CHAPTER 3

Sensation and Perception

CHAPTER OUTLINE

I. SENSING AND PERCEIVING THE WORLD
What is the difference between sensation and perception?

A sense is a system that translates outside information into activity in the nervous system. Messages from the senses are called sensations. Perception is the process of using information and your understanding of the world, so that sensations become meaningful experiences.

II. SENSORY SYSTEMS
How does information from my eyes and ears get to my brain?

Each sensory system detects a specific form of environmental energy (e.g., sound, light, heat, physical pressure), and encodes this energy into neural activity, and relays these signals to the brain.

A. Accessory structures modify the incoming stimulus.
B. Transduction is the process of converting incoming energy into neural activity.
   1. Transduction takes place at receptors, specialized cells that detect certain forms of energy.
   2. Sensory receptors respond best to changes in energy. Adaptation is a decreasing responsiveness to constant stimulation over time.
   3. Sensory nerves carry information from the receptors to the brain. For all senses except smell, the information first goes to the thalamus and then to the cerebral cortex.
C. Coding Sensations: Did You Feel That?
Coding translates the physical properties of a stimulus into patterns of neural activity.
D. Absolute Thresholds: Is Something Out There?
   1. The absolute threshold is the minimum detectable amount of physical energy a sensory system can detect 50 percent of the time.
   2. Psychophysics focuses on the relationship between physical energy in the environment and the psychological experience of that energy.
   3. The absolute threshold varies over time and between people according to two factors.
      a) Internal noise, the spontaneous random firing of neurons, gives a background “noise.” If the amount of internal noise is high at a moment, it may be mistakenly interpreted as a stimulus.
      b) Response criterion is a person’s willingness or reluctance (bias) to respond to a stimulus. It is the amount of energy needed for a person to justify saying that a signal has occurred. It reflects both motivation and expectations.
   4. Signal-Detection Theory
      Signal-detection theory is a mathematical model of how personal sensitivity and response criterion combine to determine your decision about whether a near-threshold stimulus has occurred.
      a) Sensitivity is a person’s physical ability to discriminate a stimulus from its background.
5. Judging Differences Between Stimuli
   a) **Weber’s law** states that the smallest detectable difference in stimulus energy is a constant fraction of the intensity of the stimulus.
   b) The **difference threshold**, or **just-noticeable difference (JND)**, is the smallest detectable difference in the stimulus.

6. Sensory Energy
   The sensory energies of light and sound vibrate as waves passing through space. These energies have three properties that determine what is sensed and perceived:
   a) **Wavelength** is the distance from one peak of the wave to the next.
   b) Wave **frequency** is the number of complete waves or cycles that pass a given point per unit of time.
   c) **Amplitude** is the height of the wave from baseline to peak.

III. SEEING

*Why do some people need eyeglasses?*

A. Light
   Light is a form of energy known as **electromagnetic radiation**. Most electromagnetic radiation passes through space undetected by the human eye.
   1. **Visible light** is electromagnetic radiation with wavelengths between 400 and 750 nanometers. Light can be referred to as either light waves or light rays.
   2. Sensations of light depend on the intensity and wavelength of light waves.
      a) **Light intensity** refers to how much energy the light contains; it determines the brightness of light.
      b) **Light wavelengths** create the sensation of different colors.

B. Focusing Light
   1. Accessory structures of the eye modify incoming light rays.
   2. Light waves enter the eyeball through a curved, protective transparent membrane, the **cornea**.
   3. Light then passes through the **pupil**, an opening just behind the cornea.
   4. The iris adjusts the amount of entering light by constricting to reduce the size of the pupil or relaxing to enlarge it.
      *Note:* Students can try this at home by watching their pupils in a mirror as lights go on and off.
   5. The curved **lens**, behind the pupil, bends and focuses light waves onto the **retina** at the back of the eye. Light rays from the top of an object are focused at the bottom of the image on the retinal surface, and those from the right side of the object end up on the left side of the retinal image. The brain then rearranges this upside-down and reversed image so we see the object as it really is.
   6. In **accommodation**, the lens changes shape to focus images at different distances onto the retina. This ability declines with age as the lens loses flexibility.

