Sensation and Perception

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RESOURCES

Introducing Sensation and Perception

Podcast/Leccture/Discussion Topic: Person Perception

As an extension of the text chapter's opening description of Heather Seller's problem with recognizing faces, have students listen to RadioLab's podcast "Strangers in the Mirror." Radiolab is a radio program produced by WNYC and heard across the country on public broadcasting stations. The episodes, hosted by Jad Abumrad and Robert Krulwich, are witty, insightful, and focused on understanding and informing the public about interesting (even intriguing) scientific issues and phenomena. The podcasts are produced from its weekly episode. They are available as free downloads from iTunes, as well as directly from their website (www.radiolab.org); they vary in length from about 6 minutes to more than an hour (depending on the topic and purpose of the episode). They are well produced (lots of sound effects, music, suspense); you and your students will enjoy listening to them as well as learning from them.

In the "Strangers in the Mirror" episode (www.radiolab.org/story/91967-strangers-in-the-mirror), which was recorded at the annual World Science Festival in New York City, we listen in on a conversation among Robert Krulwich and two famous individuals who suffer from face blindness, the inability to recognize familiar faces. One is Oliver Sacks, the famous neuroscientist and prolific author. The other is Chuck Close, a painter made popular by his unusual style of painting faces. This episode was broadcast June 15, 2010, and is 26:25 minutes long.

Another Radiolab episode related to prosopagnosia/face blindness is "Do I Know You?" (www.radiolab.org/story/91947-do-i-know-you//) in which the hosts discuss interviews with Dr. Carol Berman and Dr. V. S. Ramachandran to understand a rare delusional disorder called capgras. In this disorder, the person can process and recognize faces, but suffers a disturbing "disconnection" between knowledge of the face's familiarity (e.g., "That person looks just like my mother . . .") and associating that face to the presence of the actual person (e.g., ". . . but that person is NOT my mother"). This leaves the sufferer to experience the perception that the person (s)he is literally seeing is merely an "imposter" of the familiar person. This experience seems to be limited to visual processing. This episode was broadcast March 8, 2010, and is 9:43 minutes long.

Another related reading is an article by Abumrad and Krulwich, called *Seeing Imposters: When Loved Ones Suddenly Aren't,* on National Public Radio's website: www.npr.org/templates/story/story.php?storyId=124745692.

Basic Principles of Sensation and Perception

Lecture/Discussion Topic: Sensation Versus Perception

Sensation refers to how our sensory receptors and nervous system receive and represent stimulus energies from our environment. Perception refers to how we organize and interpret sensory information. Sensation provides the raw information that perception constructs into our experiences.

Douglas Bloomquist suggests using a "puzzle picture" to illustrate the complex nature of perception as opposed to sensation. Distribute a copy of Handout 1 to each student. Most will not immediately perceive a meaningful configuration. For the top figure, K. M. Dallenbach states that the picture "appears when first scrutinized as an amorphous blotch without meaning or organization. Clearly, one is receiving stimulation, but it is a meaningless array of black, white, and gray." Another psychologist likens the experience to what William James described as a baby's first perceptual experience, that is, "one great, blooming, buzzing confusion."

Bloomquist argues that in viewing puzzle pictures we readily come to appreciate that perception is an active process. We struggle to impose some organization upon the meaningless array we are sensing. We may even generate hypotheses about the figures, then test them by searching the picture for features that are congruent with those hypotheses. After a few minutes of unsuccessful inspection, we are likely to experience some degree of frustration.

The subject of the picture is a Dalmatian dog. Why is it difficult to see? First, it is not a complete figure. Dallenbach suggests that even when asked to see a dog, we may adopt a set to perceive an entire figure, not part of one. A related explanation is that the contours are insufficient to readily differentiate figure from ground. Both figure and ground are made up of irregular spots of black and white.

The bottom figure, which is known as a Fraser spiral, is provided by Stanley Coren and his colleagues as another example of the distinction between sensation and perception. Although the figure appears to form a spiral, it is actually a set of concentric circles. Instruct students to place one figure on any line composing the spiral. Then have them place a finger from the other hand beside it and begin tracing the circle while holding their first finger in place. Eventually, they will return to the first finger confirming the figure to be a circle.

Bloomquist, D. W. (1985). Teaching sensation and perception: Its ambiguous and subliminal aspects. In A. M. Rogers and C. J. Sheirer (Eds.), *The G. Stanley Hall lecture series: Volume 5* (pp. 157–203). Washington, DC: American Psychological Association.

Coren, S., Ward, L. M., & Enns, J. T. (2003). *Sensation and perception* (6th ed.). New York: Wiley.

Dallenbach, K. M. (1951). A puzzle-picture with a new principle of concealment. *American Journal of Psychology, 64,* 431–433.

Goldstein, E. B. (2010). *Sensation and perception* (8th ed.). Pacific Grove, CA: Wadsworth.

Classroom Exercise/Student Project: The Wundt-Jastrow Illusion

David Pick suggests use of the Wundt-Jastrow illusion to highlight the distinction between sensation and perception. This compelling and reliable illusion is easy to demonstrate and is a wonderful opener to class discussion of perception. On the next page is the template for constructing the illusion. Enlarge it approximately 300 percent, using an 11" x 17" sheet of paper and then trace two copies onto posterboard. Cut out the two segments for presentation in class. Initially, present them side by side, curving in the same direction, and ask if one appears larger. *This is truly a dramatic illusion with the segment on the inside curve appearing undeniably larger*. Reverse the position of the two segments, and your class will be astonished to find that the apparently smaller segment now appears to be the larger. Then place one over the other to convince your audience that they are indeed the same. Finally, present the segments curving away from each other and they will also appear equivalent. Emphasize that while the same *sensation* is produced by the two stimuli, under certain conditions the *perception* of them is very different. By the late nineteenth century, when psychology was emerging as a discipline, perceptual illusions such as this one had already begun to fascinate scientists. Illusions mislead us by playing on the ways we organize and interpret our sensations. Understanding illusions can sometimes provide valuable clues to the ordinary mechanisms of perception.

Pick suggests making the illusion the basis for a project in which students attempt to discover its underlying explanation. He suggests that they begin by searching the literature. It is variously referred to as the Wundt-Jastrow illusion, the Jastrow illusion, the ring segment illusion, and the concentric arc illusion.

Pick notes that J. O. Robinson's work contains the most extensive discussion of the illusion but offers no final explanation of it. Students might also formulate their own hypotheses and design appropriate experimental tests to be presented in class.

Pick, D. (1992, August). The Wundt-Jastrow illusion as a classroom demonstration. In Smith, R. A. (chair), Live from Washington—It's Sunday afternoon! An invited presentation made at the 100th Annual Convention of the American Psychological Association, Washington, DC.

Lecture/Discussion Topic: Top-Down Processing

Christopher Green passed along the following sentences that you might present in class to introduce top-down processing when discussing differences between sensation and perception.

> Aoccdrnig to rscheearch at Cmabrigde Uinervtisy, it deosn't mttaer in waht oredr the ltteers in a wrod are, the olny iprmoetnt tihng is taht the frist and lsat ltteer be at the rghit pclae. The rset can be a total mses and you can sitll raed it wouthit a porbelm. Tihs is bcuseae the huamn mnid deos not raed ervey lteter by istlef, but the wrod as a wlohe.

Our experience and expectations enable us to immediately perceive the scrambled letters as meaningful words and sentences.

The notion that higher-level processes guide our perceptions can be traced all the way back to Herman von Helmholtz's proposed *likelihood principle*: We will perceive the object that is most likely to be the cause of our sensory stimulation. That is, if a number of different objects could have caused a specific pattern of light and dark on the retina, we will perceive the object that is most likely to occur in that particular situation. For example, in one study participants were shown a kitchen scene and then briefly flashing pictures of a drum, mailbox, and loaf of bread. Most correctly identified the loaf of bread (which, of course, is appropriate to the kitchen scene) but not the mailbox or drum.

A contemporary extension of the likelihood principle is Richard Gregory's suggestion that perception is governed by *hypothesis testing*. He states, "We may think of sensory stimulation as providing data for hypotheses concerning the state of the external world." We may hypothesize that a dimly lit object across the room is a small table but in looking more closely in the corner find the hypothesis is incorrect. On the basis of new data gathered, we revise the hypothesis: the "table" is actually a chest of drawers. In summary, we do not perceive in an automatic, nonthinking way. Rather, as Goldstein concludes, "Our perceptions are determined by a combination of automatic processes that begin with properties of the stimulus, and individualistic processes that depend on a person's past experiences, knowledge, and expectations."

Goldstein, E. B. (2010). *Sensation and perception* (8th ed.). Pacific Grove, CA: Wadsworth.

Green, C. (2003, September 17). FW: Wrkos for me. Message posted to tips@acsun.frostburg.edu.

Classroom Exercise: A Scale to Assess Sensory-Processing Sensitivity

In her 1999 book, *The Highly Sensitive Person: How to Thrive When the World Overwhelms You,* Elaine Aron suggests that high sensitivity is an innate trait found in as many as one out of every five people. It is as common in men as it is in women. Aron claims that high sensitivity has sometimes been confused with shyness or introversion. However, these are quite different personality dimensions. In fact, she estimates that 30 percent of highly sensitive persons are extraverts. Very likely, a culture that prefers confident, bold extraverts is one that views sensitivity as a weakness and confuses it with timidity. Aron's Highly Sensitive Person website, includes a 27-item checklist students can complete to determine their relative level of sensitivity (see hsperson.com/test/highly-sensitive-test).

Highly sensitive persons only appear inhibited because they are more aware of all the possibilities in a situation. They naturally process information from the environment more carefully and study it thoroughly before acting. Highly sensitive people possess a more sensitive nervous system and thus are more aware of subtleties in their surroundings, an advantage in many situations. Indeed, many are intellectually gifted, unusually creative and productive workers, and attentive and thoughtful in close relationships. However, highly sensitive persons are also more easily overwhelmed when in a highly stimulating environment. They become exhausted when bombarded by multiple stimuli, and they need more down time to recover. In short, high sensitivity, concludes Aron, is neither a flaw nor a reason to brag. Rather, it is a trait that highly sensitive persons must learn to use wisely.

The Sensory-Processing Sensitivity Scale is positively correlated with stress, depression, and anxiety and negatively correlated with mindfulness (being aware of what is happening in the moment) and acceptance (accepting whatever is happening without judgment). Researchers are investigating whether mindfulness training could be an effective psychotherapeutic technique for those who struggle with high sensory-processing sensitivity (Bakker & Moulding, 2012).

Aron, E. N. (1999). *The highly sensitive person: How to thrive when the world overwhelms you*. New York: Random House.

Bakker, K., & Moulding, R. (2012). Sensory-processing sensitivity, dispositional mindfulness and negative psychological symptoms. *Personality and Individual Differences, 53*(3), 341–346. doi: 10.1016/j.paid.2012.04.006.

Zeff, T., & Aron, E. N. (2004). *The highly sensitive person's survival guide: Essential skills for living well in an overstimulating world.* Oakland, CA: New Harbinger Publications.

Classroom Exercise: Human Senses Demonstration Kits

Carolina Biological Supply Company (carolina.com) provides two demonstration kits for the human senses. Materials and suggested activities illustrate principles of vision, touch, taste, and smell. Each kit provides supplies for up to 30 students. Lab-Aids Human Senses Experiment Kit (Item #694505) retails for $114.50; Human Senses Biokit (Item #694506) costs $79.95. A complete description of each can be found at the Carolina website. To order and obtain more information you can also call Customer Service at 800-334-5551.

Lecture/Discussion Topic: "Thin-Slicing"

We all speedily and efficiently transform sensations into perceptions. Even microslices of people's appearance and behavior tell us something. For example, John Bargh's research indicates that we always interpret an object or a face, even if we see it for only 200 milliseconds. "We're finding that everything is evaluated as good or bad within a quarter of a second of seeing it," argues Bargh. In an eyeblink, we find ourselves loving or hating a new roommate, an abstract painting, or a relative's new car.

These instantaneous perceptions make biological sense. When encountering a stranger in the forest, one had to immediately assess whether that person was friend or foe. Those who read the person's expression accurately were more likely to survive and reproduce, which helps explain why people today can read in a glance facial expressions of fear, anger, sadness, or pleasure.

Nalini Abady and Robert Rosenthal (1993) discovered the speed of our perceptions within the classroom setting. They videotaped 13 Harvard University graduate students teaching undergraduate courses. Research participants observed three 10-second slices of each teacher's behavior from the beginning, middle, and end of a class and then rated the teacher's confidence, activeness, warmth, and so on. The ratings based on watching only 30 seconds of behavior very accurately predicted average student ratings of teachers at the end of the semester. In fact, even thinner slices—three 2-second clips—gave ratings that still correlated +.72 with end-of-course evaluations. Thus, instant first impressions predicted lasting impressions.

In other studies, research participants hear people recite the alphabet and accurately perceive their social assertiveness. They also watch 90 seconds of people walking and talking and accurately predict how others evaluate them. After a quick glance at someone's photo, people have a pretty good sense of the person's extraversion and agreeableness.

Ambady and her graduate student Nicholas Rule (2008) reported that observers can accurately spot a man's sexual orientation at levels greater than chance with a less than half-second glance at his face. Using photographs from online personal ads for homosexual and heterosexual men, the researchers asked their research participants to choose whether the men were likely to be gay or straight. Results indicated that participants accurately picked sexual orientation about 70 percent of the time within one-tenth of a second. Ambady suggests that the human ability to recognize sexual orientation may be tied to the evolutionary drive to find a mate.

How much information do we need from our friends to know how well they're doing after a break up? Not much. Ashley Mason and colleagues (2010) at the University of Arizona interviewed 66 people who experienced a marital separation in the last few months. Each was then asked to speak for 4 minutes about the separation and complete an objective adjustment measure. The adjustment measure was completed again 3 months later. A 30-second clip was taken from each of the interviews. One group of research participants listened to the clips; another group read the transcripts of those same clips. Each research participant was then asked on a scale of 1 to 7 to evaluate how well the person was doing—for example, how is the person coping, how much is the person ruminating about their former partner. The assessments of both research groups correlated with how the recently separated said they were doing, but only the assessments of those who listened to the clips predicted how the recently separated would do 3 months later.

For more on the strengths and weaknesses of our social perceptions, see Myers' *Intuition: Its Powers and Perils* (Yale University Press, 20202) and Malcolm Gladwell's *Blink: The Power of Thinking Without Thinking* (Little, Brown, 2005).

Ambady, N., & Rosenthal, R. (1993). Half a minute: Predicting teacher evaluations from thin slices of nonverbal behavior and physical attractiveness. *Journal of Personality and Social Psychology, 64,* 431–441.

Azar, B. (1998, September). Split-second evaluations shape our moods. *APA Monitor,* 13.

Mason, A. E., Sbarra, D. A., & Mehl, M. R. (2010). Thin-slicing divorce: Thirty seconds of information predict changes in psychological adjustment over 90 days. *Psychological Science, 21*(10), 1420–1422. doi: 10.1177/0956797610381507

Rule, N., & Ambady, N. (2008). Brief exposures: Male sexual orientation is accurately perceived at 50 ms. *Journal of Experimental Social Psychology, 44,* 1100–1105.

Thresholds

Lecture/Discussion Topic: Gustav Fechner and Psychophysics

In pioneering the study of the relationship between physical energy and psychological experience, Gustav Fechner (1801–1887) was actually attempting to promote his belief that every person, animal, and plant in the universe is composed of both matter and soul. Although trained in medicine, Fechner soon turned his attention to physics and mathematics and held a professorship at the University of Leipzig. As part of his research, he discovered that after staring at the sun for some time, he would see an afterimage (blue, the complement of yellow). He began to devote all his time to this psychological research. Although his findings were well-received, the work led him to suffer photophobia and emotional collapse. Virtually blind, he spent a long period in a darkened room where, Morton Hunt reports, "he was tormented by pain, emotional distress, intolerable boredom, and severe digestive problems." He eventually began to improve and to see again without pain. As he emerged from his room he walked into a garden where the flowers appeared brighter, more beautiful, and more intensely colored than ever before. This led him to write a book about the mental life of plants, and for the rest of his life he sought to promote his theory that consciousness and matter coexist throughout the world. Hunt describes how this mystical notion led Fechner to his historic work in experimental psychology.

Lying in bed on the morning of October 22, 1850, wondering how to prove that mind and body are two aspects of a fundamental unity, Fechner had a sudden insight. He thought that if somehow he could show a consistent mathematical relationship between the force of stimuli and the intensity of the sensations they produce, he would have established the identity of body and mind. Fechner asked the important question: Is there a consistent mathematical relationship between the magnitude of a stimulus and the magnitude of the sensation it creates? Although he could measure stimulus intensity directly, Fechner thought he faced an enormous problem in measuring sensations. They are subjective. Finally, he realized he could do so indirectly by using sensitivity as the guide. He could determine the smallest increase in stimulus strength that would be just barely noticeable to the research participant. "Just barely noticeable" meant the same thing at any level. That measurement of sensation could be compared with the increase in stimulus necessary to produce the awareness.

The three methods of experimental measurement used by Fechner continue to be used in psychophysical research. In the *method of limits,* the researcher begins with a minimal stimulus and increases it until the participant can perceive it. To determine a just noticeable difference, the researcher presents a standard stimulus and a comparison stimulus and increases the difference between them by small steps until the participant says it is perceptible.

In the *method of right and wrong cases,* the experimenter presents identical stimuli repeatedly—either single stimuli at the threshold or pairs of stimuli that are very similar. The participant responds “Yes” (if she perceives it, or the two are different) or “No” (if she does not perceive it or the two are not different). The responses yield averages and these tell how likely it is that at any given stimulus level or difference between stimuli, the participant will perceive the stimulus or the difference.

In the *method of adjustment,* the researcher or participant adjusts a comparison stimulus until it appears identical to the standard stimulus. Of course, there is always a small margin of error. Every error is recorded and after many trials, the average error is computed. It, too, provides a measure of just noticeable difference.

In recognizing Fechner’s contributions, the great historian of psychology Edwin G. Boring writes, “Fechner, because of what he did and the time at which he did it, set experimental quantitative psychology off upon the course which it has followed. One may call him the ‘founder’ of experimental psychology, or one may assign that title to Wundt. It does not matter. Fechner had a fertile idea which grew and brought forth fruit abundantly.”

Hunt, M. (2007). *The story of psychology*. New York: Doubleday.

Student Project: The Variability of the Absolute Threshold

An absolute threshold is defined as the minimum amount of stimulation a person needs for a particular stimulus to be detected 50 percent of the time. Students can experience the variability of the absolute threshold for sound by placing a kitchen timer on a table in an otherwise quiet room. They should move away so that they can no longer hear the ticking, then gradually move toward the timer until they begin to hear the sound. This is their “momentary” threshold. If they remain where they are, they will notice that occasionally they won’t be able to hear the sound and will need to step forward to reach threshold. At other times the sound will get louder and they will be able to step back. This changing sensitivity indicates that the “absolute threshold” is anything but absolute. Our sensitivity changes from moment to moment and from measurement to measurement. As long ago as 1888, Joseph Jastrow speculated that lapses of attention, slight fatigue, and other psychological changes could cause fluctuations in the absolute threshold.

Coren, S., Ward, L., & Enns, J. T. (2003). *Sensation and perception* (6th ed.). New York: Wiley.

Lecture/Discussion Topic: Subliminal Smells

You may want to expand your discussion of subliminal stimulation to cover research on the impact of subliminal odors. Wen Li and her research team at Northwestern University reported that subliminal scents can affect how much we like someone. “We evaluate people every day and make judgments about who we like or don’t like,” claims Li. “We may think our judgments are based only on various conscious bits of information, but our senses also may provide subliminal perceptual information that affects our behavior.”

To assess whether subliminal smells affect social preferences, research participants sniffed three different scents: lemon (good), sweat (bad), and ethereal (neutral). The odors were delivered just below detection levels. (Research participants were told that an odor would be present in 75 percent of the trials.) Most people proved unaware of the barely perceptible odors.

After sniffing from each of the bottles, the research participants were shown a face with a neutral expression. They were asked to evaluate it using ratings that ranged from extremely likable to extremely unlikable. Odor significantly affected likability ratings for those participants who lacked conscious awareness of the smells. People who discerned that the minimal smell was present were not affected by the scents. “The study suggests that people conscious of the barely noticeable scents were able to discount that sensory information and just evaluate the faces,” observed Li. “It only was when smell sneaked in without being noticed that judgments about likability were biased.”

“When sensory input is insufficient to provoke a conscious olfactory experience, subliminal processing prevails and biases perception,” Ken Paller added. “But as the awareness of a scent increases, greater executive control in the brain is engaged to counteract unconscious olfaction.”

The acute sensitivity of human olfaction tends to be underappreciated. “In general, people tend to be dismissive of human olfaction and discount the role smell plays in our everyday life,” concluded Jay Gottfried. “Our study offers direct evidence that human social behavior is under the influence of miniscule amounts of odor, at concentrations too low to be consciously perceived, indicating that the human sense of smell is much keener than commonly thought.”

Lee Sela and Noam Sobel (2010) of the Weizmann Institute of Science in Israel have written a wonderful summary of the literature on the effects of subliminal smells. In addition to influencing social perception, for example, subliminal smells have been found to influence mood, cognitive performance, and behavior.

Li, W., Moallem, I., Paller, K.A., & Gottfried, J. A. (2007). Subliminal smells can guide social preferences. *Psychological Science, 18,* 1044–1049.

Northwestern University (2007, December 8). Subliminal Smells Bias Perception About A Person's Likeability. *ScienceDaily.* Retrieved August 4, 2008, from www.sciencedaily.com/releases/2007/12/071206163437.htm.

