of the opposing red, white, and blue colors.*

F. COLOR BLINDNESS

1. Color blindness is a genetic disorder that prevents an individual from distinguishing between certain colors. People who are color blind typically have a deficiency in their cones.
2. The most common form of color blindness is related to deficiencies in the red-green system.
3. It is very rare to see no color at all. There have only been about 500 reported cases of total color blindness.

IV. THE HUMAN AUDITORY SYSTEM

A. INTRODUCTION

1. Hearing plays a vital role in language development and social interactions. It also alerts us to dangerous situations.
2. The auditory system transduces sound waves into neural messages that the brain then processes into what we consciously hear.

B. THE OUTER EAR

1. The outer ear collects sound waves.
2. The pinna
   - *The flap of skin and cartilage attached to each side of our head.*
   - *The pinna catches sound waves and channels them into the auditory canal.*
3. The auditory canal
   - *Sound waves travel down the auditory canal and bounce into the ear drum.*
4. The eardrum or tympanic membrane
   - *A tightly stretched membrane located at the end of the auditory canal.*
   - *The eardrum vibrates when hit by sound waves. The vibrations of the eardrum match the intensity and frequency of the incoming sound waves.*

C. THE MIDDLE EAR

1. The middle ear amplifies sound waves.
2. Hammer, anvil, and stirrup
   - *Three tiny bones in the middle ear*
   - *Their joint action doubles the amplification of sound*
3. Oval window
   - *The stirrup transmits the amplified vibrations to the oval window.*
   - *The oval window is a small membrane separating the middle ear from the inner ear. It relays the vibrations to the cochlea.*

D. THE INNER EAR

1. The inner ear transduces sound waves into neural messages.
2. Cochlea
   - *A spiral-shaped, fluid-filled structure that contains the basilar membrane and hair cells.*
   - *It is interesting to note that the word* cochlea *comes from the Greek word for "snail."*
3. Basilar membrane
   - *Runs the length of the cochlea*
   - *Holds the hair cell receptors for hearing*

4. Hair cells
    - *Sensory receptors embedded in the basilar membrane*
    - *The hair cells transduce the physical vibration of the sound waves into neural impulses.*

E. THE BRAIN

1. As the hair cells bend, they stimulate the cells of the auditory nerve.
2. The auditory nerve carries the neural messages to the thalamus and then to the temporal lobe's auditory cortex.

F. DISTINGUISHING PITCH

1. Pitch is the relative highness or lowness of a sound.
2. Frequency theory
    - *According to the frequency theory, the basilar membrane vibrates at the same frequency as the sound wave.*
    - *The frequency theory explains how low-frequency sounds are transmitted to the brain.*
    - *However, since individual neurons cannot fire faster than about 1000 times per second, the frequency theory does not explain how the much faster high-frequency sounds are transmitted.*
3. Place theory
    - *According to place theory, different frequencies excite different hair cells at different locations along the basilar membrane.*
    - *High-frequency sounds cause maximum vibrations near the stirrup end of the basilar membrane. Lower-frequency sounds cause maximum vibrations at the opposite end.*

G. THE LOSS OF HEARING

1. Conduction deafness
    - *Caused when the tiny bones in the middle ear are damaged and cannot transmit sound waves to the inner ear.*
    - *Hearing aids can amplify sound and help overcome conduction deafness.*

2. Nerve deafness
    - *Caused by damage to the cochlea, hair cells, or auditory nerve.*
    - *Exposure to noises such as headphones playing at full blast can damage hair cells and cause permanent hearing loss.*
    - *Hearing aids cannot help nerve deafness since damage to the hair cells and auditory nerve is almost always irreversible.*

V. THE CHEMICAL SENSES

A. INTRODUCTION

1. Smell and taste are sometimes referred to as the chemical senses because they respond to chemical molecules rather than to forms of energy such as light and sound waves.
2. Smell and taste receptors are located near each other and often interact. As a result, we often have difficulty separating the two sensations.

B. SMELL OR OLFACTION

1. The mucous membrane at the top of each nostril contains receptor cells that absorb airborne chemical molecules. Our olfactory receptors can detect over 10,000 distinct smells. This ability can help us detect odors ranging from fragrant flowers to dangerous leaking gas.
2. The receptor cells communicate neural messages to the olfactory bulb.
3. It is important to note that unlike all other bodily sensations, impulses from the olfactory bulb do not go to the thalamus. Instead, the nerve fibers from the olfactory bulb connect to the brain at the amygdala and then to the hippocampus. This direct connection to these limbic system structures may explain why smell is capable of triggering such vivid memories and emotions.