C. Converting Light into Images
   1. **Rods and Cones**
      a) Conversion of light energy into neural activity takes place in the retina in specialized cells called **photoreceptors**.
      b) **Rods** and **cones** are two main types of photoreceptors that contain chemicals that are light-sensitive.
      c) **Dark adaptation** is the increasing ability to see in the dark over time due to the build up of light-sensitive chemicals in the rods. Rods are more sensitive to light.
than cones and allow you to see in dim light. There are no rods in the fovea (the center of the retina), but there are large numbers in the periphery of the retina.

d) Cones allow you to see color. Most cones are packed in the fovea. The density of cones accounts for differences in visual acuity, or the ability to see details. Cones do not work well in low light.

2. From the Retina to the Brain
a) Signals generated by the rods and cones go back toward the surface of the retina, making connections with bipolar and ganglion cells. This allows the eye to begin analyzing visual information in the retina.

b) The axons of ganglion cells form the optic nerve, which then goes to the brain. Because there are no receptors for visual stimuli at the point where the optic nerve exits the eyeball, a blind spot is created.

c) About half of the optic nerve fibers from each eye cross to the opposite side of the brain at the optic chiasm. Fibers from the inside half of each eye, nearest to the nose, cross over. Fibers from the outside half of each eye do not. All visual information from the left half of the visual world goes to the right hemisphere of the brain and vice versa.

d) The optic chiasm is part of the bottom of the brain. Beyond this optic fibers extend into the brain, with most ganglion cells forming synapses in the thalamus. Then visual input is sent to the primary visual cortex in the occipital lobe at the back of the brain and to many association areas of the brain for processing.

e) Certain cells in the brain’s cerebral cortex are called feature detectors because they respond to specific characteristics of objects in the visual field.

D. Seeing Color
1. Wavelengths and Color Sensations
a) The sensation produced by a mixture of different wavelengths of light is not the same as the sensations produced by separate wavelengths. Three separate aspects of the sensation of color are hue, saturation, and brightness. They are the psychological dimensions.

(1) Hue, the essential “color” you see, is determined by a light mixture’s dominant wavelength.

(2) Saturation is the “purity” of a color. A color is more saturated (more pure) if a single wavelength is more intense (contains more energy) than others. Pastels are colors that have been desaturated by the addition of whiteness.

(3) Brightness refers to the intensity of the light.

b) Additive color mixing occurs when two lights of different colors are mixed. White is the result of adding all different colored lights.

c) Subtractive color mixing occurs when two colors absorb (subtract) more wavelengths of light than either one does alone. Mixing paints is an example.

E. Theories of Color Vision
1. Trichromatic Theory of Color Vision
The trichromatic theory was proposed by Thomas Young and Hermann von Helmholtz. They proved that by mixing pure versions of blue, green, and red light in different ratios, they could produce any color.

a) There are three types of cones, each most sensitive to a different wavelength.

(1) Short-wavelength cones respond most to light in the blue range.

(2) Medium-wavelength cones respond most to light in the green range.

(3) Long-wavelength cones respond most to light in the reddish-yellow range, although by tradition they are known as the red cones.
b) The ratio of the three cone types’ activities determines the color sensation. This theory was applied to the creation of color television screens.

2. Opponent-Process Theory of Color Vision

The opponent-process theory of color vision, proposed by Ewald Hering, holds that color-sensitive visual elements are organized as pairs, with the pair members opposing, or inhibiting, each other.

a) The three pairs are red-green, blue-yellow, and black-white. Each element signals one color or the other, but never both.

b) This theory explains color afterimages.

3. Summing Up

Both trichromatic and opponent-process theories are needed to explain what is known about color vision.

a) There are three types of cones, as the trichromatic theory predicts. Any color can be produced by mixing three pure wavelengths of light.

b) The cones connect to ganglion cells containing pairs of opposing elements that respond to different colors and inhibit each other. This explains afterimages.

F. Colorblindness

People with colorblindness discriminate fewer colors because they are missing one or more of the three color-sensitive pigments in cones. Colorblindness is more common in men than in women.

IV. HEARING

How would my voice sound on the moon?

Sound is a repetitive vibration in the pressure of a substance, such as air. As the moon has almost no atmosphere or air pressure, sound cannot exist there.

A. Sound

1. Vibration of an object produces the fluctuations in pressure that make sound. A wave is a repetitive change in pressure that spreads out in three dimensions.