Sela, L., & Sobel, N. (2010). Human olfaction: A constant state of change-blindness. *Experimental Brain Research, 205*(1), 13–29. doi: 10.1007/s00221-010-2348-6.

Lecture/Discussion Topic: Subliminal Persuasion

Anthony Pratkanis notes that at various times a claim regarding subliminal persuasion has been made and, although it has been unsubstantiated or validly criticized on methodological grounds, the original claim has gained acceptance in lay audiences. To understand this acceptance, Pratkanis did a content analysis of popular-press articles on subliminal persuasion published between 1955 and 1987. He identified five factors that contribute to their effect on the public's beliefs regarding subliminal influence. His analysis, first reported in 1990, remains instructive today.

First, popular accounts of subliminal influence appeal to the "pop" psychology of the day. Many Americans believe in a powerful unconscious capable of performing amazing feats. Subliminal influence is portrayed in the media and by proponents as a means of directly communicating to this unconscious.

Second, popular accounts link subliminal influence to the issue of the day. Subliminal influence first emerged as a national concern after the Korean war when brainwashing and hypnotic suggestion captured the nation's imagination in films such as *The Manchurian Candidate*. In the post-Watergate years, Americans felt that their leaders were involved in devious conspiracies of the type dramatized in *Network*. Wilson Bryan Key, author of *Subliminal Seduction,* capitalized on the idea that big business and big government were conspiring to get us. Today's producers of subliminal tapes link their products to the growing interest in human potentials and self-enhancement.

Third, those advertisers accused of using subliminal persuasion to manipulate the public are subjected to what can be termed "the witch test." During the Middle Ages, a woman accused of witchcraft would be bound and thrown into a pond. If she floated, she was a witch. Only if she drowned was her innocence affirmed. How do we know that advertisers use subliminals and that they work? According to writers such as Key, advertisers would not spend so much money on them if they did not work. The fact that subliminal messages cannot be readily identified demonstrates the advertiser's craftiness. The protestations of the accused are merely signs of guilt. The only way advertisers could prove their innocence is by going out of business. In contrast, the motives of the proponents of subliminal seduction who frequently profit by the sale of more books and tapes are rarely questioned.

Fourth, many of the popular articles fail to report scientific evidence that is critical of claims for subliminal persuasion. If negative information is given, it is often presented at the end of the article, giving the reader the impression that, at best, the claims for subliminal effectiveness are somewhat controversial.

Finally, belief in subliminal persuasion may serve a need for many individuals. We live in an age of persuasion. The average American is likely to see more than 6 million ads in a lifetime, yet he or she knows little or nothing about the persuasion process. Subliminal persuasion is presented as an irrational force outside the control of the message recipient. In this way, it takes on a supernatural "the devil made me do it" quality capable of explaining why Americans engage in irrational consumer behavior. "Why did I buy this worthless product at such a high price?" Subliminal sorcery!

Pratkanis, A. (1990). Subliminal sorcery then and now: Who is seducing whom? In Haugtveldt, C., & Rosen D. (Eds.), P*roceedings: Society for Consumer Psychology,* 84–86.

Student Project: Understanding Weber's Law

Stanley Coren and his associates suggest a simple demonstration of Weber's law for the perception of heaviness. Students need three quarters, two envelopes, and a pair of shoes. Have them place one quarter in one envelope and the remaining two quarters in the other. Lifting each envelope, they can easily determine which is heavier. Now have them put each envelope in a shoe. When they lift the shoes, one at a time, the weight difference will be imperceptible. Weber's principle: Difference thresholds grow with the magnitude of the stimulus.

Students can also try a more precise weight discrimination task to demonstrate Weber's law. Art Kohn and Max Brill describe how students can prepare an ascending scale of weights by inserting increasing numbers of BBs from a pop gun, or other similar items, into small containers (like a plastic pill or travel bottle). The weights must differ by exactly equal increments and should be noted on the bottom of each bottle. Volunteers can then be asked to arrange the bottles from lightest to heaviest. Difficulty in discrimination will increase as the bottles get heavier.

Coren, S., Ward, L., & Enns, J. T. (2003). *Sensation and perception* (6th ed.). New York: Wiley.

Kohn, A., & Brill, M. (1981). An introductory laboratory demonstration produced entirely by undergraduates. *Teaching of Psychology, 8*(3), 133–138.

Lecture/Discussion Topic: Applying Weber's Law

Weber's law can be applied to many situations. For example, a $10-per-hour worker may require a 50-cent pay raise to notice the difference; a $20-per-hour worker may need to receive a $1 raise to notice.

Robert Cialdini illustrates the principle for sales. Assume that a man wants to buy a suit and a sweater. If you were the salesperson, which should you show him first to get him to spend the most money? You might think it best to sell the sweater first. Having spent a lot on a suit, the customer might be reluctant to spend more on a sweater. However, sales motivation analysts suggest the opposite. Sell the suit first because the additional cost of the sweater will not be so readily noticed. If the man has just paid $300 for a suit, an additional $75 for a sweater will not seem excessive. The same applies to other accessories, such as a shirt or shoes. As a rule, people will almost always pay more for accessories if they buy them after rather than before a more expensive purchase.

The same principle holds for the purchase of accessories on a new car. After paying $32,000 for the car, the customer will hardly notice $700 for a sound system to go with it. The trick, of course, is to mention these accessories independently so that each addition will seem negligible in comparison to the much larger commitment already made.

Cialdini, R. B. (2009). *Influence: Science and practice* (5th ed.). Needham Heights, MA: Allyn and Bacon.

Sensory Adaptation

Student Project: Sensory Adaptation

Adaptation to the taste of one substance can affect the taste of another, either decreasing or increasing our sensitivity to it. This phenomenon has sometimes been called "cross-adaptation." After drinking tea with lemon, for example, a grapefruit will not taste sour. After eating a sweet roll, on the other hand, grapefruit juice may taste extremely sour.

The variability in the taste of ordinary tap water following adaptation to various substances will surprise many students. Have them mix a strong solution of water and salt and hold it in their mouth for a time; it will gradually taste less salty. If they then take a glass of fresh water, it will taste bitter or sour. Conversely, if they first take a mouthful of diluted vinegar or strong, caffeinated coffee, the glass of water will taste sweet. (A way to make anything taste sweet is to eat miracle fruit first. You can purchase tablets made from miracle fruit online for approximately $1.50 per tablet. They typically come in packages of 10.)

Dani Raap brings the familiar fruity-smelling magic markers to class to demonstrate adaptation to odor. Give each student a marker to sniff and rate his or her perception of the intensity of the aroma from 1 to 20. Have students repeat quick successive sniffs and each time again rate the strength of the odor. Raap indicates that the aroma completely disappears by the fourth or fifth sniff. After a few minutes of discussion and no sniffing, each student should pair up with a partner. After sniffing to adaptation, have students quickly change markers and whiff. In a class of 30, Raap reports that 3 experienced cross-adaptation (smelled nothing); the remaining students easily smelled the new stimulus. Many of them actually experienced facilitation (heightened intensity) of the new smell.

Raap, D. (2000, April 13). Sensation/perception. Message posted to TIPS@fre.fsu.umd.edu.

Fisher, J. (1979). *Body magic*. New York: Stein and Day.

Classroom Exercise: Eye Movements

Our eyes are always moving, quivering just enough to guarantee that the retinal image continually changes. If our eyes were to stop moving, sense receptors would be fatigued and images would vanish.

The figures in Handout 2 will vividly demonstrate these eye movements, as well as their importance in maintaining vision. Fixating on the center of the pattern of (a) leads immediately to the perception of movement. After students stare at it for 30 seconds, they should stare at a white surface (e.g., a piece of paper or a wall). Most will see an afterimage of rotary motion, owing in part to the involuntary eye movements during fixation. Next, have your students stare at the small black dot in the middle of (b) for about 60 seconds and then look at the white dot. Even if they try very hard to look steadily at the white dot, they will see an image of the grid pattern jiggling on top of the figure. Again, this jiggle is due to involuntary eye movements. Finally, have them stare at the fuzzy-contoured disc on the right in (c). If they keep their eyes very still for about 30 seconds, the disc will disappear. They will find that it is very difficult, if not impossible, to do this with the sharp-contoured disc on the left side of the figure. The explanation for this difference? The image of the fuzzy disc jiggling on the retina causes only slight changes in the amount of light stimulating the receptors near the contour. If the eyes are kept still enough, the small change in stimulation caused by movement of this fuzzy contour is not enough to maintain perception and the disc fades from view. When looking at the sharp disc, the slight jiggling of the eyes causes the sharp contour to fall first on some receptors and then on others. Thus, the amount of light stimulating the receptors is constantly changing and the disc remains visible.

Ninio, J. (2001). *The science of illusions.* Ithaca, NY: Cornell University Press.

Classroom Exercise: Sensory Adaptation in the Marketplace

At least two different household products are available in the marketplace that make use of the phenomenon of sensory adaptation: Febreze's NOTICEables. and Glade's Lasting Impressions Air Freshener. Both products are air fresheners that use warmed oil to scent the air with fragrances. To assess your students' understanding of sensory adaptation, ask them to answer the first two questions without any leading information or explanation from you.

1. Provide a general definition for the concept of sensory adaptation.
2. If you were a marketing manager for an air freshener company, why should you be concerned about sensory adaptation?

Students can work individually or in small groups to answer these questions. You can present the questions one at a time, or together. Allow about 10 minutes for them to respond.

Now, on a classroom computer, pull up the product web pages for either NOTICEables or Lasting Impressions and have students do the following:

3. Explain, from a psychological standpoint, how this product works to support the claims made by the company. Be sure to include at least two features of human sensation or perception in your response.

Perceptual Set

Lecture/Discussion Topic: Do Red Objects Feel Warmer or Colder Than Blue Objects?

Looking at red and blue objects, we expect the red objects to feel warmer than the blue objects. When we actually touch the objects, though, we perceive the red object to be cooler. Ask students why they think this might be.

If we expect a red object to be warm, and we touch it and it is not warm, we overcorrect and perceive it to be cool. If we expect a blue object to be cool, and we touch it and it is not cool, we overcorrect and perceive it to be warm. Our expectations influence our experience.

Fogleson, B. (2014, July 3). Red objects strangely feel cooler to the touch than blue ones. Retrieved from http://www.scientificamerican.com/article/red-objects-strangely-feel-cooler-to-the-touch-than-blue-ones.

Classroom Exercise: Perceptual Set

The role of our expectations in perception is readily demonstrated in class. John Fisher provides two very simple, yet effective exercises. Ask your students to call out the number that follows each of these: 32 . . . 73 . . . 373 . . . 2624 . . . 4099. Most will follow the last with 5000 rather than the correct 4100. Or, try the following word game. Ask a volunteer to pronounce some words you will spell out. Then spell: MAC DONALD . . . MAC HENRY. . . MAC MAHON . . . MACHINERY. Most will be trapped into pronouncing the last word as a fictitious Scottish surname.

Marvin Grosswirth and Abbie Salny suggest other misperceptions resulting from expectations. Write the following on the board and ask students to provide punctuation that will make the words meaningful: "TIME FLIES I CANT THEYRE TOO FAST." The apostrophes come easily, but the rest is difficult. TIME FLIES. I CAN'T. THEY'RE TOO FAST. It still does not seem to make sense because we're too familiar with the slogan, "Time flies" in which "time" is a noun and "flies" is a verb. Tell students to read "time" as the verb and "flies" as the noun. It now makes perfect sense.

Ask students to pronounce the following after you have printed it on the chalkboard:

CHO
PHO
USE

You are likely to get "shoe-foe-use." Then string the letters out to spell, "Chophouse."

Read the following riddle: "Sally announces to her kindergarten classmates that today is the birthday of both her father and her grandfather. Both are exactly 50. Her teacher says that's impossible. Can Sally be right?" Yes, Sally's father is 50 and her mother's father (Sally's grandfather) is 50. Obviously, her mother is much younger than her father.

Perceptual set based on sound is also illustrated by asking your class to shout out the answers to the following questions. "What do these letters spell?" (Write FOLK on the board.) "How about these?" (Write CROAK.) "And what do these letters spell?" (Write SOAK.) "What do we call the white of an egg?" Students will respond, "YOLK." Or, ask your class to read the letters SHOP. Then ask them to call out what they do when they come to a green light. STOP?

What we see can influence what we hear. In this 2-minute YouTube video (youtu.be/7-ZnPE3G_YY) a congregation is singing, but the acoustics are such that the words are hard to make out. Humorous subtitles included with the video influence what words we hear. Sometimes, listeners mishear lyrics all on their own. Once they impose those lyrics on a song, it's difficult for them to hear any other words. For examples of misheard lyrics, see kissthisguy.com.

J. R. Corey provides students with different lists of anagrams to demonstrate perceptual set. Half your class should get the "animal" list: LULB, CALEM, NUKKS, SEUMO, BAZER, EAP. The other half should get the "vegetable" list: NORC, NOONI, MATOOT, PREPPE, TEBE, EAP. Instruct your students to work independently and to solve the anagrams in order. Then ask those given the animal list if they solved the last anagram as APE; ask those given the vegetable list if their last solution was PEA. Corey reports that 80 to 90 percent of students follow the established set.

In the summer of 2010, this example of perceptual set made the rounds on the Internet. Show students an image of a mallard so that the beak is in full view. Now point out that the beak looks like the face of a dog. See, for example: cheezburger.com/4405184768. Show other images of ducks with similar beak markings, such as the Muscovy duck, ruddy duck, and wigeons, Once students have the experience of seeing dog faces in duck beaks, they can't help but see dogs faces in duck beaks. What has been seen cannot be unseen.

Corey, J. R. (1990). Psychological set and the solution of anagrams. In V. P. Makosky, C. C. Sileo, L. G. Whittemore, C. P. Landry, & M. L. Skutley (Eds.), *Activities handbook for the teaching of psychology* (Vol. 3). Washington, DC: American Psychological Association.

Fisher, J. (1979). *Body magic*. New York: Stein and Day.

Grosswirth, M., & Salny, A. (1981). *The Mensa genius quiz book*. Reading, MA: Addison-Wesley.

Classroom Exercise: Perceptual Set and Gender Stereotypes

Stereotypes about gender or culture provide examples of perceptual sets that can affect perception. Kathryn Ganske and Michelle Hebl have designed a classroom demonstration that shows the powerful impact of gender stereotyping.

The exercise requires six student volunteers, divided into two groups of three. Have them leave the room, then tell your class that the volunteers will simply be asked to retell a story. The class should listen carefully and record how the story changes as each volunteer retells the story. Have the first volunteer return to the classroom. Explain that you are going to read a brief story and his or her task will be to retell it as accurately as possible to the second volunteer. Proceed by reading the following:

> John received a letter in the mail notifying him that he had lost the Texas State Achievement in Math Competition. He had wanted to win and was unhappy with the results. He had been the best student in his math class last year. Losing really hurt his self-esteem. He found out that Terry Browning had done better than him. He hated Terry Browning for that. To make himself feel better, he cried, baked cookies, kicked something, took a long bath, and talked to his best friend. After that, he went to the mall where he shopped and played video games in the arcade until he had beaten all the records. He then went running and came home to watch *The Princess Bride.*

After the volunteer has heard the entire story, have the second student reenter the room and have the first volunteer retell the story. Afterward, the third student should return to hear the second retelling. Finally, have the third student retell the story to the entire class.

For the second group of three students, follow the same procedure with a second story:

> Sylvia received a letter in the mail notifying her that she had lost the Texas State Achievement in Math Competition. She had wanted to win and was unhappy with the results. She had been the best student in her math class last year. Losing really hurt her self-esteem. She found out that Terry Browning had done better than her. She hated Terry Browning for that. To make herself feel better, she cried, baked cookies, kicked something, took a long bath, and talked to her best friend. After that, she went to the mall where she shopped and played video games in the arcade until she had beaten all the records. She then went running and came home to watch *The Princess Bride*.

In beginning classroom discussion, reread the story; better yet, present it on an overhead. Ask students to indicate how each story changed in its retelling. Ganske and Hebl report that consistent themes of sharpening and leveling will unfold. John is an overly aggressive man whose anger led him to semiviolent and competitive acts. Observers "level" details such as his baking cookies and talking to a friend. Students add details such as he "drank a beer," "played basketball," or "beat his head against the wall." Sylvia tends to be perceived as more gentle, frail, and emotional. Her shopping trip and emotional outbursts are "sharpened" and her competitive, aggressive behaviors are leveled. Students add details such as she "hugged her teddy bear," "worried about her weight," and "complained and pouted." Interestingly, observers refer to "Terry Browning," whose gender is not specified in the story, as a male.

Ganske, K. H., & Hebl, M. R. (2001). Once upon a time there was a math contest: Gender stereotyping and memory. *Teaching of Psychology, 28,* 266–268.

Context Effects

Classroom Exercise: Context and Perception

Stanley Coren and his colleagues provide an excellent example of how speech perception varies with the context. Their exercise can be presented in class. Tell your students that you will read a simple sentence and they should immediately write down precisely what they heard. Then read the following phrase (drawn from Raj Reddy's research) in a smooth, conversational tone: "In mud eels are, in clay none are." Give the class a minute or two to write down what they heard.

Next, tell your class that you are going to read a sentence from a book that describes where various types of amphibians can be found. Read the same sentence at the same speed you did before. Again, students should write down precisely what they heard.

Finally, write the sentence on the board and have them compare their first and second transcriptions of the same sentence with and without the context. The first reading was likely heard as meaningless, producing responses such as "In middies, sar, in clay nanar" or "In may deals are, en clainanar." However, when the proper context is supplied, the same speech sounds are interpreted as meaningful units.

Robert Cialdini provides additional examples of how the principle operates in social influence. He relates the story of a real-estate salesman who would first show a potential customer a couple of rundown houses, which he called "setup" properties. These houses, listed at inflated prices, were shown so that the genuine listings would benefit from comparison. "The house I got them spotted for looks really great," noted the salesman, "after they've first looked at a couple of dumps."

Cialdini also notes that people may be less satisfied with the physical attractiveness of their own mates after being bombarded by the media with extremely attractive models. College students rated an average-looking member of the opposite sex as less attractive if they had first paged through popular magazine ads. Similarly, male college dormitory residents rated a potential blind date as less attractive if they had just viewed an episode of the *Charlie's Angels* TV series than if they had watched a different show.

Cialdini, R. B. *Influence: Science and practice.* Boston, MA: Allyn & Bacon.

Coren, S., Ward, L. M., Enns, J. T. (2004). *Sensation and perception* (6th ed.). New York: Wiley.

Reddy, D. R. (1976). Speech recognition by machine: A review: *Proceedings of the IEEE, 64,* 501–531.

Vision: Sensory and Perceptual Processing

Classroom Exercise/Student Project: Physiology of the Eye—A CD-ROM for Teaching Sensation and Perception

Interactive exercises, full-color 3-D animations, visual illusions, and various eye tests are all important components of this CD (a revision of *Human Vision*) available through iKnow Digital Media at www.iknow.net. In addition to the topics covered in the text, such as the structure of the eye and principles of visual information processing, the CD explores the development of vision, 40 of the most common eye disorders, principles of light, and optics. You can more fully sample the CD's content at the website above. A single CD can be purchased at the educational rate of $89. A five-pack is $189. Larger quantities are available at reduced rates.

The Eye and the Stimulus Input

Student Project: Color the Eyeball

Distribute Handout 3 to your students. Ask students to color the seven structures of the eye. Encourage students to choose colors based on function. For example, gray may be a good choice for the periphery of the retina, representing the location of rods. Choosing a color with a rationale tied to the eye structure's role provides the deep processing in this assignment. On the back of the handout, students can name the structures and write a bit about what each structure does, and why they chose that particular color.

Lecture/Discussion: Classroom as Eyeball

When covering the structures of the eye, ask your students to imagine the classroom as the inside of the eye. The back wall is the cornea, and a spot on that wall is the pupil and iris. In a space near the back row of students is the lens. The ceiling, floor, front wall, and side walls represent the retina. If you are using a projector, the projector screen represents the fovea. A spot off to the side of the projector screen is where the optic nerve exits the eye, leaving a blind spot.

Student Project: Locating the Retinal Blood Vessels

The term "retina" is derived from a Latin word meaning "net" and refers to the intricate network of blood vessels that nourish the retina's nerve cells. Students will be fascinated to learn that they look through these blood vessels all the time. With a flashlight and a light-colored wall, they can see and even map their own retinal blood vessels. Have them stand in a darkened room and look at the wall, then hold the flashlight near the outer edge of their left or right eye and jiggle it around. If they are patient, they will eventually see a netlike pattern on the wall. It helps if they hold their head slightly downward while staring upward at an angle of about 45 degrees. By steadily shaking the flashlight with one hand and tracing the shadows with the other, students will be able to map their own blood vessels. If they focus intently on the image, they will also see that the blood vessels converge in the center. This is the beginning of the optic nerve, the area producing the blind spot.

Fisher, J. (1979). *Body magic*. New York: Stein and Day.

Student Project/Classroom Exercise: Rods, Cones, and Color Vision

The text indicates that rods enable black-and-white vision and cones enable us to see color. Furthermore, cones are concentrated in the center of the eye and rods are located in the periphery. Students can detect the differences in color discrimination for the different parts of the retina by inspecting a small orange piece of paper on a gray surface. Keeping head fixed, they should move their eyes to the side (left or right), thereby activating more peripheral parts of the retina. Eventually, the orange is likely to look yellowish and then merely gray. The larger the orange patch, the farther observers need to move their eyes to detect these color changes.