C. TASTE OR GUSTATION

1. Our tongue is covered with bumps called papillae. The papillae are in turn covered with taste buds. Taste buds are also found in the palate at the back of the throat.
2. Humans have four major taste sensations—sweet, sour, salty, and bitter. In recent years, researchers have added *umami* (meaning "delicious" or "savory") to this traditional list. *Umami* is associated with the taste of protein found in meats and meat broths.
3. Although taste is often called the least critical of our senses, it can play an important survival role by helping us avoid eating or drinking harmful substances. On a positive note, taste (aided by smell) plays an important role in our enjoyment of everything from savory fruits to delicious desserts!

VI. SKIN AND BODY SENSES

A. INTRODUCTION

1. Skin senses
   - *Skin is our largest and heaviest sense organ.*
   - *Skin protects our internal organs, holds body fluids, produces sensations of touch, warmth, and cold and provides essential information about pain.*
2. Body senses
   - *Body senses provide essential information about your position and orientation in space.*

B. SKIN SENSES

1. Touch
   - *Touch or pressure receptors are not evenly distributed among the different areas of our bodies. For example, they are more densely concentrated in the hands, face, and lips than on the legs or back.*
   - *Touch plays a particularly important role in human relationships by helping communicate feelings of support, conformity, and love.*

2. Pain
    - *Pain is the unpleasant sensation of physical discomfort or suffering.*
    - *Pain plays a key survival role by warning about potential or actual injuries.*
3. The gate-control theory of pain
    - *According to the gate-control theory, the brain regulates pain by sending signals down the spinal cord that either open or close sensory pathways or "gates."*
    - *If the brain signals the gates to open, pain is experienced or intensified.*
    - *If the brain signals the gates to close, pain is reduced.*
    - *Psychological factors such as anxiety and fear can intensify pain while positive emotions such as laughter can help minimize pain.*

C. THE VESTIBULAR SENSE

1. The vestibular sense provides a sense of balance and equilibrium.
2. The inner ear contains receptors that are especially important for maintaining balance.
3. The semicircular canals are filled with fluid and lined with hairlike receptor cells that shift in response to motion. They provide the brain with important information about the body's posture and head position.
4. The vestibular and auditory systems are alike in that both depend upon hair cells to transduce a stimulus into neural messages.

Test Tip

Because of the importance of the retina and cochlea, it is easy to overlook the semicircular canals. Don't make this mistake. Be sure you know that the semicircular canals are located in the inner ear and are closely associated with the vestibular sense of balance.

VII. SELECTION

A. INTRODUCTION

1. Selecting where to direct our attention is the first step in perception.
2. Selective attention and feature detectors help explain why we pay attention to some stimuli in our environment and not to others.

B. SELECTIVE ATTENTION

1. Selective attention is the cognitive process of selectively concentrating on one or more aspects of the environment while filtering out or ignoring other information.
2. Examples
    - *Gavin is playing a new video game with his friend. He doesn't hear his mother call for him to come to dinner. However, he does respond when his cell phone rings because he is expecting a call from his girlfriend.*
    - *Chloe is the star guard on her high school basketball team. During a big game she doesn't hear the fans cheering for her. However, she does respond when her coach calls out a special play for her to run.*

C. FEATURE DETECTORS

1. The brain contains specialized neurons called feature detectors that respond only to certain sensory information.
2. David Hubel and Torsten Wiesel demonstrated that specialized neurons in the occipital lobe's visual cortex have the ability to respond to specific features of an image such as angles, lines, curves, and movements.
3. For example, an area just behind your right ear enables you to perceive faces. Damage to this area can result in prosopagnosia, a disorder that causes an inability to detect differences in faces. Persons suffering from prosopagnosia cannot recognize their own face in a mirror.

VIII. GESTALT PRINCIPLES OF ORGANIZATION

A. INTRODUCTION

1. The German psychologist Max Wertheimer founded Gestalt psychology in the early 1900s.
2. Gestalt psychologists maintained that we actively process our sensations according to consistent perceptual rules. These rules create whole perceptions, or *gestalts,* that are meaningful, symmetrical, and as simple as conditions will allow.