2. Physical characteristics of sound waves determine psychological dimensions of sound.

   a) **Loudness**, measured in **decibels (dB)**, is determined by sound wave amplitude or height. The minimum detectable sound for normal hearing is 0 decibels.

   b) **Pitch**, how low or high a tone sounds, is the frequency of complete waves that pass a point in one second. One cycle per second is 1 **hertz (Hz)**. Humans can hear sounds ranging from about 20 Hz to 20,000 Hz.

   c) **Timbre** is a sound’s quality. It is determined by mixtures of frequencies and amplitudes that result in complex wave patterns that are added to the lowest, or **fundamental**, frequency of a sound.

B. The Ear

The human ear converts sound energy into neural activity through a series of accessory structures and transduction mechanisms.

1. The **pinna** is the crumpled, oddly-shaped external ear on the side of the head that collects sound waves in the outer ear and funnels them into the ear canal.

   a) At the end of the ear canal, sound waves strike the tightly stretched **tympanic membrane (eardrum)** of the middle ear.

   b) Tympanic membrane movements shake a chain of three tiny bones: the **hammer, anvil, and stirrup**. These bones amplify the vibrations and direct them onto a smaller membrane called the **oval window**.

2. The **cochlea** of the inner ear.

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b) The cochlea is a fluid-filled “tube” coiled into a spiral that begins at the oval window. The basilar membrane is the floor of this tube.
c) When a sound wave passes through the fluid in the tube, it moves the basilar membrane, which in turn bends hair cells on the membrane.
d) Hair cells make connections with fibers from the auditory nerve, a bundle of axons that go into the brain. The stimulated auditory nerve sends signals to the brain about the amplitude and frequency of sound waves, enabling the sensation of sound.

3. Deafness
There are two basic forms of deafness:

a) Conduction deafness occurs when the middle ear’s bones fuse so that they cannot properly amplify vibrations. Treatment includes hearing aids, which amplify the signals reaching the inner ear; surgery to break the bones apart; or replacing the natural bones with plastic ones.
b) Nerve deafness results from damage to the auditory nerve or the hair cells. High-intensity sound can actually rip off the hair cells of the inner ear. Scientists are working on regenerating hair cells in human ears. In the meantime, artificial cochlear implants have been developed to stimulate the auditory nerve.

4. Auditory Pathways to the Brain
a) The auditory nerve carries input to the thalamus.
b) The information is then relayed to the primary auditory cortex of the temporal lobe.
c) Cells in the auditory cortex have preferred frequencies, and each neuron in the auditory nerve has a “favorite,” or characteristic, frequency.
d) Parts of the auditory cortex specialize in processing certain types of sounds and also information from other senses. For example, the primary auditory cortex is activated when you watch someone say words, but not by other facial movements.

C. Coding Sounds
The more intense the sound, the more rapid the firing of given neurons. This is coded in two ways:

1. The place on the basilar membrane where the wave peaks depends on the sound frequency. High-frequency sounds peak at the beginning of the basilar membrane; lower-frequency sounds peak farther down. According to place theory, the greatest response by hair cells occurs at the peak of the wave. When cells with a particular characteristic frequency fire, we sense a sound of that frequency.
2. Frequency-matching, or volley, theory says that the firing rate of auditory nerve neurons matches the frequency of a sound wave.
3. Very low frequencies are coded by frequency matching. Low to moderate ones are coded by both frequency matching and place. High frequencies are coded solely by the place where waves peak.

V. THE CHEMICAL SENSES: SMELL AND TASTE
Why can’t I taste anything when I have a cold?

A. Smell, Taste, and Flavor
1. A food’s flavor depends on both smell and taste. Both tastes and odors prompt strong emotional responses. Humans learn aversions to odors more readily than to tastes.
2. Variations in our nutritional state also affect our experience of taste and flavor, as well as our motivation.
3. Warm foods taste sweeter, and the aroma of warm food can create more flavor sensations.
4. Spicy “hot” foods actually stimulate pain fibers in the mouth because they contain a substance called capsaicin.