Alternatively, invite a volunteer with normal color vision to come to the front of the room. Ask your volunteer to stare at a spot at the back of the room. Standing behind your volunteer, slowly pass a colorful object, such as a colored pencil or crayon, over the volunteer's shoulder. Ask your volunteer to tell you when they can see it. Hold the object in that location, and ask your volunteer to identify the color of the object. Your volunteer will offer some guesses such as a dark color like blue or purple for a dark object or a light color like yellow or orange for a light object. If your volunteer happens to guess the correct color, ask how certain they are about the guess. Now slowly move the object forward, and ask the volunteer to name the color when they can identify it. Once the light waves from the object fall on the fovea, the volunteer will be able to identify the color. This is also appropriate as a paired activity or a take-home assignment.

Johnson, M. A. (1986). Color vision in the peripheral retina. *American Journal of Optometry and Physiological Optics, 63,* 97–103.

Coren, S., Ward, L. M., & Enns, J. T. (2003). *Sensation and perception* (6th ed.). New York: Wiley.

Student Project/Classroom Exercise: Locating the Blind Spot

There are no receptor cells where the optic nerve leaves the eye. This creates a blind spot in our vision. The text provides one demonstration of the blind spot; another striking demonstration involves a lighted candle.

Students should stand across the room from the candle and, with the left eye closed, slowly shift their gaze away from it by looking with their right eye inward toward their nose. When the angle of the incoming image of the candle is at the blind spot, the candle will disappear. By moving their point of focus around carefully, students will be able to explore the size and shape of their blind spot.

Alternatively, tell students to cover one eye and hold up a finger at arm's length. Have them focus straight ahead, and then gradually move the finger about two palm-widths to the side until it disappears.

Students may wonder why even with one eye shut we don't notice the hole in our visual field. Do we ignore it, like a speck on a windshield, or do we fill it in by making an educated guess?

V. S. Ramachandran, a neuropsychologist at the University of California, San Diego, created an artificial blind spot by having resarch participants stare at a television screen that was filled with twinkling "snow" except for a small gray square in the corner. The square quickly disappeared as the brain cells receiving information about it became fatigued. The cells seeing the rest of the screen were constantly refreshed by turning off and on in response to the flickering static. As the square disappeared, thus becoming a blind spot, the participants reported that the surrounding static seemed to fill it in. Of particular importance was that for a few seconds after the television was turned off, the participants continued to see static only in the place where the small gray square had been. In other words, the brain was still filling it in with static. When given no information, the brain apparently makes an educated guess based on what it knows of the surrounding area (Wallace, 1991).

By deliberately aiming the blind spot, one can block out any appropriately sized object. Legend has it that King Charles II of England did this with his courtiers. Ramachandran (1998) reports, "He used to make their heads disappear. One story is that he used to do it to people he had sentenced to die, to see what they would look like without their heads."

Albrecht, K. (1980). *Brain power*. Upper Saddle River, NJ: Prentice Hall.

Ramachandran, V. S., & Blakeslee, S. (1998). *Phantoms in the brain: Probing the mysteries of the human mind.* New York: William Morrow.

Staff. (1991, September/October). See your blind spot. *In Health,* 13–14.

Wallace, A. (1991, April 25). UCSD researcher 'fills in' blind spots: Science: The brain makes educated guesses to compensate for natural gaps in our vision, professor reports. Retrieved August 9, 2014, from articles.latimes.com/1991-04-25/local/me-722_1_blind-spot.

Color Vision and Visual Information Processing

PsychSim 6: Colorful World

This activity reviews the principles of color sensation, including a comparison of the trichromatic and opponent-process theory of color vision. Students demonstrate some aspects of color sensation with their own eyes.

Classroom Exercise: The Color Vision Screening Inventory and Color Blindness

Handout 4 is the Color Vision Screening Inventory developed by Stanley Coren and A. Ralph Hakstian, which can be used as a preliminary test for color blindness. Students should answer all the questions as directed, then score their responses as follows: 1 for Never, 2 for Seldom, 3 for Occasionally, 4 for Frequently, and 5 for Always. Those students whose total scores are above 16 have an 81 percent likelihood of failing a standard screening test for color vision. Students with such scores may want to get their vision tested by a doctor or in a perception laboratory.

Color vision defects provide an interesting lecture topic. Slightly more than 8 percent of all men show color weaknesses, but slightly less than .05 percent of all women show similar deficits. Color defects are genetically transmitted; research has conclusively mapped the pattern of this transmission.

Monochromats have either no functioning cones or only one functioning cone type and respond to light in much the same way that a black-and-white film does. All colors are recorded simply as gradations in intensity. Those who have no functioning cones are likely to find daylight very uncomfortable; those with one cone type see comfortably under both daylight and dim levels of illumination, but they still lack the ability to discriminate colors. Only a very small percentage of people actually suffer from this form of color blindness.

Dichromats have one malfunctioning cone system. John Dalton, an eighteenth-century English chemist, discovered that he was a dichromat when he wore a scarlet robe to receive his doctoral degree. As a Quaker, he was expected to shun bright colors. Critics were silenced only after they learned that crimson and dark blue-green appeared to be the same color to him. Dalton's color defect—an insensitivity to long wavelengths normally perceived as red light—is referred to as *protanopia*. Dalton described his experiences when viewing the spectrum as follows: "I see only two or at most three distinctions. These I should call yellow and blue, or yellow, blue, and purple. My yellow comprehends the red, orange, yellow, and green of others and my blue and purple coincide with theirs."

Deuteranopia, the most common form of dichromacy, is a malfunction in the green cone system. People with this deficiency are able to respond to green light but cannot distinguish green from certain combinations of red and blue. Interestingly, this is most similar to color vision in canines (Miller & Murphy, 1995).

Tritanopia, an absence or malfunction of the blue cone system, was not discovered until about 1950, when a magazine article with a color vision plate appeared as part of an intensive search throughout England. The 17 individuals with this disorder, who were found by the magazine search, instead of seeing the spectrum as composed of blues and yellows as do other dichromats, see the longer wavelengths as red and the shorter ones as bluish-green. The discovery of persons with this defect provided strong support for a trichromatic theory of color vision.

What do colors look like to a dichromat? We are provided some insight by a rare person who was deuteranope in her left eye but color-normal in her right eye. Researchers had her adjust the color seen by her normal eye so that it appeared to be the same hue as the color seen by her defective eye. The colors over the entire range from red to green (red, orange, yellow, green) all appeared to have the same yellow hue, and the colors blue and violet appeared to be blue. Blue-green appeared to be a neutral gray.

To help students see what websites look like to people with various types of color deficiency, have them visit colorfilter.wickline.org, a website to assist those who are creating web pages to ensure that the color scheme of the website works regardless of the visitor's color vision. Then, have them enter a website URL, perhaps that of your institution, select the type of color deficiency they'd like to see, then click the "Fetch and Filter" button. On the rendered page, students will get a menu that will allow them to select among different forms of color deficiency.

Coren, S., Ward, L., & Enns, J. T. (2003). *Sensation and perception* (6th ed.). New York: Wiley.

Miller, P. E., & Murphy, C. J. (1995). Vision in dogs. *Journal of the American Veterinary Medical Association, 207*(12), 1623–1634.

Lecture/Discussion Topic: Color Vision in Primates

Color vision differs between new world primates (such as Central and South American monkeys) and old world primates (such as chimpanzees and humans), giving us a glimpse into evolutionary history. The split between the two categories occurred about 40 million years ago.

Old world primates are all trichromats, but new world primate males are dichromats (blue/green or blue/red) and new world primate females can be dichromats (blue/green or blue/red) or trichromats (blue/green/red). Why is this?

The gene that produces the photosensitive pigment for blue cones resides on chromosome 7. In fact, this gene exists in almost all vertebrates, both male and female. The gene that produces the photosensitive pigments for green and red cones resides on the X chromosome. In new world primates, green and red are actually different alleles of the same gene. Because new world primate males have only one X chromosome, they have only one of those alleles; this makes them dichromats. So, these new world primates have blue from chromosome 7, and then either the red allele or the green allele on the X chromosome. Because new world primate females have two X chromosomes, they have either two green alleles (blue/green dichromats), two red alleles (blue/red dichromats), or a green allele and a red allele (trichromats). Only one of these alleles can be expressed at a time due to X inactivation, but which X is shut off appears to be random. In practice, this means that in one cone, the green allele is shut down and red photosensitive pigment is produced. In another cone, the red allele is shut off and green photosensitive pigment is produced.

In old world primates, this X chromosome red/green gene was duplicated sometime after the split with the common ancestor whose line went on to produce new world primates, giving us two genes, one for red photosensitive pigment and the other for green photosensitive pigment, making humans (and gorillas, and chimpanzees, for example) trichromats.

To see how closely the red and green photosensitive pigments mirror each other, visit this website: photo.net/learn/optics/edscott/vis00010. You can view a wonderful graphic that shows how fast the three cones fire in relation to the light's wavelength. Blue cones, for example, fire maximally when hit by a light wavelength of 450 nm, but fire some at both a little less than 400 nm and up to almost 550 nm. Pay particular attention to the overlap in wavelengths to which red and green cones respond, about 200 nm worth.

Jacobs, G. H., & Nathans, J. (2009, April). The evolution of primate color vision. *Scientific American, 300*(4), 56–63.

Classroom Exercise: Subjective Colors

John Kremer's *Turntable Illusions* is a wonderful source of material for classroom demonstrations of illusions (the Fechner-Benham disc described below is useful for illustrating color vision). The book includes 40 discs that, when rotated, demonstrate a variety of perceptual phenomena. Kremer provides explanations for each. Although the title of his book suggests that the discs be played on an old record player, using a variable speed drill to display them works even better. Many also work well when simply rotated on the tip of a pin. Often the stationary patterns are intriguing in their own right.

The Fechner-Benham disc (www.youtube.com/watch?v=9_0Z4Bi3JQo) illustrates subjective colors (colors that appear in the absence of the appropriate wavelengths of light). The pattern is adapted from a design first used in the 1890s on a popular children's toy called a Benham top, named after its inventor. (German physicist and psychologist Gustav Fechner first reported subjective colors in 1838. Thus, they are sometimes called *Fechner colors* and the black-and-white patterns that produce the colors are known as Fechner discs or Fechner-Benham discs.) When the disc is rotated at 33 or 45 rpm, the black lines within the white spaces will appear colored. For many, the colors are surprisingly vivid.

Subjective colors remain somewhat of a puzzle. Harvey Schiffman suggests that the patterns of black-and-white alternations in the disc bypass the contribution of the retina. Patterns of excitation beyond the retina may be set up that produce a sequence of neural events mimicking the different temporal patterns of neural activity that normally result from viewing colored stimuli. Stanley Coren and his colleagues state that, at least on the surface, the existence of subjective colors is more consistent with the idea that some sort of Morse code carries color information, rather than with the concept of a spatial opponent-process system that contemporary data seem to support.

A second figure, Handout 5, demonstrates how a black-and-white stationary pattern can also produce subjective colors. Have students examine the center of the figure. A faint, shimmering pattern of pastel streaks will appear. For many people, they will run vertically up and down the pattern crossing both white-and-black lines. Others will see a fishnetlike pattern over the grid. As we view the pattern, small voluntary and involuntary eye movements occur. These movements displace the image of the diagonal lines over the retinal receptors and create a pattern of receptor activity that typically occurs from viewing colored stimuli.

Coren, S., Ward, L. M., & Enns, J. T. (2003). *Sensation and perception* (6th ed.). New York: Wiley.

Kremer, J. (2000). *Turntable illusions*. Tao, NM: Open Horizons Publishing. (Address: Open Horizons Publishing Company, P.O. Box 2887, Taos, NM 87571.)

Schiffman, H. R. (2001). *Sensation and perception* (5th ed.). New York: Wiley.

Classroom Exercise/Student Project: Movement Aftereffects

Michael Levine and Jeremy Shefner cite movement aftereffects (MAEs) as evidence for the presence of direction-specific movement detectors in the human visual system. Many students will be familiar with MAEs in one form or another. Perhaps they have stared at a waterfall and then, looking away, experienced the illusion of everything floating upward. Or they have seen video games such as Rock Band or Guitar Hero in which they stare for some time at the notes moving along the screen. When they look away and at a wall, they perceive the wall moving. Or, as passengers on a train that has come to a stop, they may have had the feeling of the train moving backward. Or, after watching a movie's closing credits move up the TV screen, they may have had the sensation that the entire TV was moving downward.

One of the most dramatic MAEs (sure to elicit a chuckle) is the plateau spiral illusion, which can be demonstrated with Handout 6 (cut out the spiral and glue it to a cardboard disk of the same size). Rotate the spiral on a color wheel, turntable, or even the end of a pencil so that it appears to be receding. Have students stare at the center of the spiral for about one minute, then look at your face. Your head will seem to swell in size. (Rotating the circle in the opposite direction will create a shrinking head.)

If you have Internet access in your classroom, visit this website to demonstrate the motion aftereffect: www.michaelbach.de/ot/mot-adapt/index.html. Use the controls to make the movement expand or contract, to make an image of Buddha appear or not, and to change how fast the motion is (cps, cycles per second). (If the moving image does not appear, use a different web browser.)

MAEs are apparently caused by the adaptation of motion-specific detectors that are tuned to the direction of the movement of the stimuli being viewed. For example, in watching a waterfall, all the detectors sensitive to downward movement are continuously stimulated. These detectors gradually adapt and become less sensitive. Thus, shifting our gaze will activate the movement detectors sensitive to upward movement more than the downward-movement detectors; as a result, objects will appear to be moving upward.

Levine, M., & Shefner, J. (1991). *Sensation and perception* (2nd ed.). Belmont, CA: Wadsworth.

Lecture/Discussion Topic: Blindsight

A Lecture/Discussion Topic on blindsight appears in the unit on Consciousness and the Two-Track Mind, found elsewhere in these resources. That item is also relevant to a discussion about parallel processing.

Perceptual Organization

Illusions reveal the ways we normally organize and interpret our sensations, so a discussion of illusions, with some fun demonstrations, might be a good way to introduce the basics of visual organization. Following are several suggestions for such a discussion.

PsychSim 6: Visual Illusions

With this program, students see how the Müller-Lyer, Ponzo, Poggendorf, and horizontal-vertical illusions work by trying to guess the length of a line or the size of objects at varying distances. The results of their performance are graphed. You may prefer to use this in conjunction with the explanation of the illusions in the latter part of this unit.

Classroom Exercise: Perceptual Illusions and Principles

An illusion that is easy to demonstrate and will involve the entire class is the horizontal-vertical illusion (see also PsychSim 6). Before students arrive, draw a 3-foot horizontal line on the board. When class begins, slowly bisect it with a vertical line, asking students to raise their hands when they believe the vertical equals the horizontal. Mark the point at which half the class believe the lines are equal. Continue the vertical line until every student agrees it equals the horizontal. Then measure the two lines and extend the vertical until the two lines are equal. The class median will usually be 30 percent or so short, and rarely will a single student have requested a vertical line sufficiently long. While vertical lines generally look longer than horizontal lines, the effect is accentuated by the bisection. When one line is interrupted by another, we estimate the interrupted line as being shorter. If you draw an "L" so that the two lines are equal in length, students will be more accurate.

Handout 7 can be used to introduce a discussion of visual organization.

1. *The Gestalt Law of Pragnanz*
   Have students look at the figures for just a moment, turn the page over, and reproduce them on another sheet. Then have them compare their drawings with the originals. Did they draw a circle instead of a tilted ellipse, a square with 90-degree angles, a complete triangle without rounded corners, and an "X" without curved lines? If so, they have demonstrated the Gestalt law of Pragnanz, which states that our perceptions will always be as "good" as prevailing conditions allow. Literally, "Pragnanz" refers to "conveying the essence of something." We tend to simplify and perfect figures in our perceptions.

2. *Context Effects*
   In the series of letters and numbers, "B" and "13" are identical. The handwritten statements are clearly legible, but did students notice that "is" and "15" are identical, as are "h" in "phone" and "b" in "number," and "d" in "code" and "l" in "Please"? In each case context determined their perception of the script.

3. *The Oblique Effect*
   The oblique effect demonstrates the impact of living in a carpentered world. Our visual sensitivity is better for horizontal and vertical stimuli than for obliquely oriented stimuli. Students need to stand back from the three stimuli (you might tape this one to the wall) until they can no longer resolve clearly the oblique lines in the center circle. It will appear uniformly gray. However, they will still see the lines in the left and right circles. People who do not live in a carpentered world are able to see all three equally well.

Lecture/Discussion Topic: Object Recognition

As you begin your discussion of how we organize and interpret what we see so it becomes a meaningful perception, remind students of the distinction between bottom-up processing (starting with entry-level sensory analysis) and top-down processing (using our experiences and expectations to interpret those sensations). Modern theories of object recognition make a closely related distinction between data-driven and conceptually driven processing. Stanley Coren and his colleagues use the top figure in Handout 8 to illustrate. What do students see? For those having difficulty, suggest that it is a drawing of an animal they have seen many times before. If they still can't figure it out, sketch the drawing below on the board or project it as an overhead. (Once they see the cow, they wonder how they missed it initially.)

In our first look at a figure, data-driven processes extract shapes of various sizes and features. In the subsequent conceptual driven process, we match the collection of features with objects in our long-term memory. Organizational strategies and expectations based on our knowledge of the world guide our search for patterns in sensory input.

Data-driven processing tends to emphasize the *local* features in object recognition. Local features are the detailed aspects of a figure. In contrast, the overall or global aspects give the entire figure its meaningful shape. The bottom figure in Handout 8 illustrates the distinction between local and global processing and highlights how local features can interfere with a more global percept. The figure is a computer-processed block representation of a photograph, produced by locally averaging brightness information so that the brightness value in each of the squares is an average of a number of brightness samples taken in the same area of the picture. The strategy seeks to determine whether local brightness information can elicit the perception of the original photograph. Squinting or looking at the photograph from a greater distance typically helps. It is, of course, a picture of Abraham Lincoln.

Coren, S., Ward, L. M., & Enns, J. T. (2003). *Sensation and perception* (6th ed.). New York: Wiley.

Student Project: Playing Cards and Illusions

Psychologists Jules Block and Harold Yuker have prepared two standard decks of playing cards with each card containing a separate illusion. The cards, which are accompanied by a brochure that explains the illusions, are available for $9.95 from Edmund Scientific Company (scientificsonline.com), 60 Pearce Ave., Tonawanda, NY 14150–6711 (1-800-728-6999).

Student Project: Hollow Face Illusion

A concave mask can appear convex. We are accustomed to seeing faces with the nose out in front, not recessed, so our brain reverses reality and produces the illusion of a face. As the angle of our vision shifts, so does the face.

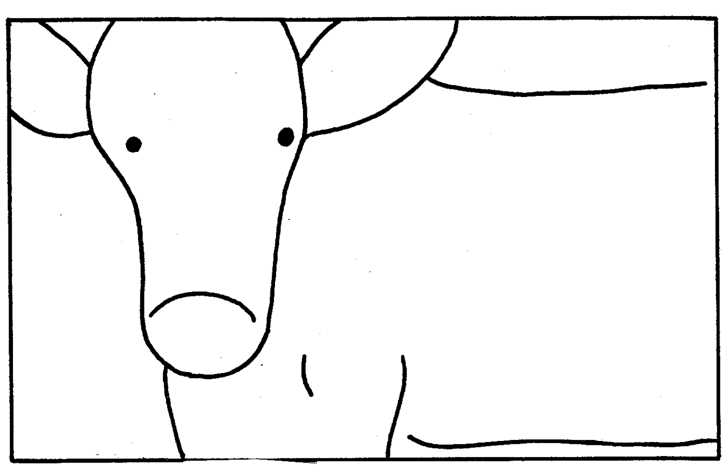
Your students can experience this illusion for themselves. Go to www.thinkfun.com/thinkythedragon and download and print copies of the dragon illusion. The first page will be the hollow face dragon. The second page contains instructions on how to assemble it. Once assembled, cover one eye, and the hollow face of the dragon will reverse, and its recessed snout will appear outward facing. Also, if you move around the room, the dragon's face appears to move to follow you.

You can watch a video of the illusion at youtu.be/ti8Vul5s-GE.

Student Project: Instant Object Recognition

Given the complexity, limits, and even predictable errors of the perceptual process, you may want to assign students a simple homework assignment that will help them to appreciate the counterpoint, namely, that perception is effective and efficient. Suggested by both Irving Biederman and Margaret Matlin, the project highlights how we recognize objects instantly.

Tell students that the next time they watch television, they should adjust the sound to "mute." With their eyes closed, they should change channels, then open their eyes and immediately shut them again. They should repeat the exercise several times. In the fraction of a second they have to view a channel, they will easily identify and interpret the images, even though they have never seen them before and do not know what to expect. Biederman indicates that most people can usually interpret the meaning of a new scene in one-tenth of a second. This also explains, as Matlin notes, why



viewers can recognize the rapidly presented images on music videos even when they are shown at a rate of five per second.

Biederman, I. (1995). Visual object recognition. In S. F. Kosslyn & D. N. Osherson (Eds.), *An invitation to cognitive science* (2nd ed., pp. 121–165). Cambridge, MA: MIT Press.

Matlin, M. W. (2013). *Cognition* (8th ed.). New York: Wiley.

Lecture/Discussion Topic: Visual Agnosia

A discussion of *visual agnosia,* defined by Stanley Coren and his colleagues as "a syndrome in which all parts of the visual field are seen, but the objects seen are without meaning," provides an excellent introduction to a discussion of how we organize our sights to form meaningful perceptions.

Oliver Sacks' opening tale in *The Man Who Mistook His Wife for a Hat* provides the interesting case study of Dr. P., a distinguished musician and teacher who could see but not recognize familiar faces. Likewise, he saw faces where there were none and acted accordingly—for example, patting the heads of parking meters and addressing carved knobs on furniture. When Dr. P. was examined and asked to describe the pictures in a *National Geographic* magazine, his eyes would dart across the page picking up only tiny details. A striking color or shape might catch his attention and elicit comment but in no case did he perceive the scene as a whole. After his examination, the patient looked around for his hat. He reached out and took hold of his wife's head and tried to lift it up to put it on. He had mistaken his wife for a hat!