B. THE FIGURE-GROUND RELATIONSHIP

1. The human tendency to distinguish between figure and ground is the most fundamental Gestalt principle or organization.
2. The figure is the main element of a scene that clearly stands out. In contrast, the ground is the less distinct background of a scene.
3. For example, the page you are now reading consists of lines of black markings on a white page. Your brain organizes these black markings into letters and groups them into words and sentences. The letters constitute the figure while the white page is the ground.

C. PERCEPTUAL GROUPING

1. The law of similarity
    - *States that there is a tendency to perceive objects of a similar size, shape, or color as a unit or figure.*
    - *For example, the crowd at a football game includes a wide assortment of different people. If you are following the law of similarity, you could perceptually organize the crowd into home fans, visiting fans, band members, and cheerleaders.*
2. The law of proximity
    - *States that there is a tendency to perceive objects that are physically close to one another as a single unit.*

- *For example, home fans and visiting fans usually group themselves on opposing sides of the stadium. Based upon the law of proximity, you would perceptually group the visiting fans into a single homogeneous group.*

3. The law of closure
   - *States that there is a tendency to fill in the gaps in an incomplete image.*
   - *For example, scoreboards always have headings labeled HOME and VISITORS. If your scoreboard said HO E and VISI ORS, you would fill in the missing letters M and T and thus complete the words.*

IX. DEPTH PERCEPTION

A. INTRODUCTION

1. Depth perception is the ability to perceive three-dimensional space and to accurately judge distance.
2. Although it is possible to use sound and even smell to judge distances, we rely heavily on vision to perceive both distance and three-dimensional space.

B. THE "VISUAL CLIFF" EXPERIMENT

1. In a famous experiment, Eleanor Gibson placed infants old enough to crawl on a Plexiglas-topped table. On one side, Gibson placed a sheet of high-contrast red-and-white-checkered cloth flush against the underside of the glass. This gave both the appearance and the reality of a solid surface. On the other side, she placed a sheet of the same material four feet below the glass. This created the illusion of a "deep end" with a "visual cliff."
2. The infants almost always refused to venture beyond the shallow side of the visual cliff. They turned away from the "deep end" even when their mothers held a spinning toy and beckoned encouragingly for them to crawl forward.
3. The visual cliff experiment supports the conclusion that depth perception in humans is an innate capacity that emerges during infancy.

C. MONOCULAR DEPTH CUES

1. Require the use of only one eye to process distance or depth cues.
2. Linear perspective
    - *Parallel lines appear to converge toward a vanishing point as they recede into the distance.*
    - *See* The Annunciation *by Carlo Crivelli and* The Avenue *by Meindert Hobbema for famous paintings that use linear perspective.*
3. Aerial perspective
    - *Distance objects often appear hazy and blurred compared to close objects.*
    - *See* The Virgin *of the Rocks by Leonardo da Vinci and* The Harvesters *by Pieter Bruegel the Elder for famous paintings that use aerial perspective.*
4. Relative size
    - *If two or more objects are assumed to be similar in size, the object that appears larger is perceived as being closer.*
    - *See* Sunday Afternoon on the Island of La Grande Jatte *by George Seurat for a famous painting that illustrates relative size.*
5. Motion parallax
    - *As you move, you use the speed of passing objects to estimate the distance of the objects.*
    - *For example, when you are driving on an interstate highway, nearby telephone poles, fences, and roadside signs seem to zip by faster than distant hills.*

D. BINOCULAR DEPTH CUES

1. Require the use of both eyes to process distance or depth cues.
2. Convergence
    - *Binocular depth cue in which the closer the object, the more the eyes converge, or turn inward.*
3. Retinal disparity
    - *Binocular depth cue in which the separation of the eyes causes different images to fall on each retina.*

- *When two retinal images are very different, we interpret the object as being close by. When two retinal images are more nearly identical, the object is perceived as being farther away.*
- *A person with only one eye lacks retinal disparity and would have difficulty climbing an irregular set of stairs.*

Many students find retinal disparity a difficult concept to grasp. Don't spend valuable study time trying to master the scientific principles of how retinal disparity works. For purposes of the AP Psychology exam the key point is to know that retinal disparity is a binocular clue for depth perception.