B. Our Sense of Smell
1. The sense of smell (olfaction) detects chemicals that are airborne. Neurons in the upper nose detect molecules that pass into its moist lining, the mucous membrane. Odor molecules bind to receptors on the dendrites of olfactory neurons and lead to changes in the firing rates of these neurons, whose axons combine to form the olfactory nerve.
2. Different odors are sensed because of different patterns of responses by odorant receptors.
3. Olfaction is the only sense that does not send its messages through the thalamus. Olfactory axons extend directly into the brain to synapse in the olfactory bulb. The olfactory bulb’s connections to the amygdala, which plays important roles in emotion and memory, may underlie the special relationship between smells and emotions or memories.
4. Some animals release pheromones, chemicals that other animals detect and respond to behaviorally and physiologically. The role of pheromones in humans is not well understood. But odorants that cannot consciously be detected can influence mood and stimulate activity in nonolfactory areas of the brain.

C. Our Sense of Taste
1. The sense of taste (gustation) detects chemicals in solution that come into contact with receptors inside the mouth. Gustatory receptors are in taste buds, grouped together as papillae, on the tongue, roof of the mouth, and throat.
2. The human taste system detects only few basic sensations: sweet, sour, bitter, and salty.
3. Research has revealed two more taste sensations:
   a) Umami, which is triggered by monosodium glutamate (MSG) and certain other proteins.
   b) Astringent, which is produced by tannins, like those found in tea.
4. About 25 percent of the population are “supertasters”—individuals whose genes have given them a large number of papillae on their tongues and who are more sensitive to bitterness.

VI. SENSING YOUR BODY
Which is the largest organ in my body?

The somatic senses, or somatosensory systems, are located throughout the body rather than in a localized, specific organ.

A. Touch and Temperature
The stimulus for touch is the mechanical deformation of the skin by direct pressure or by bending hairs on the skin.
1. Coding Touch Information
   The sense of touch codes information about an object’s weight and location.
   a) Intensity of the stimulus (how heavy it is) is coded by the firing rate of individual neurons and by the number of firing neurons.
   b) The brain “knows” where the touch occurs based on the location of the nerves that sense the touch information.
2. Adapting to Touch Stimuli
The somatosensory system responds best to changes in touch. Constant input leads to adaptation, but a few neurons will adapt more slowly so that we can sense a constant stimulus.

3. Sensing Temperature
Many of the fibers that respond to temperature also respond to touch, so these sensations sometimes interact. “Warm fibers” and “cold fibers” respond to specific temperature changes only.

B. Pain
Pain tells you about the impact of the world on your body and has a distinctly negative emotional component that interrupts whatever you are doing.

1. Pain as an Information Sense
   a) The receptors for pain are free nerve endings, which come from the spinal cord, enter the skin, and then end.
   b) Two types of nerve fibers carry pain signals to the spinal cord; one for sharp, pricking pain, called A-delta fibers; the other for chronic, dull aches and burning sensations, called C-fibers.

2. Emotional Aspects of Pain
   a) There are specific pathways that carry the emotional component of a painful stimulus to areas of the hindbrain, reticular formation, and cortex via the thalamus.
   b) However, cognition affects emotional responses to pain. Knowing about the nature of pain, when to expect it, or engaging in distracting thoughts makes the same stimuli less unpleasant.

3. Modulating Pain: The Gate Control Theory
The gate control theory says that there is a “gate” in the spinal cord that either allows pain signals to reach the brain or stops them.
   a) Input from other skin senses may “take over” pathways that pain impulses would have used. This may explain why rubbing eases pain and scratching relieves itching (which is low-level pain).
   b) The brain can close the gate with descending signals into the spinal cord. The result is analgesia, a reduction in pain sensation following a normally painful stimulus. Drugs that dull pain are called analgesics.

4. Natural Analgesics
   a) Natural opiates, called endorphins, act as neurotransmitters and can block several levels of pain pathways into and within the brain.
   b) The more endorphin receptors a person has inherited, the more pain tolerance that person has.
   c) An endorphin system is activated during periods of real or imagined stress. For example, endorphins operate during late pregnancy, perhaps to reduce labor pains, and also when people merely believe they are receiving a real drug even if they are receiving only a placebo.