Coren describes several other forms of agnosia, including the following. In *visual object agnosia,* people who have no damage to the visual apparatus are unable to recognize familiar objects. For example, one patient given a line drawing of a pair of eyeglasses admitted confusion and started to guess: "There is a circle . . . and another circle . . . a cross bar . . . Why, it must be a bicycle." Such patients also have trouble separating the parts of a figure from their overall context. Shown a picture of a clock they may identify it. However, if the clock is crossed out with a couple of straight lines, recognition is lost.

In *simultagnosia,* the individual cannot pay attention to more than one stimulus at a time. For example, the person may not be able to place a dot inside a circle because that would require paying attention to both the dot and the circle simultaneously. Visual object agnosia and simultagnosia often appear in the same patients and the disorders are sometimes grouped together as *visual integrative agnosia*.

Other agnosia effects are more general and may involve more than one sense. People with these problems may be just as impaired using, say, their tactile or kinesthetic sense as with their visual sense. For example, those suffering *spatial agnosia* have difficulty negotiating their way through the world. Even in familiar settings, they make wrong turns. They become lost in their own homes. Strangely, such patients also often show a tendency to ignore one side of an object in space. So when asked to draw symmetrical objects, they produce an imperfection on one side.

Agnosia seems to be a result of physiological damage, typically to the higher brain centers involved in the interpretation of stimuli. Although the damaged areas may be quite specific, they are not the primary receiving areas of the cortex. For example, visual agnosias are often associated with damage to the more forward portions of the occipital cortex, which are the secondary visual areas and to the temporal lobes, which are tertiary visual processing areas associated with complex visual analysis.

Coren, S., Ward, L. M., & Enns, J. T. (2003). *Sensation and perception* (6th ed.). New York: Wiley.

Sacks, O. (1987). *The man who mistook his wife for a hat*. New York: Summit.

Classroom Exercise: Perceptual Organization

Handout 9 can be used to reinforce and extend your discussion of perceptual organization.

Stanley Coren and his colleagues note that Figure 1 demonstrates how "the perceptual system automatically, and without any sense of effort, organizes and integrates these 33 black blobs into 3 meaningful figures." Even though the drawings are incomplete, in fact, they are simply black blotches on a white background with no figures actually present, we easily recognize two dogs looking at a seated cat. (We even recognize the dogs' breeds: German Shepherd and Poodle!).

Figure 2 reveals what Stanley Coren calls the "urge to organize." The various small elements can be organized in a variety of ways, which continually change as we shift from one organization to another—in a sense, reversible figure-ground. Have students stare at the figure, identifying the various patterns they see. Our organization of elements into various patterns demonstrates that perception is an active, constructive process. In the mid-1970s, psychologist Bernard Karmel delightfully demonstrated this with a string of blinking Christmas lights and a Beatles recording. Although the lights had no real pattern, they were perceived as pulsating in rhythm with the music; the observers simply filtered out the lights that did not fit the beat and amplified those that did.

Figures 3A and 3B, provided by Roger Shepard, are additional examples of reversible figure and ground. Shepard notes that the figure-ground ambiguity is particularly strong for the first two letters in 3A, thanks to a fortuitous complementarity of shape between the "F" of "Figure" and "G" of "Ground" and between the "i" of "Figure" and "r" of "Ground." These letters tend to be seen as "F" or "G" and "i" or "r" but not fully as both at once.

Figures 4A and 4B provided by J. Richard Block and Harold Yuker are examples of "ambiguous figures" in which reorganizations of the figures create totally new perceptions. 4A is called the Wilson figure and is both an Inuit (the dark area is an igloo and the Eskimo is facing toward it) and a Native American head (the dark area is the Native American's headdress). In the second figure, the bird can be seen as either a goose or a hawk depending on the direction it's flying. Although we know both pictures are there, we cannot see them simultaneously. At the same time, it is difficult to maintain focus on only one without the other reappearing.

Most students will initially perceive Figure 4C (from Coren) as a man's face. Ask how many can also see a handwritten word. Again, as was the case for 4A and 4B, once we see the word "Liar," the face and the word compete for our attention.

Figure 5 from Coren provides additional examples of the Gestalt principles described in the text. The 12 circles in 5A are organized into two groups, illustrating the principle of proximity. In 5B, a triangle of black dots appears against a background of Xs, and in 5C, the two halves of the circular field appear quite separate, both illustrating the principle of similarity. Figure 5D is typically seen as a spiral of dots with one dot outside, illustrating the principle of continuity. Figure 5E is seen as a diamond between two vertical lines, and 5F is seen as a triangle; both illustrate the principle of closure. Were it not for the principle of closure, 5E could be seen as a letter W stacked on a letter M (or as a letter K faced by a mirror image K), and 5F could be seen as three separate acute angles. Finally, Coren suggests that Figures G and H show how Gestalt principles can be so powerful they produce visual illusions. Distances between parts of a pattern that are organized into the same group (proximity principle) are underestimated relative to the same distances when the parts belong to different groups.

For one more example of reversible figure and ground, suggest to your students that they pay particular attention the next time they see the FedEx logo. Have they ever noticed the arrow lodged between the "E" and the "x"? Typically, we look at the letters, making the letters the figure and the background the ground. Once you see the arrow, the arrow becomes the figure and the letters become the ground. For more reversible figure and ground logos, see: www.graphicdesignblog.org/hidden-logos-in-graphic-designing.

Block, J. R., & Yuker, H. (1989). *Can you believe your eyes?* New York: Gardner Press.

Coren, S., Ward, L. M., & Enns, J. T. (2003). *Sensation and perception* (6th ed.). New York: Wiley.

Shepard, R. N. (1990). *Mind sights*. New York: Freeman.

Classroom Exercise: An Auditory Analogue of the Visual Reversible Figure

Because of visual capture, as noted on page 24 of this unit, visual illusions tend to dominate those of the other senses. However, auditory and other sensory illusions also occur. For example, the steady beat of a metronome or clock is heard as if it were a repeating rhythm of two, three, or four beats—not as an unaccented click-click-click. Similarly, as suggested by Richard Warren and Richard Gregory, when speech sounds—either words or short phrases—are repeated without pause, the verbal organization undergoes abrupt transitions into other words and phrases, sometimes accompanied by apparent changes in the component sounds. Students may discover this for themselves by simply repeating aloud a word such as *say*. It will shift abruptly to *ace* and back again. Warren and Gregory suggest that there are dozens of such reversible words and that this verbal effect of alteration seems similar in principle to the reversal of the figure-ground relationship in visual figures.

This verbal alteration is studied best with a recording of a word repeated continuously. Warren and Gregory suggest the word *rest*. After making a tape of 3 to 5 minutes, have students listen carefully and write down every word or phrase they hear. As *rest* is repeated, students are likely to hear it shift to *tress*, *stress*, or even *Esther.* Like visual perception, our perception of auditory stimuli is organized by the meanings our minds impose. Have students volunteer their responses, or collect their written responses, and place them on the board. Although there will be many common responses, there will also be evidence of unique perspectives.

Warren, R., & Gregory, R. (1958). An auditory analogue of the visual reversible figure. *American Journal of Psychology, 71,* 612–613.

Classroom Exercise: The Ganzfeld

The perception of contours—locations in which there is a sudden change of brightness—is basic to form perception. Without them, there is no perception of shape. A simple contour, and certainly one of the simplest visual forms, is a black line drawn on a white sheet of paper. Eliminate contours and you effectively eliminate visual perception.

Gestalt psychologists call a field that contains no visible contours a Ganzfeld ("whole field"). In a series of studies, they showed that perception in a Ganzfeld is very unusual. Participants generally report that they see only a "shapeless fog that goes on forever." Even when colored light is introduced, the hue of the light fades quickly and the gray fog returns.

Students can experience the Ganzfeld for themselves by using white plastic spoons (one held up to cover each eye) or by cutting Ping-Pong balls in half along the seam. The halves that bear the manufacturer's stamp should be discarded. Although not essential, gluing some cotton around the rims that are saved will facilitate a comfortable fit. Students should then cover each eye with half a Ping-Pong ball. Have them direct their gaze toward a light source so that their view will be flooded with diffuse, contourless light. Have students reflect on their experience. Any color will soon fade into gray. Eventually, they will experience a perceptual "blank out," the impression that all sense of vision has been lost. In the absence of contours, we actually experience a feeling of blindness. If someone passes an object across the field, say a pencil, vision will immediately return. Often, those experiencing the Ganzfeld will frantically search for something to focus on, simply in order to orient themselves. Students can experiment with their "Ping-Pong Ganzfelds" by painting halves different colors—say, green, red, and blue. They can then place a different colored half over each eye and determine how the brain handles this unique situation. Some will see only one color, some will report seeing half one color and half the other, still others will alternate in seeing one and then the other.

In a laboratory, where Ganzfeld situations are produced with more elaborate equipment and are experienced for a longer time, many observers become extremely fatigued and report that their bodies feel light. Motor coordination, balance, and time judgment may also be disrupted. Dizziness is not uncommon. A few observers seem to lose their sight completely for a time after being in the Ganzfeld for 15 minutes.

"Blank outs" may also occur in natural environments. For example, in the snow-covered Arctic where there is often little sensory change, observers may complain of "snow blindness." The Ganzfeld experience clearly demonstrates that vision requires temporal and spatial change to function normally.

Classroom Exercise: Binocular Vision

The importance of binocular cues to depth perception is easily demonstrated. Have students close one eye, point their two forefingers toward each other, then bring them together quickly. They are likely to miss. If they repeat the test, they ought to drop their arms out of view before they try again. This will eliminate the perception of any depth cues from the position of the hands and arms.

Binocular vision is also responsible for an illusion in which we see a hole in our hand. Have students roll a sheet of paper into a tube and raise it to their right eye like a telescope. Tell them to look through it, focusing on a blank wall in front of them. Now have them hold their open left hand beside the tube and continue to focus ahead. The images received by the two eyes will fuse and the hole in the tube will appear to be in the student's hand. They may need to slide the hand alongside the tube until they find the precise spot where the hole appears to go through the very center of the palm.

Fisher, J. (1979). *Body magic*. New York: Stein and Day.

Classroom Exercise/Student Project: Binocular Vision Versus Monocular Vision

Larry Boehm suggests a useful classroom exercise that, in just a few minutes, demonstrates the value of binocular cues (it also makes a good student project for an out-of-class assignment). After discussing depth cues and depth perception, distribute a copy of Handout 10 to each student. Divide your class into groups of three. Tell your students they will take turns in filling the roles of pitcher, catcher (the research participant), and data recorder. The pitcher, standing about 10 feet from the catcher, is to toss a tennis ball 20 times to the catcher. The catcher's job is to catch as many throws as possible with one hand, first by using both eyes, then only one eye (with appropriate counterbalancing). The recorder keeps track of the number of successful catches. In using this demonstration, Boehm found students were significantly better at catching the tennis ball with two eyes (mean = 9.8) than with one eye (mean = 6.8).

Boehm, L. (1996, May). *An inexpensive and reliable demonstration of monocular and binocular depth perception for sensation and perception or statistics*. Paper presented at the 68th Annual Meeting of the Midwestern Psychological Association, Chicago, IL.

Classroom Exercise: Identifying Cues to Depth and Distance

The best way to help your students understand depth and distance cues is to have them pick the cues out themselves. You can use a 10-minute lecture break to engage your students in a picture-viewing task in which you ask them to identify specific monocular cues to depth and distance.

Distribute Handout 11 to your students. They can work individually or in small groups. You can even make this a homework assignment; students can select their own images and submit them with their responses, or you can assign specific images.

Lecture/Discussion Topic: Autostereograms

Retinal disparity is an important binocular cue to depth perception. The creators of 3-D movies simulate retinal disparity by photographing a scene with two cameras placed a few inches apart. When viewed through spectacles that allow the left eye to see only the image from the left camera and the right eye the image from the right camera, the 3-D effect mimics normal retinal disparity. For more information on how 3-D movies are made, see the *Wired* article referenced at the end of this article.

By now many, if not all, of your students will have encountered the "hidden pictures" that have appeared in newspapers and in malls and specialty shops throughout the country. At first glance, these pictures appear to form repetitive and meaningless patterns. However, as the observer fixates on something at a different distance (often instructions suggest the reflection in the glass covering the hidden picture or viewing the picture cross-eyed), an enchanting 3-D image springs to life. Like the old stereograms viewed through spectacles, these autostereograms rely on retinal disparity to produce their effect. Rather than using two separate images, however, they use repeating columns that potentially present a slightly different image to each eye. When one views the picture directly, there is no retinal disparity. However, if one focuses through the image so that the fixation point is behind the plane of the picture, retinal disparity produces a rather startling 3-D image. Handout 12a provides an example to use in class. The figure is a rat pressing a bar. Handout 12b displays the specific figure. For those students having difficulty seeing the 3-D images, suggest the following: Look cross-eyed at the stereogram, or hold the figure close to the eyes and then gradually move it back while maintaining the same focus. Still a third strategy is to place glass or clear plastic over the image. If a person focuses on his or her own reflection in the glass, the image should start to appear in the background. In addition to illustrating the effects of retinal disparity, it is a wonderful example of how perception is an active process involving organization that occurs in the brain after the eyes' images have been fused. You and your students can create your own autostereograms at easystereogrambuilder.com.

Be aware, however, that not everyone has 3-D vision. For example, lack of stereopsis (3-D vision) may occur because the eyes that are not aligned or because one eye is much stronger than the other. Inform students that there are treatments available for developing stereopsis; and they should check with their optometrist for more information (American Optometric Association, 2011). To learn more about living without stereopsis and what it is like to gain it as an adult, read Susan Barry's book, *Fixing My Gaze.*

American Optometric Association. (2011). 3D in the classroom: See well, learn well (Rep.). Retrieved August 9, 2014, from the3dclassroom.com/wp-content/uploads/2013/06/American-optometric-association-Final.pdf.

Barry, S. R. (2009). *Fixing my gaze: A scientist's journey into seeing in three dimensions.* New York: Basic Books.

Chen, B. X. (2009, December 21). "Wired Explains: How 3-D Movie Projection Works." Retrieved July 15, 2014, from wired.com/2009/12/3d-movies.

Classroom Exercise: Brightness Contrast

Handout 13 provides two startling illusions that illustrate the phenomenon of brightness contrast. You might also use this phenomenon to introduce context effects that are covered later in the sensation/perception chapter.

They are Dr. Edward H. Adelson's argyle and snake illusions. In both illusions the diamond-shaped regions are identical gray. So powerful are these illusions that most students will need to block out the context to be convinced. Alternatively, they may cut out the relevant figures and place them side by side.

Perceived lightness stays roughly constant, given an unchanging context. What happens when the surrounding context changes? As both illusions dramatically illustrate, the visual system computes brightness and color relative to surrounding objects. Thus, perceived lightness changes with context.

Ninio, J. (2001). *The science of illusions.* Ithaca, NY: Cornell University Press.

Classroom Exercise: Variation in the Size of the Retinal Image

As distance between the eye and an object increases, the size of the retinal image decreases. Normally, we compensate for the size changes related to distance changes, and the perceived sizes of objects remain constant. Students can experience the relationship between retinal image size, distance, and size constancy through a simple demonstration.

Have students hold a hand in front of them at arm's length and move it toward their head, then away; they will perceive no change in size. The size of the retinal image is, of course, changing. Is there a way to detect this change? Have students hold the forefinger of their left hand about 8 inches in front of their face and focus on it. They should then position their right hand at arm's length past their left forefinger. While maintaining fixation on their left fingertip, they should move their right hand toward and away from their face. Although their focus should be on the finger, they should also notice the image of the hand as it moves. It will change dramatically in size.

Coren, S., Ward, L., & Enns, J. T. (2003). *Sensation and perception* (6th ed.). New York: Wiley.

Classroom Exercise: Perceived Distance and Perceived Size

The close connection between an object's perceived distance and perceived size is readily demonstrated. Distribute a copy of the figure below to each student in class. Under reasonably good light, have students focus on the "X" in the white rectangle. After a minute or so they will form an afterimage. That is, gazing at a blank piece of paper on their desk, they will see a floating dark rectangle. If they now transfer their gaze to a more distant, light-colored wall, they will see a much larger dark rectangle. As the afterimage is projected against surfaces of varying distances, its apparent size changes. This vividly illustrates how size and distance interact through the size constancy mechanism.

Allan LaVoie suggests another simple way of demonstrating how we automatically correct for distance with an increase in perceived size. He notes that an artist sometimes uses an independent standard, such as holding up a thumb, to judge accurately the size of a distant object. Have your students go to the classroom windows and estimate the size of a distant object, say a lamppost. They should return to their seats and draw a line the length of which produces the same-size retinal image that the post did. Then, have them go to the window, hold up a thumb to measure the post, and, returning to their seats, measure their lines with their thumbs. Most will have drawn a line that is much too long.

Coren, S., Ward, L., & Enns, J. T. (2003). *Sensation and perception* (6th ed.). New York: Wiley.

LaVoie, A. (1987). Emmert's law. In V. P. Makosky, C. C. Sileo, L. G. Whittemore, C. P. Landry, & M. L. Skutley (Eds.), *Activities handbook for the teaching of psychology* (Vol. 2, pp. 46–48). Washington, DC: American Psychological Association.

Classroom Exercise: Binocular Disparity and Size Constancy

Stanley Coren and his colleagues note that the greater the number of cues to distance, the stronger is the size constancy effect. To reinforce the role of binocular disparity in the perception of depth, and its potential contribution to size constancy, have your students perform a very simple exercise in the classroom.

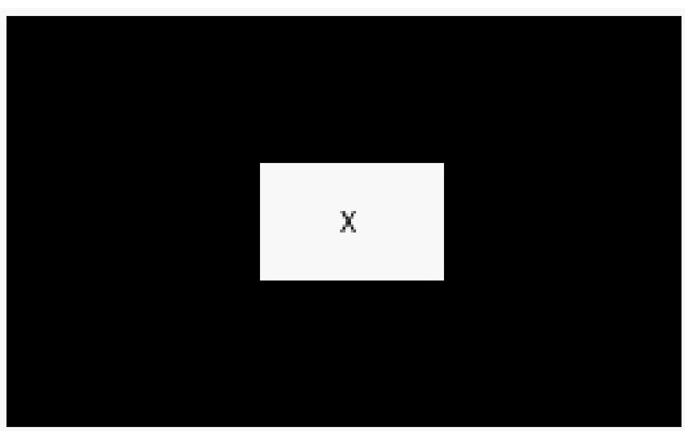
Instruct your students to hold out their hands (backs of hands toward them) at varying distances. One should be close (say, 8 in or 20 cm), and the other at arm's length. Both hands will appear to be the same size. Now have students remove the binocular disparity cue by closing one eye. Maintaining the distance difference between the two hands and holding their heads steady (motion parallax provides another cue to depth), observers will now likely see a weakening of size constancy. That is, the more distant hand will appear smaller than the one close by. Students can restore size constancy by opening both eyes and adding other depth cues, for example, swinging their heads from side to side.

Coren, S., Ward, L.M., Enns, J. T. (2003). *Sensation and perception* (6th ed.). New York: Wiley.

Classroom Exercise/Student Project: Perceived Lunar Size

Both Gordon Hodge and Mark Kunkel have suggested student projects or classroom activities that involve judgments of lunar size. They provide a useful strategy for introducing the important distinction between distal and proximal stimuli as well as the Moon illusion. Handout 14, designed by Kunkel, asks students to imagine themselves outside on a clear evening with a bright full Moon and then to mentally select from a group of items one that will occlude or cover up the full Moon when held in the outstretched hand. (The list of objects was chosen based on previous investigations of estimated lunar size.) If you use the handout to introduce the Moon illusion you will, of course, want to have students make two judgments: one of the "zenith" Moon, the other of the "horizon" Moon. Hodge reports that, as one might expect, average judgments are quite different.

If you use the handout as a classroom activity, you can compile students' responses. Then ask for raised hands for each item choice. Alternatively, responses may be written on small slips of paper and passed forward. Create a frequency histogram of estimates. (This is also a good demonstration for highlighting basic statistical concepts, including measures of central tenden-



cy and variation.) Kunkel reports that students typically overestimate lunar size, with the modal responses being between a quarter and a softball. While students can check their estimates during the next full Moon, the full Moon actually occupies one degree (or 1/180th) of the night sky, regardless of its altitude or the time of year, and can be occluded by a pea held at arm's length.

The exercise typically leads to a lively discussion of the Moon illusion, as well as the more general task of perception. It provides a good opportunity to review the fundamental question in any discussion of sensation and perception: How does the world out there get in? How do we construct our representations of the external world? To begin with, we must clearly distinguish between two general classes of stimuli: A distal stimulus is an actual object "out there" in the world, and a proximal stimulus is the representation of objects in contact with a sense organ, in this case the visual image on the retina.

Hodge, G. (1990, January). The moon illusion as a stimulus for critical thinking: A demonstration. Paper presented at the 12th Annual National Institute on the Teaching of Psychology, St. Petersburg, FL.

Kunkel, M. (1993). A teaching demonstration involving perceived lunar size. *Teaching of Psychology, 20,* 178–180.