C. Thinking Critically: Does Acupuncture Relieve Pain?
Acupuncture is based on the idea that body energy flows along fourteen specific channels, the balance among which determines health. Fine needles inserted into the skin and twirled are thought to stimulate specific channels and thus affect physical health. The needles produce an achy, tingling sensation, called Teeh-ch’i, at the site but relieve pain at distant, seemingly unrelated parts of the body.

1. What am I being asked to believe or accept?
Acupuncturists assert that twirling a needle in the skin can relieve pain caused by everything from tooth extraction to cancer.

2. **Is there evidence available to support the claim?**
   PET and MRI studies show that stimulating acupuncture sites changes activity in the brain. Numerous studies show that acupuncture reduces various kinds of pain in 50 to 80 percent of patients. But well-controlled studies are rare, and results are often contradictory. Nonetheless, evidence suggests that acupuncture does cause analgesia by activating the endorphin system, even in monkeys and rats, who presumably are not biased by an expectations about acupuncture.

3. **Can that evidence be interpreted another way?**
   The evidence may simply confirm that the body’s painkilling system can be stimulated by external means, and acupuncture may just be one method of doing so.

4. **What evidence would help to evaluate the alternatives?**
   More well-controlled studies are needed to address the general relationship between internal painkilling systems and external methods for stimulating them, the ways in which acupuncture activates the endorphin system, and the types of pain for which acupuncture is most effective.

5. **What conclusions are most reasonable?**
   In some circumstances, acupuncture can relieve pain and nausea. Further research is needed.

D. Sensing Body Position

**Proprioception** refers to sensory information about one’s body, as opposed to sensory information about the external environment.

1. Kinesthesia
   a) **Kinesthesia** is sensory information about where your body parts are relative to each other.
   b) The brain depends on kinesthetic inputs to guide movements.
   c) The primary source of kinesthetic inputs is from receptors in muscles and skeletal joints. Kinesthetic inputs eventually reach the somatosensory cortex and the cerebellum.

2. Balance
   Information about the position of the head in space and about its general movements is supplied by the **vestibular sense**. It is often thought of as the **sense of balance**.
   a) **Vestibular sacs** are inner-ear structures filled with fluid and containing small crystals called **otoliths**, which rest on hair endings.
   b) **Semicircular canals** are fluid-filled inner-ear structures with tiny hairs extending into the fluid.
   c) Head movements cause otoliths to shift in vestibular sacs, and movement in fluid in the semicircular canals, stimulating hair endings. This activates neurons that travel along the auditory nerve, signaling the brain about the amount and direction of head movement.
   d) Vestibular information feeds into three brain areas: the cerebellum, autonomic regions that coordinate digestive activity, and systems that control eye movements. The latter can cause **vestibular-ocular reflexes**, which cause your eyes to move opposite to your head movements, thus allowing you to focus on one spot even when your head is moving.
How do sensations become perceptions?

To illustrate the workings of complex processes necessary for turning sensory information into meaningful experiences, psychologists draw attention to cases in which we perceive stimuli incorrectly, called perceptual failures.

VIII. ORGANIZING THE PERCEPTUAL WORLD

What determines how I perceive my world?

A. Principles of Perceptual Organization

1. Figure and Ground
   a) When faced with complex stimuli, perceptual systems automatically pick out certain features, objects, or sounds to emphasize.
   b) **Figure** is the emphasized features, and **ground** is the less meaningful background.
   c) Reversible figures show that our perceptual systems are actively organizing stimuli.

2. Grouping
   Grouping occurs as certain properties of stimuli lead you to group them together, more or less automatically. **Gestalt** psychologists argue that people perceive sights and sounds as organized wholes that are more than just the sum of their parts. Their principles that describe how grouping occurs are:
   a) **Proximity**: Objects that are close to each other tend to be grouped together.
   b) **Similarity**: Similar things are perceived to belong to a group.
   c) **Continuity**: Sensations that appear to create a continuous form are perceived as belonging together.
   d) **Closure**: People tend to “fill in” missing information to complete an object.
   e) **Texture**: Stimuli that have the same texture (e.g., oriented along the same directions) tend to be grouped together.
   f) **Simplicity**: People group stimuli to provide the simplest interpretation of the world.
   g) **Common fate**: Objects that are moving in the same direction at the same speed are perceived as a group.
   h) **Synchrony**: Stimuli that occur at the same time are likely to be perceived as coming from the same source.
   i) **Common region**: Elements located within some boundary tend to be grouped together.
   j) **Connectedness**: Stimuli that are connected by other elements tend to be grouped together.