Lecture/Discussion Topic: Auditory Organization

We organize and interpret all our sensory experiences, not just visual ones. Jacques Ninio notes how this applies to hearing. For example, different lines of research indicate that we hear a sound signal as complete even though we may have received only fragments of it. He quotes Radau's *L'Acoustique,* published in 1867:

> A very odd phenomenon is the one that Mr. Willis referred to by the name of *paracousis*. Here is what it consists of. Certain hard-of-hearing persons who usually do not hear faint sound, suddenly do hear them when they are accompanied by a loud noise. Mr. Willis knew a woman who was always attended by a servant with the job of beating a drum when somebody was talking to her; she then heard very clearly. Another person heard only when bells were ringing. Mr. Holder cites two other similar cases: that of a man who was deaf when one did not beat a nearby bass drum, and that of another person who heard best when he was in a carriage that was jolting over the cobblestones.

The explanation of this intriguing phenomenon is that the noise, adding to the words, communicates parts of the speech above the hearing threshold. Having the illusion of hearing continuously, the hearing impaired reconstruct the whole of the communication.

More contemporary research studies also demonstrate the principle of closure or completion when applied to hearing. Research participants with normal hearing are asked to lip-read someone they know, first when the speech is inaudible, then when the acoustic speech signal is replaced by a signal without meaning but with the same timbre as the voice of the person being lip-read. In the latter situation, they show greatly increased understanding of the message.

In a laboratory experiment, R. M. Warren recorded the word *legislature* and then erased one syllable so that one could hear only the remaining fragments. When he replaced the missing syllable with a very loud noise, the audience heard the whole word. Apparently, notes Ninio, the brain interprets the loud noise superimposed on a syllable as masking it. We assume that the whole word was pronounced, and our brain completes the signal by automatically forming a hypothesis about the missing part.

Giovanni Vicario performed musical experiments showing that if a note in a rising scale is replaced by some white noise 20 decibels louder, the listener hears a note of an intermediate pitch between the ones that have been retained on both sides of the noise. People always perceive the natural note that is missing from the scale.

Ninio, J. (2001). *The science of illusions.* Ithaca, NY: Cornell University Press.

Student Project: Visual Capture

You might want to extend your discussion of vision to include *visual capture,* that is, when there is a conflict between vision and other sensations, vision usually dominates—except in some cases. Thaddeus Cowan describes a remarkable exception that students can demonstrate for themselves. The procedure is simple. Take a flash camera (or a smart phone with a camera flash app) into a room with figured or patterned wallpaper. It should be a room that can be darkened (an interior bathroom with a towel against the bottom door crack is ideal). Turn off the lights and dark adapt for 5 minutes. Now, while holding your arm outstretched with an open hand toward the wallpaper, aim and click the camera so the flash hits your hand. In a second or two, you will see a strong positive afterimage of your hand against the wallpaper. Now move your hand downward. Although you are in total darkness, you will see your afterimage hand slip downward, leaving a black hole in the shape of your hand in its place. Kinesthesis has captured vision.

Perceptual Interpretation

Lecture/Discussion Topic: Cases of Restored Vision

In class, you can readily expand on the brief text examples of restored vision. Michael May's vision was restored in March 2000. May has had difficulty recognizing faces of family and friends as well as emotional expressions on unfamiliar faces. He has also had difficulty mastering depth perception. For example, he perceives people who walk away from him as shrinking. On the other hand, he does track his own and others' movements with precision. He can play soccer with his sons, and he enjoys movies. He also distinguishes shaded areas from illuminated surfaces. He's successfully made the transition from being an expert blind skier using verbal guidance to being a competent sighted skier. May sees learning to see as an exciting challenge, perhaps partly because he is an outgoing, optimistic person with a supportive spouse. In an 8-minute interview from 2010 (youtu.be/bnefTJx2sCo), he talks about his decision to have the surgery and the risks involved. Ten years post-surgery he reports that he can see such things as color and motion. For example, he can catch a ball because of the motion, but he cannot see a hole in the ground. He refers to himself as a "hybrid," because he can see some things but not others. He still reads Braille and has a guide dog.

Adults who regain sight after being blind for most or all of their lives often experience initial elation followed by emotional distress, depression, and sometimes even suicide. For example, in *An Anthropologist on Mars,* Oliver Sacks relates the case of Virgil, who saw little until after having cataract surgery at age 50. Sacks describes Virgil as a "mental blind" person who could see but could not decipher what was out there. Virgil was often in conflict between looking at objects or touching them as he had always done. And when feeling visually overwhelmed, he would act as if he were still blind. Virgil quickly fell into depression and just four months after his surgery died of pneumonia.

As Bruce Bower explains, restored vision requires enormous accommodation from the brain. Brain-imaging studies reveal that in primates as much as one-quarter of the brain is normally devoted to vision. In blind individuals, these areas take on entirely new responsibilities. For example, the visual cortex shows increased activity when blind people use their fingers to read Braille publications. With restored vision, these areas must be reclaimed.

Of special interest are studies of blind children in India and Canada who, as a result of cataract surgery, regain vision early in life. For example, neuroscientist Pawan Sinha describes the case of a 10-year-old in Calcutta who, not long after surgery, could catch a paper ball thrown to him, recognize drawings of animals, and greet all of his physicians and nurses by name. Sinha and his colleagues are tracking the progress of 20 Indian children, ages 6 to 15, who grew up sightless before surgical removal of their cataracts. They are surprised by how much the kids recognize shortly after their surgery. These findings do not seem entirely consistent with those who have studied children elsewhere.

Working at McGill University in Canada, psychologist Daphne Maurer has studied young children who have had cataract-induced blindness in only one eye. During infancy, visual information entering the left eye goes mainly to the right hemisphere, while the right eye sends its input mainly to the left hemisphere. Interestingly, those who are blind in only the left eye for the first two to six months of life lose elements crucial for discerning facial recognition, for example, the ability to detect differences in the spacing of the eyes. Those of the same age with right-eye cataracts do not have this difficulty. It seems that the capacity to notice the spacing of facial features develops only if the right hemisphere receives visual stimulation during a brief period early in life.

Bower, B. (2003, November 22). Vision seekers: Giving eyesight to the blind raises questions about how people see. *Science News,* 331–332.

Sacks, O. (1995). An anthropologist on Mars: Seven paradoxical tales. New York: Vintage Books.

Feature Film: At First Sight (MGM, 10 minutes)

Based on Oliver Sacks' story from *An Anthropologist on Mars* (see previous Lecture/Discussion Topic: Cases of Restored Vision), this feature film presents the story of Virgil Adamson, who, through cataract surgery, comes to see for the first time. The film provides a wonderful complement to the text discussion of visual interpretation, specifically, the topic of sensory deprivation and restored vision. Dozens of adults who were born blind have now gained sight. Such patients can distinguish figure from ground and sense colors but they perceive little more. Clearly, this is the case for Virgil Adamson. Beginning with the surgery at 51 minutes into the film, show a 10-minute clip that portrays the bandage removal and the operation's outcome. If time allows, show another clip running from 1:06 to 1:14 that shows Virgil's visit to the therapist, who relates the characteristics of visual agnosia. This 8-minute clip vividly demonstrates Virgil's limited perception and his experience in learning to see.

Classroom Exercise: Displacement Glasses

Glasses that visually displace objects to the left or right are not difficult to construct, and they provide students with a memorable demonstration of perceptual adaptation. Alternatively, ready-made inversion goggles are available from PsychKits. The plastic safety goggles have a 4″ 45-degree prism welded onto each goggle lens. When students look through them, their vision is offset by about 30 degrees. The goggles are $15 a pair and come with several suggested activities. Contact PsychKits, 28835 Herky Drive #112, Lake Bluff, IL 60044-1464, Phone: (847) 234-8096, Fax: (847) 295-3757, web: www.PsychKits.com, and e-mail: info@PsychKits.com.

In constructing your own goggles, Ludy Benjamin suggests using welding safety goggles. They permit the participant to wear prescription glasses under the goggles, and they have a rectangular faceplate with no dividing bridge. Replace the existing lens with a clear piece of one-eighth-inch thick plexiglass. Then, using a pair of scissors, cut from one-inch plexiglass two triangular prisms that will completely cover the exposed faceplate surface. The best prism angle is between 20 degrees and 30 degrees. After polishing the two large faces of each prism, cover them with masking tape. This will enable you to spray-paint (preferably with flat black) the three exposed surfaces. After these are dry, use plexiglass glue to attach the prisms, smooth side down, to the plexiglass faceplate.

Fresnel prisms, according to Robert Terborg, also can be used to create a set of lightweight, compact eyeglasses that distort vision. You can order fresnel prisms called “3M Press-on Optics” from Western Ophthalmics Corporation (www.west-op.com/pressonprism.html). Each Press-on Optic is approximately 2.5 inches in diameter and costs $19.95. It can be cut to match the size of a standard lens, with the smooth side adhering to the inside surface of the lens when pressed in place. The prisms can be ordered in various angles (30 degrees is probably best) and can be mounted so they distort to the right, left, up, or down.

Two demonstrations using the glasses have worked well. The first involves having a volunteer wear the glasses and attempt to throw a rubber ball to the middle person in a group of three who are standing about 6 feet apart at the front of the classroom. Have the student throw from a distance of about 25 feet. Invariably, the first few tosses will go to the person on the far left. Gradually, the student’s aim will improve. When the glasses are removed, the student’s first few tosses will invariably go to the person on the far right.

An even simpler demonstration involves drawing a vertical line on the board and asking the volunteer wearing the glasses to stand at arm’s length from it. Ask her to raise her arm quickly, point to the line, and then immediately lower her arm. She should repeat this until her aim is accurate. After she removes the glasses, her initial aim will be displaced in the opposite direction.

In discussing the results of this demonstration, emphasize that students do not come to see the visual field differently but rather learn new motor responses that are consistent with the visual displacement.

Benjamin, L. T. (1985). Perceptual demonstrations—Or what to do with an equipment budget of $75. In L. T. Benjamin, R. S. Daniel, & C. Brewer (Eds.), *Handbook for teaching introductory psychology*. Hillsdale, NJ: Erlbaum.

Terborg, R. (1990). An improved device for studying adaptation to displaced vision. *Teaching of Psychology, 4,* 243–245.

Lecture/Discussion Topic: Living Without Vision

Tommy Edison has been blind since birth. He has published short videos to YouTube since 2010, answering all sorts of questions about what it is like to live without vision. Some typical questions include “How do blind people dream?” and “How do blind people cross the street?.” Visit his YouTube channel: www.youtube.com/user/TommyEdisonXP.

Hearing

PsychSim 6: The Auditory System

Tom Ludwig’s computer program will help students understand the auditory process. Students are first asked to identify the parts of the ear. Then, through a series of explanations, diagrams, and questions, they develop a sense of how sound waves are processed and interpreted by the ear and the brain. The psychological and physical characteristics of hearing are explained and contrasted. This fully interactive program brings the two-dimensional drawings from the text to life.

Student Project: Color the Ear

Distribute Handout 15 to your students. Ask students to color the eight structures of the ear. Encourage students to choose colors based on function. Blue may be a good choice for the semicircular canals because of the role they play in balance (*B* for blue and balance). Choosing a color with a rationale tied to the ear structure’s role provides the deep processing in this assignment. On the back of the handout, students can name the structures and write a bit about what each structure does and why they chose that particular color.

Lecture/Discussion Topic: Recognizing Our Own Voice

Why does our own voice sound unfamiliar when we hear it on tape? When we listen to ourselves speak, we hear both the sound conducted by air waves to the outer ear and that carried directly to the auditory nerve by bone conduction. The latter is easily demonstrated by clicking the teeth or munching popcorn, or by striking the prongs of a fork on a table and quickly applying its handle to the bone behind the ear. An even more resounding effect will be produced if the handle is clenched between the teeth. The strictly air-conducted sound that others normally hear (like a sound we hear when our voice is on tape) is thinner. Students can hear the sound waves conducted by bone if they plug their ears and talk in a normal voice.

Students can also demonstrate bone-conducted sound with a metal coat hanger tied to the center of a thin string about four feet long. They should first press one end of the string into each ear with the tips of the index fingers while plugging their ears. Then they should ask someone to tap the coat hanger with a knife or fork. John Fisher reports that the effect will sound like “Big Ben.”

People who are deaf due to a defect in either the inner or middle ear may still be able to hear by bone conduction. When Beethoven became deaf, he could still hear a piano being played by placing one end of his walking stick against it and gripping the other end between his teeth. To determine the nature and degree of their hearing loss, deaf violinists reportedly applied their teeth to some part of their vibrating instruments. If they could not hear sound, they concluded that the auditory nerves were the problem and the deafness was past cure.

A few companies now manufacture bone conduction headphones. The headphones wrap around the head with the "ear" pieces set against the cheekbones in front of the ears. You hear what's coming through the headset via bone conduction while still being able to hear what's going on around you through the auditory canal.

Fisher, J. (1979). *Body magic*. New York: Stein and Day.

Lecture/Discussion Topic: Hearing Loss

A Lecture/Discussion Topic on hearing loss appears in the unit on Thinking and Language, found elsewhere in these resources. That item is also relevant to a discussion about the auditory system.

Classroom Exercise: Range of Human Hearing

In general, humans are capable of hearing sounds between 20 Hz and 20,000 Hz. This 144-second YouTube video plays thate range of frequencies humans, in general, are capable of hearing: youtu.be/qNf9nzvnd1k.

Invite your students to share what they can hear. Ask participating students to raise their hands when the video starts, then drop their hands when they can no longer hear the sound.

Students who are frequently exposed to loud sounds, such as music played loudly through headphones, may not be able to hear the highest-pitched sounds.

Students who are concerned about their hearing or the hearing of a loved one can find an audiologist through the American Academy of Audiologists (audiology.org).

Lecture/Discussion Topic: A Quiet World—Living With Hearing Loss

In his book A Quiet World, text author David Myers gives a personal account of his mother's and now his own personal challenge in dealing with hearing loss. It's a book you will want to recommend to your students.

In diary fashion, Myers relates the problems at home and at work that accompany gradual hearing loss. He recounts errors tragic and humorous. Both from his personal experience and his expertise as a research psychologist he helps readers understand the impact of the impairment on sufferers and on those closest to them. As Paul Chance observes, Myers helps his audience appreciate how the inability to hear can become the inability to connect. Myers' later journal entries describe, for example, his encounters with new technologies and insights into the nature of hearing. An appendix provides a host of helpful resources for the hard of hearing.

Of special note is the chapter on "Aids and Advice." Myers passes along these specific tips for friends, colleagues, and family members.

1. Invite us to a quiet place, for example, a room without loud music, a carpeted restaurant, a chair away from the air conditioning.
2. Capture our attention. If we are reading or watching television, make certain we're looking at you.
3. Face the light and face us. Since we all do some lip reading, it helps to see your mouth. And don't conclude that we are rude if we look at your mouth rather than your eyes.
4. Rephrase. If we don't seem to hear it, restate it. Try using different words to express the same thought. Change "Do you want something from the store?" to "Can I get you something at Safeway?"
5. Create a context. Help us to know the subject. Have a printed agenda for meetings, use visual aids. Caller I.D. is a blessing for us.
6. Speak slowly. Don't holler, but enunciate each word with pauses between phrases and sentences.
7. Ask us if we have heard. Remember, we don't like to seem inept or to embarrass both of us by volunteering that we did not hear.

Myers, D. G. (2000). A *quiet world: Living with hearing loss.* New Haven: Yale University Press.

Classroom Exercise: Locating Sounds

We localize sound by detecting small differences in the loudness and timing of the sounds received by the two ears. To demonstrate principles of sound localization, invite a volunteer to sit with eyes closed in a chair facing the class. Clap at varying locations around the volunteer's head. The person will confidently and accurately locate sounds coming from either side (which strike the two ears differently), but will have more difficulty locating sound in the 360-degree plane equidistant between the two ears (overhead, in back, or in front). When asked, the class will readily provide the correct explanations for this.

The perceived direction of a sound is related to differences in the time at which the sound is received by each ear. Stanley Coren and his colleagues show how to demonstrate this with a four-foot length of flexible plastic tubing or hose. A student holds one end of the tube up to each ear, while the circle formed is kept down and in front of the body. Another person then taps the tube with a pencil. A sound wave will move in both directions to the ears. If the tube is tapped at any point other than the middle, the sound will reach the two ears at different times. Thus, the sound will seem to come from different directions as different spots on the tube are struck.

(PsychKits also sells an auditory localization demo for $5. Take a look at www.PsychKits.com. You can order online, mail, phone, or fax: PsychKits, 28835 Herky Drive #112, Lake Bluff, IL 60044-1464, Phone: (847) 234-8096, Fax: (847) 295-3757.)

Coren, S., Ward, L., & Enns, J. T. (2003). *Sensation and perception* (6th ed.). New York: Wiley.

The Other Senses

Touch

Lecture/Discussion Topic: The Amazing Capabilities of Touch

E. Bruce Goldstein cites two wonderful examples of the amazing human capacity of touch that you can use in class to introduce the topic.

Blind from the age of 4, Netherlands-born Geerat Vermeij came with his family to the United States at an early age and studied in both residential and regular schools before attending Princeton University. During his senior year, he applied to graduate schools to pursue evolutionary biology with a specialty in mollusks. Most told him that his blindness would make such study impossible. Edgar Boell at Yale finally granted an interview. He took Vermeij to the museum, introduced him to the curator, and gave him a shell. Vermeij relates what happened:

> "Here's something. Do you know what it is?" Boell asked as he handed me a specimen.
>
> My fingers and mind raced. Widely separated ribs parallel to outer lip; large aperture; low spire; glossy; ribs reflected backward. "It's a Harpa," I replied tentatively. "It must be Harpa major." Right so far.
>
> "How about his one?" inquired Boell, as another fine shell changed hands. Smooth, sleek, channeled suture, narrow opening; could be any olive. "It's an olive. I'm pretty sure it's Oliva sayana, the common one from Florida, but they all look alike."
>
> Both men were momentarily speechless. They had planned this little exercise all along to call my bluff. Now that I had passed, Boell had undergone an instant metamorphosis. Beaming with enthusiasm and warmth, he promised me his full support. (Vermeij, 1997, pp. 79–80)

Goldstein explains that Vermeij graduated with a Ph.D. and became professor of geology at the University of California, Davis, and editor of the scientific journal *Evolution*. Through his exquisite sense of touch, he focuses on the physical characteristics of shells and necessarily ignores extraneous visual details. Ironically, this has enabled him to surpass many of his sighted colleagues.

Braille, the system of raised dots that allows blind people to read with their fingers, provides another example of the remarkable capabilities of touch. The Braille alphabet consists of raised dots in a 2 x 3 matrix. There are characters for each letter of the alphabet and for numbers, punctuation marks, and common speech sounds and words. Until Louis Braille introduced his system to students at the Paris School for the Young Blind in 1824, the only reading materials available to blind people were a few books that embossed the shapes of conventional letters onto the page. They were rarely read because each letter had to be laboriously scanned to determine its complete shape. Although the dots eliminated this problem, many sighted educators thought it absurd to teach the blind such a different and difficult system. Nonetheless, blind students loved it and, in 1854, the system was officially recognized in France. Those who have learned the system can read at a rate of about 100 words per minute. This speed is particularly impressive given that the touch of raised dots must be transformed into vast amounts of information that go well beyond simply sensations on the skin.

There are businesses, such as access-usa.com, that will take business cards and convert them to Braille. Through the National Braille Press (www.nbp.org/ic/nbp/braille/alphacard.html), you can download a PDF of the card that shows where the embossed dots would go. You can request a free embossed card by completing the form via that same website, or you can order a pack of 35 cards for $6.

Goldstein, E. B. (2010). *Sensation and perception* (8th ed.). Pacific Grove, CA: Wadsworth.

Vermeij, G. (1997). *Privileged hands: A scientific life*. New York: Freeman.

Classroom Exercise: Two-Point Thresholds

Our sensitivity to tactile stimuli varies over different parts of the body. One way to demonstrate the differing sensitivities is through the two-point discrimination threshold. The ends of two toothpicks create a two-point threshold and will be felt as a single touch if they are close enough together. The two-point threshold is a measure of the distance between stimuli before they are felt as two separate touches. This distance varies considerably over the skin areas of the body.

For this series of demonstrations, it is probably best to have students work in pairs, with each pair given two toothpicks. Have them alternate the roles of research participant and experimenter. Have the experimenter hold the ends of the toothpicks about one centimeter apart and touch the participant's cheek or nose. Then repeat the touch on the calf of the leg. Two points will be experienced on the cheek or nose while only one will be felt on the calf. By varying the distance between the toothpicks, two-point thresholds can be determined for different parts of the body. The fingertips and forearm are also good areas for contrasting the thresholds and thus demonstrating differential sensitivity.

John Fisher suggests a fascinating experiment for students to attempt. Have them set the ends of the toothpicks an inch apart and then draw them from the crease of the elbow down the forearm and over the wrist, so that finally one toothpick reaches the tip of the second finger and the other the tip of the third finger. The distance between the points must remain constant. What begins as a single sensation changes strangely into two (in the hand). The distance between the toothpicks will appear to increase as they come closer to the fingertips.

The same experience can be produced by drawing the toothpicks from below the ear across the face in two parallel lines so that the mouth is sandwiched between them. The person will feel the shape of an ellipse that seems to fit the lips snugly. The distance will appear to increase and then decrease as the toothpicks move to a more sensitive area, then back to a less sensitive area.

Fisher, J. (1979). *Body magic*. New York: Stein and Day.

Classroom Exercise/Student Project: Warm Plus Cold Equals Hot

Stimulating nearby cold and warm spots on the skin produces a feeling of hot. Intertwining two separate coils through which cold and warm water are passed can be used to elicit the effect. Donald Mershon suggests a more convenient demonstration that utilizes an ice-cube tray (one that makes the very small cubes). First fill every other row in either direction with water and freeze. Then, being careful not to slop water to produce melting, fill the empty row with warm water. Have a student place his or her hand over the surface of the tray to feel the heat.