B. Perception of Depth and Distance

**Depth perception** is the ability to perceive distance. Depth perception relies partly on **stimulus cues** provided by the environment and partly on the properties of our visual system.

1. Stimulus Cues
   a) **Interposition**: Closer objects block the view of distant objects.
   b) **Relative size**: If two objects are the same size, the object producing a larger retinal image is perceived as closer than the one producing a smaller image.
   c) **Height in the visual field**: More distant objects tend to be higher in the visual field.
   d) **Linear perspective**: As two lines come closer together, the perceived distance increases.
e) **Reduced clarity:** Greater distances usually yield less clarity.
f) **Light and shadow:** Shading helps contribute to perception of three dimensions.
g) **Textural gradient:** Texture appears finer, less detailed, with increased distance.

2. **Cues Based on Properties of the Visual System**
   a) In *accommodation*, muscles alter the shape of the lens to focus objects from different depths. Feedback, *accommodation cues*, about this muscle activity gives the brain information about an object’s distance.
   b) Each eyeball rotates inwardly, or *converges*, so that an object’s image projects onto each retina. The greater the inward rotation, the closer the object. Thus feedback from muscles that move the eyeballs gives information about an object’s distance.
   c) The two eyeballs are in slightly different locations, so they receive slightly different images of the same object. The brain can use this difference between the two retinal images, called *binocular disparity*, to calculate an object’s distance, as well as its depth, height, and width.

C. **Perception of Motion**

*Optical flow* is change in retinal images across the visual field that provides cues about motion

1. **Looming** is a rapid expansion in the image size of an object so that it fills the retina. The image is automatically perceived as an approaching stimulus, not an expanding object (see Size Constancy).
2. When you are moving, the flow of visual information across the retina combines with information from the vestibular and touch senses to give you the experience of motion. If visual flow is perceived without appropriate sensations from other parts of the body, motion sickness may result.
3. **Stroboscopic motion** occurs because we tend to perceive movement when a series of still images appears, one at a time, in rapid succession.

D. **Perceptual Constancy**

*Perceptual constancy* is the perception that objects keep their size, shape, color, and other properties despite changes in their retinal image.

1. **Size Constancy**
   The visual size of an object stays more or less constant regardless of changes in the size of the retinal image. The *perceived size* of the object is equal to the size of the retinal image multiplied by the perceived distance.
2. **Shape Constancy**
   As objects change orientation, the shape of their actual retinal images changes, yet shape constancy allows you to know that the object’s shape is still the same.
3. **Brightness Constancy**
   As the amount of light striking an object changes, brightness constancy allows you to perceive the object’s brightness as relatively constant. The brightness of an object is perceived in relation to its background.

E. **Size Illusions**

1. Illusions are perceptual mistakes, inaccurate interpretations of sensations.
   *Note:* Students often confuse the following terms: *illusion*, an incorrect perception of a stimulus; *delusion*, a false belief; and *hallucination*, a perception in the absence of a stimulus.
2. **Size illusions** are illusions of the visual system. They reflect our perceptual system’s attempt to process information that violates one or more of the perceptual principles.
IX. RECOGNIZING THE PERCEPTUAL WORLD

How do I recognize familiar people?

Your brain analyzes incoming patterns of information and compares those patterns to information stored in memory. If it finds a match, recognition takes place.

Two general processes occur in recognition.

A. **Bottom-up processing** relies on specific, detailed information from sensations. This information is analyzed by certain sensory feature detector cells into basic features which are then recombined to create perceptual experience.

B. **Top-down processing** involves the imposition of higher-level mental processes (experience, context, expectations, and motivation) onto an incoming stimulus, actively constructing a perception based on more than just the raw stimulus.
   1. Previous experiences help create schemas, mental representations of what we know and expect about the world. Schemas can guide or bias perception by creating a perceptual set, a readiness to perceive a stimulus in a certain way. In a tense, potentially violent situation, someone reaching for a cell phone may be perceived as reaching for a gun.
   2. Context can affect expectations and thus perception. For example, it may be easier to recognize your bank teller in the bank than when you are at a grocery store.
   3. Motivation also affects perception. For example, a hungry person might initially mistake a sign for “Burger’s Body Shop” as indicating a place to eat rather than a car body repair shop.