Stanley Coren and his colleagues suggest another way to produce the sensation of a very hot stimulus. Have students do the following: Bend two pipe cleaners so they will fit together as shown below. Place one pipe cleaner in a glass of cool water and the other in a glass of very warm (but not unpleasantly hot) water for a few minutes. Remove the pipe cleaner from the cool water and lay it on a flat surface. Then, working quickly, take the pipe cleaner out of the warm water and position it as shown. Place your forearm over both pipe cleaners and press down; you will get the sensation of a single, very hot stimulus.

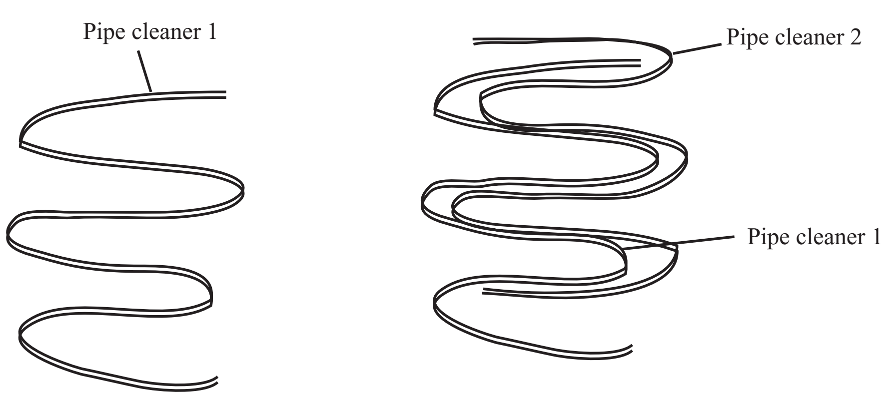
The sensation is fleeting because as soon as the water begins to evaporate, the skin will cool.

Coren, S., Ward, L., & Enns, J. T. (1994). *Sensation and perception* (4th ed., p. 310). Fort Worth, TX: Harcourt Brace.

Classroom Exercise: Touch Localization

Another interesting aspect of touch localization is that neural impulses from different parts of the skin surface take different amounts of time to reach the brain.

This can easily be demonstrated. Stanley Coren suggests having students just touch their two index fingers together. Tell them to concentrate on experiencing *where* the sensations of touch are felt, that is, on which of the two fingers. Most will report sensations of equal intensity in both fingertips. Next ask students to touch their lower lip with light, quick touches. Most people will now report that they feel the sensation mostly on the lip and little, if any, on the fingertip, although both are being stimulated. Finally, have them apply the same light, quick touches to the little toe or ankle. Now the sensation seems to be located primarily in the finger. Touch localization depends on the relative lengths of the pathways from the stimulated parts to the brain.



Source: From Stanley Coren, Lawrence M. Ward, and James T. Enns, *Sensation and perception,* 5th Edition. Copyright © 1999 John Wiley and Sons, Inc. Reproduced by permission.

Coren, S., Ward, L., & Enns, J. T. (1994). *Sensation and perception* (4th ed., p. 310). Fort Worth, TX: Harcourt Brace.

Lecture/Discussion Topic: The Remarkable Case of Ian Waterman

Ian Waterman, as a result of a rare viral infection, lost his sense of light touch and of body position and movement. He has learned to walk and eat by visually focusing on his limbs and directing them accordingly.

You may expand on Waterman's and other similar cases in class to illustrate both the complexity of the touch, or haptic, senses and the brain's remarkable ability to use back-up systems.

As Beth Azar explains, the haptic sense involves many different nerves that enable us to feel a variety of sensations. Waterman has lost use of the *muscle spindles and tendon receptors* that enable us to sense joint position and muscle stretch, as well as to know where our limbs are in space. He has also lost use of the *cutaneous receptors* that enable us to sense when we touch or are touched. On the other hand, he retains use of *subcutaneous pressure receptors* which allow us to feel deep pressure, two sets of *thermoreceptors* through which we experience warm and cold, and *small muscle receptors* that provide our experience of muscle tension, cramp, and fatigue.

Through trial and error, Waterman learned to move again by consciously controlling and visually monitoring every action. If the lights go out, he falls to the floor unable to move until they come back on. When he is not looking at his body, he moves very little, quite unlike the rest of us who tend to unconsciously move all the time. Brain imaging indicates that his frontal cortex is active when he's both making and seeing a simple finger movement. For others, this area is not active because the movement is automatic.

Research with Waterman has provided important insights into how the brain plans movement. In one study, researchers tested his ability to point at a target flashed on a screen without being able to see his arm. His assignment was to rest his arm on a tabletop and sweep it left or right to point at the target. Even with no feedback about where he moved his arm, he accomplished the task quite well. Interestingly, however, when unknown to Waterman, the researcher blocked his arm movement to the left from straight ahead, and the next target flashed straight ahead, Waterman incorrectly moved his arm to the right. From this finding, researchers now question theories that maintain that the brain plans movements around an equilibrium point that represents the actual position of the arm. Rather, the brain calculates an angle of movement and directs motion accordingly from wherever the limb happens to be.

Another interesting study is that of Ginette Lizotte of Quebec, who lost her sense of touch beginning just below the nose. Unlike Waterman, she has made a conscious choice to stay in a wheelchair and not attempt to learn to walk again. Like Waterman, though, she continues to amaze researchers with some surprising abilities. For example, she can accurately estimate the weight of objects. While the rest of us use feedback from the stretch of our tendons and muscles, Lizotte uses vision to see how her body reacts to a set movement when lifting an object. The faster and higher it moves, the lighter the object. She can detect differences as little as 10 percent of the weight of an object. With the eyes shut, the sensitivity is lost.

Lizotte also is remarkably adept at a mirror drawing task in which one must draw a star while looking in a mirror rather than at a paper. Instinctively, most of us move in the wrong direction and it takes more than seven tries to draw a recognizable star. Lizotte did it on her first try. Researchers note that most have trouble because "we see what we are doing but behind the visual cues is a signal from the muscular senses that gets in our way." For Lizotte, that obstacle is removed.

Finally, Waterman's case has taught researchers something important about gestures—the hand movements that accompany speech. His gestures have always appeared completely normal and thus appear controlled by a different mechanism than more intentional movements. In a series of experiments, researchers had him narrate a story using gestures, once while looking at his hands and again without being able to see them. The gestures were smaller when he could not see them but were almost as frequent and as well synchronized with his words as when he was watching.

The BBC aired an episode of its *Horizon* television program about Ian Waterman in 1997. Titled "The Man Who Lost His Body," the program details the cause of Waterman's disorder, the rarity of it in the human population, and the process by which he struggled to regain the ability to walk and move independently without the benefit of proprioception. The program is not currently available for purchase, but you can find at least four different clips from the episode on YouTube.

Azar, B. (1998, June). Why can't this man feel whether or not he's standing up? *APA Monitor,* 18, 20.

Pain

Classroom Exercise: The Revised Reducer–Augmenter Scale

Handout 16 is Rock L. Clapper's (1990) Revised Reducer–Augmenter Scale that can be used to introduce individual differences in pain tolerance. Some people seem unable to tolerate even slight discomfort, while others seem able to tolerate pain quite easily. Aneseth Petrie suggested that people with low pain tolerance have a nervous system that amplifies, or *augments,* sensory stimulation. People with high pain tolerance have a nervous system that dampens, or *reduces,* the effects of sensory stimulation. From her theory, it follows that augmenters will tend to prefer nonstimulating experiences while reducers tend to prefer stimulating experiences. Handout 16 is scored by adding the numbers circled. Total scores can range from 21 to 126, with lower scores reflecting a tendency toward "reducing" and higher scores reflecting a tendency toward "augmenting."

Before the design of this scale, Petrie measured respondents' tendency to either augment or reduce the impact of sensory experience by blindfolding them and presenting them with different-sized rectangular wooden blocks. Some participants regularly overestimated the size of the blocks ("augmenters"), while others underestimated the size of the blocks ("reducers"). In a series of studies, Petrie found that augmenters were indeed much less tolerant of pain than were reducers. Consistent with this analysis of pain tolerance, women who were augmenters reported more pain during childbirth than did reducers.

Some studies have examined how reducing–augmenting relates to nervous system reactivity. Investigators report that, in comparison to augmenters, reducers demonstrate relatively small brain responses to flashes of light and bursts of noise. Reducers seem motivated to seek stronger stimulation. They drink more coffee, smoke more, and have a lower threshold for boredom compared with augmenters. Furthermore, as adolescents, reducers engage in more minor delinquencies and are more likely to abuse alcohol.

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Larsen, R. J., & Buss, D. M. (2008). *Personality psychology* (3rd ed.). New York: McGraw-Hill.

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Lecture/Discussion Topic: "Amputating" a Phantom Limb

In *Phantoms in the Brain,* well-known psychological researcher and neurologist Vilayanur S. Ramachandran and science writer Sandra Blakeslee provide the following vivid example of phantom limb pain:

> I placed a coffee cup in front of John and asked him to grab it [with his phantom limb]. Just as he said he was reaching out, I yanked the cup away.
> "Ow!" he yelled. "Don't do that!"
> "What's the matter?"
> "Don't do that," he repeated. "I had just got my fingers around the cup handle when you pulled it. That really hurts!"
> Hold on a minute. I wrench a real cup from phantom fingers and the person yells, ouch! The fingers were illusory, but the pain was real—indeed, so intense that I dared not repeat the experiment (p. 43).

Often, pain occurs in a phantom limb because the victim feels that the limb is stuck in an uncomfortable or unnatural position and cannot be moved. For example, a patient of Ramachandran and his colleagues reported excruciating cramping in his phantom arm. The patient felt that his phantom hand was clenched so tightly he could feel his fingernails digging into his phantom palm. The researchers devised an unusual treatment. They placed a mirror in a cardboard box and told their patient to place his existing hand inside the box next to the mirror. When the patient looked at the mirror, the reflection of his existing hand provided an image of the phantom limb. They told the patient to imagine that the reflection was in fact the missing limb and to practice clenching and unclenching his fist (using, of course, his existing hand) while looking in the mirror. The illusion brought relief. The artificial visual feedback enabled the patient to "move" the phantom limb and to unclench it from its painful position. In two weeks the patient's pain disappeared along with his perception of a phantom arm. Research with other patients has confirmed that mirror-box therapy can be successful in "amputating" phantom limbs.

Ramachandran has also used a mirror box to "shrink" pain in a phantom limb. Instead of using only a mirror, he used a mirror in combination with a lens; as the patient looked at the mirror, the lens was adjusted so that the limb shrank. Interestingly, the patient's perception of pain also shrank.

While the mirror-box treatment works for some people with an amputated limb, it doesn't work for all—and, of course, it doesn't work for double amputees. Researchers are having some success with virtual limbs. Sensors placed on the stump of the amputated limb detect muscle movement. The sensors are connected to a computer that shows, like a mirror, the person's virtual body complete with an intact virtual arm. By contracting muscles in the stump, a person can control the intact virtual arm. One person who has tried this has experienced a significant reduction in his phantom limb pain.

For students who want to learn more about the phantom limb phenomenon, refer them to an article, "How Do You Amputate a Phantom Limb?" by Robert Krulwich and Jad Abumrad, hosts of the radio program Radiolab. The article can be found on the website for National Public Radio (see www.npr.org/templates/story/story.php?storyId=101788221). Alternatively, they can listen to the story, which is 7:46 minutes long, through that same website.

You might consider playing this podcast for your students, then break them into small groups to respond to the following questions:

1. What brain regions are likely involved in the experience of pain from phantom limbs? Why did you select those specific brain region(s)?
2. Which perceptual systems are likely to have been involved in the box-and-mirror therapy described in the article and podcast?
3. What is happening in the mind when a person "unlearns" the "learned pain"?

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Ramachandran, V. S., Rogers-Ramachandran, D. C., & Cobb, S. (1995). Touching the phantom. *Nature, 377,* 489–490.

Classroom Exercise: Experiencing Phantom Sensations

While most of your students have not experienced phantom limb sensations, they can still have an eerie phantom limb-type experience.

Begin by asking students to close their eyes and note where their hands and feet are. This is proprioception. Typically, with our eyes open, proprioception and vision match. It feels like my right hand is resting on the table in front of me, and when I look, sure enough there it is.

But what happens when proprioception and vision don't match? You can illustrate this with a mirror.

Ask students to bring a hand mirror to class; 4″ by 4″ or so will work fine. Have students prop the mirror in front of them against some books so that the mirror rests on edge perpendicular to the body, with the mirror facing right. The students then place their right hand so that it can be seen in the mirror. Now instruct students to place the left hand on the left side of the mirror so that it's in approximately the same location as the mirrored right hand. In other words, it should look and feel like a student is looking at the left hand through glass, not looking at the right hand in a mirror.

Once everyone is set up, instruct students to look in the mirror, and, while keeping the left hand still, move the right hand. Most people report a disconcerting feeling. It's a strange sensation to have conflicting information from vision and proprioception.

What happens when vision and our sense of touch don't match? As Vilayanur Ramachandran suggests, have students pair up. While one student looks at his or her right hand in the mirror, the student's partner uses a retracted pen or the eraser side of a pencil to tap or stroke that right hand. Ask students to note the sensation, but not report it out loud. Have students switch roles and repeat. Now, bring the class together and ask students to report their experience. Some may report that their left hand felt numb or that they felt some other kind of sensation in the left hand. Others may report that they felt nothing to the point where their left hands may have felt disconnected.

Ramachandran, V. S., & Rogers-Ramachandran, D. (2011, July/August). Reflections on the mind. *Scientific American Mind.* Retrieved August 7, 2014, from www.scientificamerican.com/article/reflections-on-the-mind.

Lecture/Discussion Topic: Cultural Differences in Pain

Ronald Melzack and Patrick Wall's gate-control theory explains how the experience of pain can be influenced by information from the brain. These brain-to-spinal cord messages can be deterred by psychological factors. For example, the hook-swinging ceremony practiced in parts of India is a graphic demonstration of the effect of culture on pain perception. Melzack and Wall describe the ceremony as follows:

> The ceremony derives from an ancient practice in which a member of a social group is chosen to represent the power of the gods. The role of the chosen man (or "celebrant") is to bless the children and crops in a series of neighboring villages during a particular period of the year. What is remarkable about the ritual is that steel hooks, which are attached by strong ropes to the top of a special cart, are shoved under his skin and muscles on both sides of his back. The cart is then moved from village to village. Usually the man hangs on to the ropes as the cart is moved about. But at the climax of the ceremony in each village, he swings free, hanging only from the hooks embedded in his back, to bless the children and the crops. Astonishingly, there is no evidence that the man is in pain during the ritual; rather, he appears to be in a "state of exaltation." (Melzack & Wall, 1983, p. 28)

Sports injuries may go unnoticed until well after a game. In the summer of 1996, gymnast Kerri Strug secured the gold medal for the U.S. Olympic team by completing her last vault on a badly sprained ankle. In fall 2002, Philadelphia Eagles' quarterback Donovan McNabb threw four touchdown passes while playing with a broken ankle. Then, in 2010, skiing champion Lindsey Vonn skied in the Olympic downhill with an injured shin. Despite the pain, she still won a gold medal for the United States. H. K. Beecher found that only 25 percent of men seriously injured in battle requested a narcotic for pain relief, but more than 80 percent of civilians who were about to undergo major surgery requested painkillers. The soldiers knew that their wounds would provide escape from the hazardous battlefield to hospital safety. The stress of combat may also have contributed to their relative insensitivity to pain. Research also indicates that when surgical patients were told what to expect following surgery and to relax to reduce their pain, they needed fewer painkillers and were sent home 2.7 days earlier than a control group. Finally, research indicates that up to 35 percent of patients with pathological pain obtain relief from a placebo that contains no active ingredients. All these examples show that there is more to pain than what stimulates the sense receptors.

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Lecture/Discussion Topic: Pain Control

Approximately 1 in 6 Americans suffers from chronic or recurrent pain. Telephone interviews with a random sample of 800 adults reported by the American Chronic Pain Association (theacpa.org) revealed the following statistics:

72% have had chronic pain for more than three years.

76% experience pain daily, including 48% who say it is ever present.

34% have experienced chronic pain for more than 10 years.

30% waited more than three months to see a doctor.

47% say their pain is not under control.

53% are taking a prescription medication, and 29% are taking only an over-the-counter medication.

89% with chronic pain use alternative treatments.

Pain specialists estimate its cost in medical expenses and lost income and productivity to be as much as $100 billion annually. The most common forms are recurrent headaches, low-back pain, and arthritis. Chronic pain costs the country billions annually in hospitalization, lost work time, legal costs, and disability payments. Fifty million pain sufferers are partially or totally disabled by chronic or long-term pain.

Chronic pain often begins as a result of injury, but it continues long after the injury should have healed. Whereas pain from an acute injury warns the body to seek help, chronic pain delivers no beneficial message. Pain becomes a disease in itself, as patients' lives begin to revolve around their suffering.

Pain clinics have sprung up in many cities to help these "incurable" sufferers. The clinics most often use a multidisciplinary approach. Clients are interviewed to see if the pain is organically based and to determine a treatment. A psychosocial assessment may also be done in determining treatment. Dennis Turk and his colleagues have defined three subtypes of people who are evaluated at pain centers. *Dysfunctional* patients report high levels of pain and psychological distress and believe they have little control over their lives and are extremely inactive. *Interpersonally distressed* patients feel they have little social support and report that significant others don't take their pain seriously. *Adaptive copers* report far less pain and social distress than people in the other two groups and continue to function at a relatively high level.

The four main elements of pain treatment programs are (1) drugs, (2) injection therapies such as nerve blocks like epidurals, (3) physical therapy and exercise, and (4) behavioral techniques, including relaxation training, biofeedback, and psychotherapy. Behavioral approaches are based on the assumption that pain has become a learned behavior pattern that can be changed.

Behavior treatments for pain were first used in the 1960s. Wilbert Fordyce, a psychologist at the University of Washington School of Medicine, was among the first to suggest that changing a patient's behavior might bring pain under control. In his behavior-modification program, patients are first weaned from the drugs they are taking. Painkillers are delivered on a fixed schedule rather than on demand, and as a "cocktail" in which the amount of painkiller is slowly reduced. Patients learn to increase their activity level slowly and not to give up at the first sign of pain. Complaints are ignored, successes praised. The underlying assumption is that patients will feel and function better if they learn to focus on something other than pain.

Psychologist David Corey, founder of Behavioral Health, Inc., uses a similar approach, except that patients are given much more control over the treatment process. Corey's goal is to change people's perception of their pain, as well as the way they react to it. This is accomplished by teaching patients about the factors and the kinds of behavior that influence pain and by having them perform exercises and activities to manage the pain. For some, Corey reports, the mere realization that they can control their pain drastically reduces their anxiety, and pain levels drop.

Corey's patients are encouraged to stop taking medications, but, unlike Fordyce's patients, they reduce the levels themselves. Patients adhere to a

40-hour-a-week schedule that they set up with their field workers. Days are broken down into tasks, such as relaxing, walking, exercising, and performing simple chores. Activity levels are deliberately set lower than a patient's level of ability. For example, a patient who usually can walk for three minutes without pain is told to walk for a minute and a half. The idea is to dissociate the pain from the activity. As strength increases, times are increased.

This does not mean that patients stop an activity if they experience pain. On the contrary, having patients exercise despite pain goes hand in hand with changing their attitudes from passive to active. Eventually, they realize they can control their own pain, a crucial turning point. People who expect to be "cured" of their pain won't succeed in the program, says Corey. Nothing is done for them. Rather, people are taught what they can do for themselves.

Patients in the program learn to control stress and anxiety through relaxation, cognitive imagery, and distraction. They are taught to relax through biofeedback; when they see they can control muscle tension, they begin to have confidence that they can control their pain. The staff also teaches patients to relax by using guided imagery techniques—for example, to imagine that they are lying on a warm, sunny beach. Patients may learn the Jacobsen technique, in which they alternately tense and then relax certain muscle groups. Eventually, patients are able to reduce the level of pain significantly by relaxing. One patient who uses this technique for chronic back pain reports, "Some days I get twinges. If I have one I sit down and go into relaxation for a few minutes and that's that."

Field workers frequently go to patients' homes and use the entire family in the therapeutic process. Corey believes this is a major reason for the program's success rate, which is 70 percent, measured more than a year after treatment. Not everyone, of course, is helped. The program demands a high level of energy, which some are not willing to invest. It's also expensive, with the average treatment running in the thousands.

Psychologists David Patterson and Hunter Hoffman have used virtual reality to ease pain during burn wound treatment. In an early test, teenage burn patients underwent a few minutes of wound treatment while they played a Nintendo game or while they were in SpiderWorld, a virtual environment used for treating a spider phobia. The patients reported feeling less pain and spending less time thinking about their pain while using virtual reality than while playing Nintendo. Patterson and Hoffman attributed the difference to the phenomenon known as "presence"—the illusion of actually going inside another world. "Pain requires conscious attention," explained Hoffman. "Virtual reality lures attention into this virtual world, and that drains the amount of attention available to process the pain signal. Nintendo games are very sophisticated but the illusion of presence in Nintendo was very low, compared with the virtual reality environment."

The findings have been replicated with other burn patients, whose pain decreased dramatically when they were in virtual reality compared with when they were not distracted. The researchers have now developed SnowWorld, a more compelling virtual environment than SpiderWorld. Patients in SnowWorld fly through a snowy canyon, shooting snowballs at snowmen, polar bears, and igloos. The assumption underlying this new creation is that a snowy environment is the opposite of fire, and thus it may broaden the gulf between patients' burn pain and the object of their attention during treatment.

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Lecture/Discussion Topic: Placebos and Pain Relief

A study by Rebecca L. Waber and her research team highlights the power of expectations in pain relief. The researchers informed 82 participants about a (purported) new opioid analgesic approved by the Food and Drug Administration. Described as similar to codeine but with a faster onset time, the "medication" was actually a placebo. Half the participants were informed that the drug had a regular price of $2.50 per pill and half that the price had been discounted to $0.10. When later asked to rate the intensity of their pain, 85 percent of those who received the high-priced pill reported feeling better, compared with 61 percent who received the pill costing only $0.10. "We all know that we expect more from products with high prices and good names, and we wanted to see if these things could change how we react to pain medication," observed team member Dan Ariely, "and the answer seems to be yes." Ariely suggests that the findings may help explain why people often claim that generic drugs are less effective than their name-brand equivalents.

Marta Peciña and her colleagues found that personality matters, too. Participants were subjected to pain and then given an intravenous placebo every 15 seconds. Researchers used PET scans of the brain's pain relief centers for an objective measure rather than participants' subjective reports. Those who appeared to have the greatest relief from pain were those who scored highest on the Big Five trait of agreeableness and lowest on neuroticism. Perhaps surprisingly, optimism alone did not correlate with pain relief.

Some have posited that the placebo effect is driven by classical conditioning. After repeatedly taking pills that actually relieve pain, taking a placebo pill will trigger the pain-relieving response. Others have posited that the placebo effect is driven by expectancy, that it's a cognitive mechanism. If you expect that pain relief is coming, you will experience pain relief. At this point, we don't really know. It may be that both routes work. It may be that classical conditioning is a type of expectancy (Kirsch, et.al., 2014; Stewart-Williams & Podd, 2004).

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Lecture/Discussion Topic: Is Hypnosis an Altered State of Consciousness?

Irving Kirsch and Steven Jay Lynn provide an excellent review of the literature on hypnosis, including the question of whether hypnosis produces an out-of-the-ordinary, trancelike, "altered" state of consciousness. They conclude that while this was once a central issue that divided hypnosis theorists into two opposing camps, there is now a continuum of positions. Moreover, research has shown that hypnotic responsiveness depends more on the abilities, beliefs, and interpretations of the person being hypnotized than on the use of a hypnotic induction. Hypnosis seems to increase suggestibility, but for most that increase is small. A person who responds without induction to 6 of the 12 suggestions on a standard hypnotic susceptibility scale might respond to 7 after an induction. Similar increases may occur in response to nonhypnotic procedures. Thus, Kirsch and Lynn conclude, the term *hypnotic state* is usually used today in a descriptive sense to denote the subjective changes that hypnotized people report experiencing. It is not used to explain those changes. Most researchers agree that the impressive effects of hypnosis stem from social influence and personal abilities, not from a trancelike state of altered consciousness.

Kirsch and Lynn report other important research conclusions that challenge the conventional wisdom about hypnosis. Research indicates the following:

1. The ability to experience hypnotic phenomena does not indicate gullibility or weakness.
2. Participants retain the ability to control their behavior during hypnosis; they are aware of their surroundings and can monitor events outside the framework of suggestions during hypnosis.
3. Spontaneous posthypnotic amnesia is relatively rare.
4. Hypnosis is not a dangerous procedure when practiced by qualified researchers and clinicians.
5. Hypnosis does not increase the accuracy of memory.
6. Hypnosis does not foster a literal reexperiencing of childhood events.

Current research is addressing these questions:

1. To what extent can hypnotic responsiveness be modified? Although hypnotizability has been modified in the laboratory, it still needs to be demonstrated that training gains can be translated into positive clinical outcomes in the real world.
2. Does hypnosis produce fundamental shifts in information processing? Research evidence suggesting that hypnotized subjects process information more holistically, with relatively little effort, and with greater verbal automaticity than nonhypnotized subjects needs careful evaluation. It is particularly important to determine whether these differences are specific to the induction of hypnosis or are correlates of hypnotizability.
3. What is the clinical effect of adding hypnosis to psychotherapy? Meta-analyses suggest a quite substantial positive effect. Researchers need to answer for what patients, for what problems, and for what specific treatments hypnosis produces enhancement effects. Hypnosis seems helpful for treating obesity but not drug, alcohol, or smoking addictions.
4. What are the physiological substrates of hypnosis? Finding physiological markers of hypnosis would support the notion that hypnosis is a unique altered state. Although some evidence suggests that such markers may exist, the findings need to be replicated with better controls.

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Taste

Classroom Exercise: Taste: The Basic Taste Sensations

Roger Cholewiak provides a marvelous demonstration of four taste sensations—sweet, sour, salty, and bitter. You can also include umami, in the form of MSG (found online and in Asian groceries). (If you are wondering about the relationship between MSG and umami or are concerned about any MSG-related health risks, the 2013 Smithsonian article cited below will help. Shizuko Satoh-Kuriwada and his colleagues have even developed an umami sensitivity test using MSG. As a side note, while umami may be a new concept to those in the West, MSG and the taste it produces were identified in 1908 by the Japanese chemist Kikunae Ikeda.

The demonstration utilizes Gymnema sylvestre, a taste modifier that selectively abolishes the sensation of sweet, leaving all the other taste modalities unchanged. Gymnema, sold over the counter as a tea in Japan, can be obtained at different locations, among them Best Nutrition Products at www.diabetea.com in Haywood, CA, telephone 1-510-477-9116. Prepare as instructed and store cold in the refrigerator.

At the time of the demonstration, prepare about one-third of a Dixie cup of the tea for each student. Be sure to forewarn your class that the drink tastes like spinach tea (but won't be bad if they hold their nose) and will temporarily alter their sense of taste. Give ample opportunity for students to choose not to participate. Encourage students who do participate to rinse with water immediately afterward (the effects last 10 to 20 minutes).

After the students have drunk their tea, have them taste salt, then sugar, SweeTarts, and finally M&M's (all available in small packets). The salt will taste normal. Scratch your head, look perplexed, and move on to the sugar. It will taste like melting sand on the tongue. Move to the SweeTarts that will be purely sour, and end with the chocolate, which will taste quite bitter. Students will genuinely enjoy the clearly defined demarcation of the four taste sensations.

You can expand Cholewiak's demonstration by next introducing your students to miracle fruit berries (available in tablet form at Amazon.com in packages of 10 for $12–$15). Miracle fruit berries make foods that are bitter or sour taste sweet.

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Classroom Exercise: Genetic Effects in Taste

Certain taste preferences are genetically determined. People seem to have a built-in preference for sweet foods, they find bitter and sour foods unpleasant, and they like salty foods at low concentrations but dislike them at high concentrations. In one study of infants, sweet substances elicited sucking and, in some cases, smiling. Sour tastes produced "lip pursing and wrinkling of the nose" and bitter prompted "opening of the mouth with the upper lip elevated and protrusion of the tongue." These reactions make good evolutionary sense, since bitter or sour plants are often toxic and the sweeter ones tend to be nutritious.

One of the best-documented genetic effects in taste involves people's ability to taste the bitter substance phenyltiocarbamide, or PTC. People who can taste PTC are described as "tasters" and those who cannot are called "nontasters." Roughly three-quarters of Americans are tasters. Bringing some salt substitute (potassium chloride) to class will enable you and your students to determine who is a "taster." To a nontaster, the substance will seem salty. To a taster, it will be about equally bitter and salty. You can also try saccharin. Nontasters will find it a perfect sugar substitute, but tasters will pick up a bitter taste. (The Carolina Biological Supply House (carolina.com), 2700 York Road, Burlington, NC 27215-3398, 1-800-334-5551, sells a Human Genetics Set, Catalog #173850, for $40.75 plus shipping, that contains PTC, sodium benzoate, thiourea, and control taste papers.)

Because of their genetic sensitivity to PTC, tasters may not be fond of bok choy (chinese cabbage), brussels sprouts, cauliflower, rutabaga, strong cheeses, and turnips. Caffeine also makes coffee taste bitter to tasters, but has little effect on nontasters.

More recent studies have substituted PROP (6-n-propylthiouracil) for PTC in assessing taste sensitivity, in part because it lacks the sulfurous odor of PTC. Using PROP, Linda Bartoshuk of the University of Florida divides people into three groups: supertasters (25% find PROP extremely bitter), medium tasters (50% report PROP as moderately bitter), and nontasters (25% find PROP to be tasteless). Supertasters have the most taste buds, experience the most intense taste, and perceive the most intense oral burn from irritants like the capsaicin in chili peppers (taste buds are innervated by both taste and pain neurons). Although PROP is not commercially available for use in the classroom, one can use tongue painting and a reinforcement ring to assess supertasting (see Student Project: Mapping Your Tongue).

Speaking at the 16th Annual Convention of the American Psychological Society (now called the Association for Psychological Science), Bartoshuk reported that supertasters perceive everything as more intense. She stated, "Supertasters live in a neon taste world, and nontasters live in a pastel taste world." The downside of being a supertaster is that many foods are too intense. Vegetables are especially unpalatable and so, unsurprisingly, supertasters have an increased risk of colon cancer. The upside is that fats are also experienced as too intense. Thus, supertasters' weight is lower, their blood profile is healthier, and their risk of cardiovascular disease is reduced.

Interestingly, supertasters and nontasters also respond to noise differently. Bartoshuk finds that supertasters may rate a particular noise level as very loud, between a boombox and a baby crying, while nontasters rate it much lower, between a shout and a boombox.

Jaffe, E. (2004, August). A matter of taste. *APS Observer,* 17–19.

Roach, M. (1989, November/December). Accounting for taste. *Hippocrates,* 48–54.

Student Project: Mapping Your Tongue

Eric Haseltine provides three simple experiments to demonstrate some basic principles of taste. Ideally, your student should have a few friends, a flashlight, a magnifying glass, a bottle of blue food coloring, and some cotton swabs. In addition, they should acquire some salt, sugar, instant coffee powder, lemon, and a glass of fresh water. (If you prefer, PsychKits sells a Taste Bud Demo kit for $17 that enables students to detect the density of taste bud distribution on their tongues. Contact PsychKits, 28835 Herky Drive #112, Lake Bluff, IL 60044-1464, Phone: (847) 234-8096, Fax: (847) 295-3757, Web: www.PsychKits.com, and e-mail: info@PsychKits.com.

1. Taste receptors are more numerous in some regions of the mouth than in others. To confirm this, students should wet the end of a cotton swab, dip it in some salt and touch the tip, center, sides, and the back of the tongue, raising the cotton swabs between touches. The strength of the taste varies considerably. For example, the front of the tongue registers a far greater reaction than the middle. With another dab of salt, students should touch the roof of the mouth back to the palate. They may be surprised to find receptors.
2. Students should sprinkle a few drops of blue food dye onto their tongue. Using a cotton swab, they should carefully rub in the color and inspect the results with the flashlight and magnifying glass. In the sea of blue, they should see their tastebuds in pale, mushroomlike structures (called fungi-form papillae). The little bumps each house hundreds of taste-receptor cells. There are more at the tip than at the middle of the tongue. Comparing tongues with friends will reveal differences in papillae density. About 25 percent of us are supertasters (tightly packed with taste buds) and about 25 percent of are nontasters (fewer and more sparsely distributed papillae). For a more precise assessment of supertasting, students can drop a plastic reinforcement ring for a three-ring binder (paper reinforcement rings get mushy) on top of the blue food covering and count the number of mushrooms that appear in the circle. Medium tasters have only a few. They will be loosely arranged and larger. Supertasters have at least 25 that are tightly arranged and smaller.
3. For a long time, scientists thought that different regions of the tongue were taste-specific. More recent research indicates otherwise. Although individual cells are most excited by salt, sweet, bitter, or sour, those cells do not congregate in particular regions. Again using a cotton swab, students should touch different parts of the tongue with salt, sugar, lemon, and coffee powder, rinsing thoroughly between each substance. They should compare their responses with those of others. Some have suggested that nontasters may have a higher incidence of alcohol use disorder because liquor seems less bitter to them. Similarly, supertasters may avoid healthful foods, such as broccoli, because they taste too bitter to them.

Haseltine, E. (2000, February). Map your tongue. *Discover,* 92.

Lecture/Discussion Topic: Taste Preferences

Animals tend to be neophobic, that is, suspicious of novel things. This makes evolutionary sense in that it helps them to avoid poisonous foods. Typically, an animal will try only a small portion of a foreign substance to see if it produces sickness. Humans, especially children, also tend to be suspicious of novel things. Psychologists Marcia Pelchat and Patricia Pliner devised an experiment to find out whether it is the novelty of a food or something else that prompts people to spurn it. They gave two groups of people identical foods. When the foods were accurately named—"chopped tomatoes," "oatmeal," and "beefsteak"—the people were quite willing to taste them. When the foods were referred to as "pendula fruit," "lat," and "langua steaks," people were far less cooperative.

However, as is true with other stimuli, mere exposure to new foods tends to make us like them better. "Try it, you'll like it" works much of the time.

Researchers at Monell Chemical Senses Center in Philadelphia reported that a baby's first foods may determine tastes later in life. They fed 53 two-week-old babies one of two infant formulas: a sweet, milky formula or a sour-tasting one with an unpleasant aftertaste. After being fed one or the other for seven months, the babies were offered both formulas. Those who had been given the sour-tasting formula were quite happy to keep drinking it. Those who were accustomed to the sweet formula turned up their noses at the alternative. For kids to develop preferences for healthful foods, they may need to be introduced to those foods early in life.

Conditioned taste aversions, discussed in the Learning unit, provide good examples of how experience shapes taste preferences. Most students will be able to describe how becoming sick soon after eating has led to dislike of a particular food, even though they knew the illness was not caused by the food in question. Howard Moskowitz and colleagues describe the role past experience plays in shaping taste preferences. Like most of us, Indian medical students describe citric acid as being sour and quinine as bitter. Indians of the Karnataka province, however, found both to be pleasant. Why? Perhaps because their diet consisted of many sour foods, with tamarind, a particularly sour fruit, making up a large portion of it. Being poor, they ate the tamarind out of necessity and, from constant exposure to this fruit, may have acquired a taste for sour foods.

Goldstein, E. B. (2010). *Sensation and perception* (8th ed.). Belmont, CA: Wadsworth.

Mennella, J., et al. (2004). Flavor programming during infancy. *Pediatrics, 113,* 840–845.

Roach, M. (1989, November/December). Accounting for taste. *Hippocrates,* 48–54.

Classroom Exercise/Student Project: Taste

A number of classroom exercises or student projects can be conducted to illustrate the principles of taste. Several teaching veterans, including Lenore Frigo of Shasta College, suggest the use of jelly beans to demonstrate how the various senses affect our sense of taste. Bring to class several colors and flavors of jelly beans sorted into cups. Assign students to one of four groups: normal (using all the senses), no vision (close eyes), no smell (plug nose), or no vision or smell. In each case, have them write down the flavor of the jelly beans they tasted. Accuracy improves as they use more senses.

For example, the importance of smell to taste can be readily illustrated. Prepare bite-sized pieces of apple, potato, onion, and pear. Blindfold a volunteer, ask this person to plug his or her nose, and feed him or her a bite of each food. They will be indistinguishable.

Students are probably unfamiliar with how temperature can influence the taste of food. Tell them to place two pinches of sugar in each of four small glasses. They should fill the first two with cold water from the tap. After stirring well, they should place an ice cube in glass 1. They should fill the third glass with lukewarm water and the fourth with hot water, stirring to dissolve the sugar. Finally, have them take a sip from each of the four solutions, rinsing their mouths with fresh water after each sip. Glasses 2 and 3 will be the sweetest tasting. Research has shown that people are most sensitive to tastes when the substance is served at room or body temperature, although sour solutions seem to be less affected by temperature than salty, sweet, or bitter substances. Does this have implications for serving bitter medicines or low-quality wines?

You might also ask your class if they believe that whatever smells bad tastes bad or that whatever tastes good smells good. Then ask if anyone is familiar with durian—an exotic, expensive fruit from Southeast Asia. For most, it has such a disgusting odor that it has been banned in some places. For many others, it is delicious, in fact, "a taste to die for."

Matlin, M. & Foley, H. (2010). *Sensation and perception* (5th ed.). Needham Heights, MA: Allyn and Bacon.

Smell

Lecture/Discussion Topic: Anosmia

What would life be like without the sense of smell? In *The Scent of Desire,* Rachel Herz suggests that people often attach little importance to their sense of smell. In fact, when people are asked about the possible loss of various physical capacities, losing their sense of smell seems least troublesome. Jeremy Wolfe and his colleagues report questionnaire data from students at the University of Pennsylvania in which they ranked losing the sense of smell as comparable to losing a big toe. Yet Herz writes, "For those with the devastating condition called anosmia, everything changes. Our sense of smell is essential to our humanity: emotionally, physically, sexually, and socially."

Clearly, anosmia can cause enormous distress as it affects many aspects of our lives, perhaps most importantly our sense of taste. In a poignant essay on her loss of smell, writer Elizabeth Zierah describes how it was more traumatic than adapting to the disabling effects of stroke that she had experienced in early adulthood. She writes that "As the scentless and flavorless days passed, I felt trapped inside my own head, a kid of bodily claustrophobia, dissociated. It was as though I were watching a movie of my own life. When we see actors in a love scene, we accept that we can't smell the sweat; when they take a sip of wine, we don't expect to taste the grapes. That's how I felt—like an observer watching the character of me."

Because taste and smell are intimately linked, loss of smell often spells loss of appetite. Zierah describes how her taste buds still detect sweet, salty, sour, bitter, and umami but nothing more. Food tastes like "vaguely savory cardboard." To avoid significant weight loss, she had to force herself to eat. What eventually saved her appetite was texture or what she labels "mouth feel." Thus, apples have become a favorite food, while saucy foods like daal (a spicy Indian stew) or coconut curry that were once loved feel mushy and repellant. She also prefers sour foods, such as lemon or tamarind, because they don't rely on subtlety to make themselves known.

Although changing cat litter, picking up dog poop, and cleaning up vomit has become easy, every person with anosmia is plagued by the fear of having body odor even after the usual cleaning rituals of shower, deodorant, teeth brushing. "What if I reek," writes Zierah, "and don't know it? What if I have something gross on the bottom of my shoe, and everywhere I go I leave behind a foul trail?" Life is also more dangerous. Zierah has burned food and melted pots so many times she feels that she is a walking fire hazard. And like most people with anosmia, she views any gas appliance to be an archnemesis. "I've become compulsive about making sure my gas stove is really lit when I turn the dial."

Small wonder that acquired anosmia often leads to frustration, anxiety, and depression. According to the National Institutes of Health, more than 200,000 people visit a physician annually for help with smell disorders or related problems. As many as 14 million Americans over the age of 55 have a severely compromised sense of smell. Including younger adults, about 1 in 20 Americans may have some olfactory dysfunction.

Probably everyone has experienced the temporary loss of smell caused by a cold or infection. A permanent loss of smell may be caused by death of olfactory receptor neurons in the nose, by injury to the olfactory nerve, or by damage to those brain areas that process smell. The absence of the sense of smell at birth (congenital in contrast to acquired anosmia) is usually due to genetic factors. The loss of the sense of smell can also be an early symptom of Parkinson's or Alzheimer's disease.

Herz, R. (2007). *The scent of desire: Discovering our enigmatic sense of smell.* New York: Morrow.

Wolfe, J. M., Kluender, K. R., Levi, D.M., et al. (2006). *Sensation and perception.* Sunderland, MA: Sinauer Associates.

Zierah, E. (2008, August 1). Robbed of all scents. *The Week,* pp. 40–41.

Lecture/Discussion Topic: Specific Anosmia

With generalized anosmia, the person cannot smell anything; with specific anosmia, the person cannot smell specific odors. Specific anosmia is genetic, and the genes have been isolated.

For example, asparagus is metabolized in such a way that it produces a distinctive sulfurous odor in urine. Most people can detect the odor, but Marcia Pelchat and her colleagues (2010) found that 4 percent of their participants in one study could not detect the odor in their own urine or in the urine of others.

Other specific anosmias include the inability to smell sweat (Karstensen & Tommerup, 2012) and semen (Amoore, 1975). Approximately 20 percent of the population have semen anosmia.

Amoore, J. E. (1975). Four primary modalities of man: Experimental evidence and possible significance. In Olfaction and taste: *Proceedings of the fifth international symposium.* (pp. 283–290). New York: Academic press.

Karstensen, H., & Tommerup, N. (2012). Isolated and syndromic forms of congenital anosmia. *Clinical Genetics, 81*(3), 210–215. doi:10.1111 /j.1399-0004.2011.01776.

Pelchat, M. L., Bykowski, C., Duke, F. F., & Reed, D. R. (2010). Excretion and perception of a characteristic odor in urine after asparagus ingestion: A psychophysical and genetic study. *Chemical Senses, 36*(1), 9-17. doi: 10.1093/chemse/bjq081.

Classroom Exercise: Identifying Odors

How good are we at identifying specific odors? Not very, unless we are given considerable practice. Some odors, such as chocolate and coffee, are identified correctly by most people. However, in one study only 50 percent of the participants identified peppermint and only 18 percent identified nutmeg. On the average, people could correctly label only 6 of 12 common odors.

William Cain attempted to compare people's impression of how easy it is to identify common substances by their odor with how easy it actually is. A group of 100 women were given the names of 80 products and asked to indicate how readily they thought they could be identified by odor. Cain then asked a different group to actually identify each of the 80 items.

The top 10 in anticipated and actual identifiability are given below.

Anticipated Identifiability	Actual Identifiability
1. ammonia	1. Johnson's baby powder
2. coffee	2. chocolate
3. mothballs	3. coconut
4. perfume	4. Crayola crayons
5. orange	5. mothballs
Anticipated Identifiability	**Actual Identifiability**
6. lemon	6. Ivory soap (bar)
7. bleach	7. Vicks VapoRub
8. vinegar	8. Bazooka bubble gum
9. nail polish remover	9. coffee
10. peanut butter	10. caramel

Many odors in the right column are unique to a particular brand, and people invariably mentioned the brand name when identifying the substances. While these had been included in the test because they were brand leaders in their particular category, Cain had not expected that they would be more easily identified than such generic items as orange, vinegar, lemon, ammonia, and peanut butter.