C. **Top-Down and Bottom-Up Processing Together**
   1. Both top-down and bottom-up processing work together. For example, in reading a word, the visual shape of the letters must be sensed (bottom-up processing), but a person uses knowledge, context, and expectancy to figure out the meaning of poorly written or degraded letters (top-down processing).
   2. Top-down processing can fill in the gaps between stimuli because the stimulus world is redundant—it provides multiple clues about what is going on.

D. **Culture, Experience, and Perception**

Experience and sensory history affect perception. People are better at recognizing and judging features of familiar objects than of unfamiliar objects. People who grow up with significantly different sensory histories or in different sensory environments are likely to have noticeably different perceptual experiences. For example, individuals from cultures in which pictures are seldom seen find it very difficult to perceive depth in photos or paintings, despite being able to perceive depth in real life.

X. LINKAGES: PERCEPTION AND HUMAN DEVELOPMENT

A. Infants stop looking at unchanging visual stimuli. This is called habituation. If the stimulus then changes, infants will start looking at it again. This is called dishabituation. These studies suggest that we are born with the basic components of feature detection.

B. The capacity to visually recognize whole objects requires a couple of months of visual experience.

C. Face perception may be a stimulus that we are born ready to recognize as a unique part of the perceptual world. Infants only a few hours old preferentially gaze at faces as compared to similar but nonface stimuli.

D. The capacity to perceive depth probably emerges more slowly than the development of object recognition. Studies using the visual cliff show that infants perceive depth before they are afraid of it.

E. A person’s visual system is a blending of maturation processes and experiences.

XI. ATTENTION
Can you run out of attention?

Attention is the process of directing and focusing certain psychological resources to enhance perception, performance, and mental experience.

A. It helps direct sensation and perception, select information for further processing, allocate mental energy to do that processing and analysis, and regulate the flow of mental resources necessary for performing a task or coordinating several tasks at once.

B. Three important characteristics of attention:
   1. It improves mental processing.
   2. Attention takes effort.
   3. It is limited.

C. Directing Attention
   1. Overt orienting is shifting attention by physically pointing sensory systems directly onto a to-be-attended-to stimulus, such as when you move your eyes onto something you are viewing.
   2. Covert orienting is shifting attention without making a physical effort, such as when you think about something without directly seeing it.
   3. As overt and covert orienting suggest, attention control can be voluntary (goal-directed, purposeful) or involuntary (stimulus-driven).
   4. Attention is selective, focusing on some stimuli more than others.
      a) Inattentional blindness occurs when you are so focused on one aspect of the environment that you fail to perceive changes in other parts of the environment.
      b) Parallel processing is the ability to search rapidly for targets in several locations at once. This early feature analysis is automatic, not requiring volitional effort, and allows quick “pop out” of relevant stimuli.

D. Dividing Attention
   1. Divided attention occurs when you simultaneously devote mental resources to more than one thing. Since attention is limited, it can only be divided to a certain point.
      a) Sometimes, it is difficult to focus attention on only one thing. For example, in the Stroop task it is difficult to ignore the meaning of the word and only pay attention to the color of ink it is printed in.
      b) If one task is automatic, it requires less attention, thus making it easier to attend to a second task.
      c) It may be possible to perform two tasks requiring attention simultaneously, as long as each taps into different kinds of attention.

E. Focus on Research: Attention and the Brain
   1. What was the researcher’s question?
      If directing attention to more than one task causes extra mental work to be done, does information processing in the brain slow down?
   2. How did the researcher answer the question?
      One group of participants attended to one task (responding to a light), while another split their attention between two tasks (responding to a light and counting tones). Then the speed of their reactions to the flashing light was measured.
   3. What did the researcher find?
      When attention had to be shared between information required for two tasks, reaction times were slower.
   4. What do the results mean?
Finding slower reaction times suggests that information processing in the brain was slower, too. PET scans show that when attention is divided, blood flow is shared between two locations, versus one location when faced with a single task.

5. *What do we still need to know?*

We still need to determine the limits of attention and processing, the means by which attention is shared, and the specific parts of the brain that are involved in attention, whether divided or undivided.