Students will find it both entertaining and enlightening to attempt to identify common odors. Use 12 small jars (baby food jars are ideal) painted or covered with colored paper to hide their contents. Puncture the lids with very small holes and fill the jars with different odorous substances. If you like, you might attempt a partial replication of Cain's study. Other odorous substances to test might include pencil shavings, cheese, cinnamon, a green leaf, mud, onion, or mustard. Pass the jars around the room and have students identify their contents. If they can't label some precisely, they should use whatever term they think best applies.

Cain reports that people are strangely inconsistent and often imprecise in identifying odors. Students who are given 12 common substances to smell will very likely block on at least a few. Their descriptions will typically show that they know something about the smell—sweet, woody, fruity—but the precise identity will elude them.

In general, people seem to have trouble identifying odors. However, as Cain has demonstrated, people seem to do better with practice. They improve as they associate specific labels with the odorous substances. Once attached to the odors, the names locate substances in relation to other odors and provide an internal "address" for retrieval from storage.

Cain, W. S. (1981, July). Educating your nose. *Psychology Today,* 48–56.

Matlin, M., & Foley, H. (2010). *Sensation and perception* (5th ed.). Needham Heights, MA: Allyn and Bacon.

Lecture/Discussion Topic: Odor and Sex Identification

Can we tell if a person is male or female on the basis of odor alone? Patricia Wallace sought to answer this question by having blindfolded men and women sniff a hand held one-half inch from their nose. The men and women who served as test stimuli washed their hands thoroughly before the experiment and then wore a plastic glove for 15 minutes prior to testing to promote perspiration. Wallace reported that her participants could discriminate male from female hands with more than 80 percent accuracy. Female sniffers were more accurate than male sniffers.

People are also able to make accurate judgments of sex on the basis of breath odor. Richard Doty and his colleagues had college students assess breath odor of people who sat on the other side of a partition and exhaled through a plastic tube. Donors had been instructed not to eat spicy foods or to wear odorous cosmetic products. Most judges scored better than chance, and again women outperformed men.

British psychologist Michael Russell had college freshmen wear T-shirts for 24 hours after which the shirts were individually placed in sealed containers. Each student was then presented with three containers—one holding his or her own shirt, a second holding the shirt of an unknown woman, and a third holding the shirt of an unknown man. The vast majority were able to identify not only their own shirt but also which belonged to a man and which to a woman.

Robert Sekuler and Randolph Blake suggest that the most remarkable example of acuity for body odor may be one reported by William James. A blind woman who worked in the laundry of the Hartford asylum would sort the laundry of individual inmates on the basis of smell only. Moreover, she did it after the clothes had been washed.

Blake, R., & Sekuler, R. (2006). *Perception* (5th ed.). New York: McGraw-Hill.

Russell, M. J. (1976). Human olfactory communication. *Nature, 260,* 520–522.

Lecture/Discussion Topic: Canine Olfaction

Everyone knows that dogs have a better sense of smell than humans. Dogs can detect odors at a concentration of a mere 1 to 2 parts per trillion. Humans need 10,000 to 100,000 parts per trillion. A pretty poor performance on our part, indeed.

Part of the reason for a dog's ability to smell so well is the number and density of olfactory receptors. But that's not the whole story. The canine nasal cavity contains chambers off the main airway that collect air. Each sniff brings more air into a chamber, increasing the concentration of whatever odors might be present. And, if that's not impressive enough, since there are chambers on both sides of the main airway, each chamber has its own concentration of odors, allowing dogs to determine the direction of the smell. If there is a higher concentration of an odor in the right chamber, then the smell must be coming from the right.

While the basic science of canine olfaction is valuable by itself, Brent Craven and his colleagues at Penn State are using what they are learning about the airflow through dogs' noses to create an artificial nose (Tyson, 2012). One could imagine such a device being used to detect explosives or drugs.

Craven, B. A., Paterson, E. G., & Settles, G. S. (2010). The fluid dynamics of canine olfaction: Unique nasal airflow patterns as an explanation of macrosmia. J*ournal of the Royal Society Interface, 7*(47), 933–943. doi: 10.1098/rsif.2009.0490.

Tyson, P. (2012, October 4). Dogs' dazzling sense of smell. Retrieved August 8, 2014, from www.pbs.org/wgbh/nova/nature/dogs-sense-of-smell.html.

Body Position and Movement

Classroom Exercise: Nystagmus

The text indicates that one function of the semicircular canals and vestibular sacs (the vestibular system) of the inner ear is the maintenance of balance and upright posture through a sense of the head's position and movement (the vestibular sense). A related function of this system is the control of eye position as we move our heads in viewing various objects. The primary stimulus for the vestibular system is a change in the rate of motion, or acceleration, such as that occurring when we jump up and down, spin in a rotating chair, or simply stand up and walk. Acceleration in one direction causes compensatory eye movements in the opposite direction. This enables the eye to remain fixed on an object even though the head is turning. This relationship between acceleration and eye movements is simply demonstrated.

You need a bit of space and a volunteer willing to spin around until dizzy. The continuous movement sets up currents in the semicircular canals that produce compensatory eye movements. Have the volunteer stop and look at the class. His or her eyes will drift steadily in one direction and then snap back and begin to drift again. This repetitive eye movement has been labeled nystagmus and is a reflex movement evoked by vestibular stimulation.

Coren, S., Ward, L., & Enns, J. T. (2003). *Sensation and perception* (6th ed.). New York: Wiley.

Classroom Exercise: Vision and Balance

Our ability to maintain balance depends to some extent on visual cues. Students can experience this for themselves by standing on one foot for 30 seconds first with their eyes open, then with their eyes closed. The latter is more difficult, but the vestibular and visual systems working together enable us to maintain balance. If students spin around a few times (thus disrupting their vestibular sense) and then close their eyes, they will find it impossible to balance on one foot.

Karl Albrecht suggests another simple demonstration of how our brain uses visual information in helping us to maintain balance. Have students stand on their right foot with their left foot tucked behind their right leg for good balance. Now have them close their left eye and look at some convenient point or object with their right eye. Finally, they should very carefully and gently press with their right index finger on the *eyelid* of the right eyeball. As they gently displace the eyeball toward their nose, they should continue looking at the object. Immediately, they will begin to lose balance and sway to the right. Have students also try the left foot and left eye. They may even notice this effect sitting down, as their upper body automatically sways toward the side of the eyeball pressed on.

You might use this demonstration to introduce the topic of field dependence/independence as well. In some studies participants have been seated on a chair that can be tilted from side to side. The chair is centered in a small room that can also be tilted. Participants are asked to adjust their chair until it is perfectly upright. Do they adjust the chair to match the up-down orientation of the room or do they line up straight with the force of gravity? People who rely on visual cues—that is, the orientation of the room—are called field dependent. Those who rely on vestibular cues—that is, the orientation of their bodies—are called field independent.

Research has indicated that these different "cognitive styles" are associated with different personality characteristics and social attitudes. "Dependents" tend to be more interested in other people and emotionally open, make greater use of social cues in ambiguous situations, and choose careers in the helping professions. In contrast, "independents" tend to be more impersonal, hide their emotions, rely less on social feedback, and choose careers in mathematics and science.

Albrecht, K. (1980). *Brain power*. Upper Saddle River, NJ: Prentice Hall.

Witkin, H. A., & Goodenough, D. R. (1977). Field dependence and interpersonal behavior. *Psychological Bulletin, 84,* 661–689.

Sensory Interaction

Lecture/Discussion Topic: Synesthesia

The text discussion of sensory interaction includes a brief mention of synesthesia, the extraordinary sensory condition in which stimulation of one modality leads to perceptual experience in another. Literally, the term means "to perceive together."

Neurologist Richard Cytowic (1998) describes the case of Michael Watson, who feels shapes when he tastes or smells food. After tasting a sauce he was making for chicken, he complained, that the chicken did not have enough "points." For Watson, intense flavors elicit an experience of shape that sweeps down his arms to his fingertips. Some taste shapes, like points, are experienced over his entire body. Others are felt only on the face, back, or shoulders. Cytowic devised an entire set of geometric figures that allowed Watson to communicate which shapes he associated with which flavors.

Other people with synesthesia see colors in response to pain. Gail Martino and Lawrence Marks (2001) describe the case of Carol, a professional artist, who fell and damaged her leg while climbing on rocks at the beach. She diagnosed the severity of her accident by the intensity of orange that spread across her mind's eye. She said, "When I saw that everything was orange, I knew I should be rushed to the hospital."

Since there are five primary senses, in principle there should be 10 possible synesthetic pairings. However, most pairings are in one direction. For example, while some synesthetes may see colors when they hear, they do not hear sounds when they view colors. Other sensory combinations happen rarely, if at all. It was previously thought that the most common form of synesthesia is seeing specific letters or numbers (graphemes) in specific colors. Known as grapheme-color synesthetes, they may always see a "5" in black ink on a white background as red. A "k" may always appear greenish-blue. More recent research (Simner, et.al, 2006) suggests that the most common is actually day-color synesthesia, in which each day has a color associated with it. In contrast, an extremely rare form of synesthesia is someone who can taste sounds. Elizabeth Sulston is a 27-year-old recorder player who experiences pleasant chords as the taste of sweet cream. For her, harsh dissonant chords taste sour and disgusting.

Although estimates vary, one of the most recent studies found that 4 percent of people reported some type of synesthesia (Simner, 2006). In the past, when researchers asked people with synesthetic experiences to come forward, more women than men volunteered, leading researchers to cautiously conclude a greater prevalence in women. Simner's random sample study found no such bias, leaving us to wonder if there was a reporting bias in the earlier studies.

The phenomenon of synesthesia seems to run in families, which leads some researchers to conclude that it has a genetic basis. Perhaps the most famous case is that of the Russian novelist Vladmir Nabokov. As a very young child, he complained to his mother that the letter colors on his wooden alphabet were "all wrong." His mother understood him, for she too perceived letters and words in particular colors. Although synesthetes have often worked in the visual arts or music, researchers have found little empirical support for the notion that this unusual sensory experience is linked to artistic creativity.

Different hypotheses have been offered for synesthesia. One is that, for most people, different sensory functions are assigned to separate modules in the brain with limited communication between them. The brain of synesthetes is equipped with more connections between neurons, causing the usual modularity to break down. Another theory is that "feed-backward" connections that carry information from high-level multisensory brain areas back to single sense areas are not properly inhibited. Normally, information processed in such multisensory areas is allowed to return only to its appropriate single-sense area. In the brain of a synesthete, that inhibition is disrupted, allowing the different senses to become jumbled.

Research at the University of California, San Diego, and the Salk Institute for Biological Studies provides support for the hypothesis that cross-activation of adjacent brain regions is the mechanism that underlies synesthesia. Using functional magnetic resonance imaging (fMRI) to study grapheme-color synesthetes, investigators found that their brains showed activation in the color-sensitive regions of the cortex when they viewed black-and-white letters or numbers. In short, the experience of a letter or color was activating both the standard, predictable area and "cross-activating" the color-selective area.

In this same project, behavioral measures suggested that grapheme-color synesthetes really see the colors they report. In one test, the participants were presented with a pattern of graphemes embedded in a matrix of other distracting graphemes. For example, they were shown 2s that formed a triangle surrounded by 5s. If a synesthete sees 2s as a particular color, the triangle should pop out from an otherwise black-and-white field. In other words, they should be able to identify the embedded shapes more quickly than controls would. Most of the study's synesthetes outperformed the control participants in this task, although the synesthetic colors were not as powerful or as effective an aid as when real colors were used.

Simon Baron-Cohen states, "If you ask synesthetes if they'd wish to be rid of it, they almost always say 'no.' For them, it tells what normal experience is like.

To have that taken away would make them feel like they were being deprived of one sense."

You might conclude by noting that many people readily draw associations between sensations in different modalities. For example, ask your class to arrange the colors black, brown, blue, green, red, yellow, and white in terms of high or lower pitch. Most will indicate that lighter colors have higher pitches.

Beeli, G., Esslen, M., & Lutz, J. (2005, March 3). Synesthesia: When coloured sounds taste sweet. *Nature, 434,* 38.

Carpenter, S. (2001, March). Everyday Fantasia: The world of synesthesia. *Monitor on Psychology,* 26–29.

Cytowic, R. E. (1998). *The man who tasted shapes.* Cambridge, MA: MIT Press.

Hubbard, E. M., Arman, A. C., Ramachandran, V. S., & Boynton, G. M. (2005). Individual differences among grapheme-color synesthetes: Brain-behavior correlations. *Neuron, 45,* 975–985.

Kolb, B., & Whishaw, I. Q. (2013). *An introduction to brain and behavior* (4th ed.). New York: Worth.

Linden, D. (2008). *The accidental mind: How brain evolution has given us love, memory, dreams, and God.* Cambridge, MA: Harvard University Press.

Martino, G., & Marks, L. E. (2001). Synesthesia: Strong and weak. *Current Directions in Psychological Science, 10,* 61–65.

Simner, J., Mulvenna, C., Sagiv, N., Tsakanikos, E., Witherby, S. A., Fraser, C., et al. (2006). Synaesthesia: The prevalence of atypical cross-modal experiences. *Perception, 35*(8), 1024–1033. doi: 10.1068/p5469.

Extrasensory Perception

Classroom Exercise: Belief in ESP Scale

You can introduce the topic of ESP with Handout 17, Keith Stanovich's Extrasensory Perception Scale. To obtain total scores, students should reverse the numbers they placed before statements 3, 4, 6, and 12 (i.e., 5 = 1, 4 = 2, 3 = 3, 2 = 4, and 1 = 5) and then add the numbers placed in front of all 14 items. Total scores can range from 14 to 70, with higher scores reflecting stronger belief in ESP. The mean score obtained for 163 introductory psychology students was 42.6, slightly above the neutral point of the scale. Stanovich reported that ESP scores correlated positively with dualistic views of the mind. You might ask volunteers to share their beliefs about ESP as well as the reasons for those beliefs.

In 2005, Gallup Polls conducted telephone interviews with 1002 randomly selected adults in the United States about their beliefs in the paranormal. Results showed the following percentage of respondents who believe in these concepts:

ESP – 41%
Telepathy – 31%
Clairvoyance – 25%
Communication with the dead – 21%

Of the 10 concepts Gallup Polls asked about, 75 percent of respondents said that they believed in at least one. A similar survey conducted four years earlier found similar results. There were no differences based on demographics, including education or region of the country.

Consider asking your students to respond anonymously as to whether they believe, in turn, in ESP, telepathy, clairvoyance, or communication with the dead. How does your class compare to the United States as a whole?

Moore, D. W. (2005, June 16). Three in four Americans believe in paranormal. Retrieved August 8, 2014, from www.gallup.com/poll/16915/Three-Four-Americans-Believe-Paranormal.aspx.

Lecture/Discussion Topic: Belief in ESP

Why do people believe so strongly in ESP despite no clear empirical support for its existence? This question will begin an interesting class discussion and will enable you to introduce principles that will be reinforced later in the text.

First, belief in ESP illustrates our tendency to be easily persuaded by vivid anecdotes and experiences. For example, even when college students have been forewarned about a "mindreader's" tricks, they may, after viewing her dazzling performance, be convinced that she is a true clairvoyant. Vivid personal experiences are much more compelling than the abstract statistical data from dozens of laboratory experiments that fail to show the existence of ESP.

Second, we are often unaware of the factors that influence our thought processes, which may lead us to "create" explanations for our experiences. For example, a husband and wife may be watching a TV program when one suddenly suggests they invite certain friends over for dinner. The spouse claims to have been thinking the same thought. Is this mental telepathy? Probably not. It is more likely that some stimulus on the TV screen, perhaps the image of an automobile like that of their friends, triggered a common memory.

Third, we may fail to recognize chance occurrences for what they are. Deficiencies in our statistical intuitions may lead us to see ordinary events as almost impossible. For example, what are the odds that at least two people in a group of 30 will have the same birthday? Most people grossly underestimate the correct answer—7 in 10. Given the billions of events that occur, sheer chance tells us some "extraordinary" coincidences are certain to occur. Here's one of our favorites: The King James version of the Bible was completed when William Shakespeare was 46 years old. In Psalm 46, the forty-sixth word is "shake" and the forty-sixth word from the end is "spear." (Even more incredible is that someone discovered this!)

The "illusion of personal control" may also lead us to perceive phenomena that are really not there. Yale University researchers relied on this tendency in manufacturing a false belief in ESP among their students. Students tried to mentally transmit five symbols to other students who guessed what was transmitted. ESP success rate was no better than chance. When students were drawn into the drama by being given a "warm-up" period before the actual testing began, however, they were "confident" that ESP was transpiring more than 50 percent of the time.

Finally, people may believe in ESP because they *want* to. We humans have always had a hard time accepting our finiteness. Believers in ESP proclaim a potential for omniscience. Some scientists argue that as an escape from humdrum life, pseudoscience offers phony mysteries instead of real mysteries, and that it displaces science with science fiction.

Myers, D. G. (1983). *Social psychology.* New York: McGraw-Hill.

Student Project: The Psychic Challenge

The text briefly describes James Randi's offer to pay a considerable sum to anyone who can demonstrate any paranormal ability. Students can learn the specific rules of the "One Million Dollar Paranormal Challenge" at www.randi.org/site/index.php/1m-challenge.html.

Classroom Exercise: ESP Tricks

Many Americans, including many collegians, believe in the reality of ESP. It is likely that more than a few have been convinced by the tricks of psychic entertainers. Demonstrating some psychic magic in class not only entertains but also shows how easily we can be fooled; ultimately, it may serve to raise students' skepticism. The tricks will certainly serve to underline the necessity for rigid experimental control in evaluating ESP claims.

1. To demonstrate precognition, write (and announce that you are writing but not *what* you are writing) on a slip of paper or on the board (behind a movie screen), "You will choose the 3 pile."

   Then lay out three piles of cards. Ask a student to choose one pile and confirm that that's the one he or she really wants. If the student picks the pile to your left, the student's right, confirm that the student wishes not the first or the second pile but the third pile—and then reveal your correct prediction.

   The middle pile should contain the four "3" cards, which can be revealed if chosen (after showing the right and left piles, which have a random mix of cards). Again your precognition is correct.

   The pile to your left should have five cards, the middle pile the four 3 cards, and the right pile three cards. Thus, if the latter pile is chosen, you count the three piles, demonstrating that the student has chosen not the five-card or four-card pile, but the three-card pile.

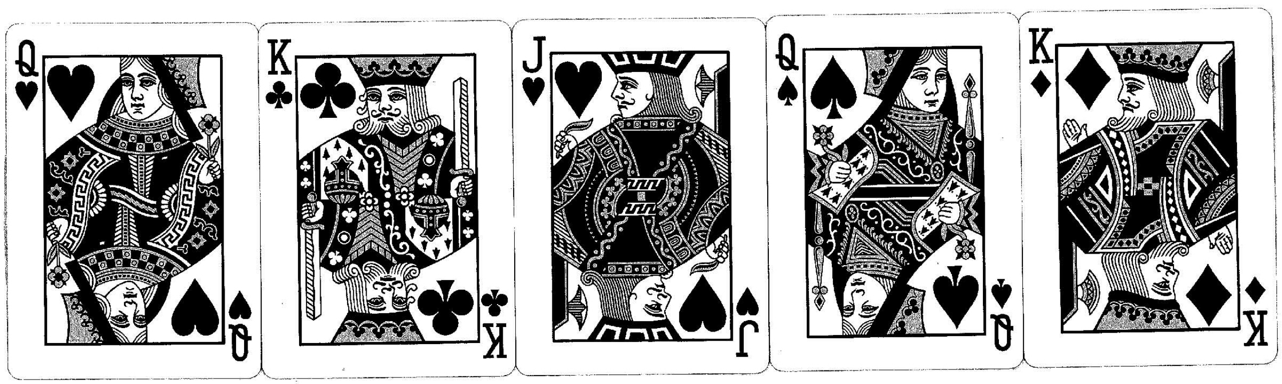
   To lay out the cards, assemble them in a deck so that you can deal out the three piles and have them end up in the correct way.
2. To demonstrate "clairvoyance," prepare an envelope containing a blank piece of paper for each student. Bring the envelopes to class and have each member of the class write a simple statement about himself or herself on the paper, sign it, place it back in the envelope, and seal it. Collect all the envelopes, hold the first to your forehead, and, with feigned difficulty, give the student's name and statement before opening the envelope. Do the same for each of the succeeding envelopes. On occasion, modify the statements slightly to make the trick appear truly credible. Your performance will leave students with their mouths gaping.

   How is it done? You simply need one student confederate who will confirm that your first statement, whatever it is, applies to him or her. When you open the first envelope, purportedly to confirm your answer, you use its contents as the message "sensed" on the second trial. Throughout your performance, you will always be one message ahead. (Obviously, the confederate should not turn in an envelope.)
3. Another way to demonstrate "precognition" is as follows. You hold a newspaper column to your left (if you are right-handed) and, without looking at it, run a pair of scissors slowly up and down the column until a randomly designated student says "CUT." You cut the column at that point, allowing the clipped off part to fall to the floor. Invite someone to pick it up without showing it to you, and read the top legible line. Ask: "Can you read the top line or did I cut through the middle of it?" Then instruct the student to choose one word from the line. Say, "Make it a difficult word, not some short common word like 'and,' 'the,' or 'but.' The student announces the word, and you then ask another student to open and read a sealed letter that has been placed on your desk. The letter states that during the class session you would ask the class to select at random one line from among many lines in a newspaper column containing some 500

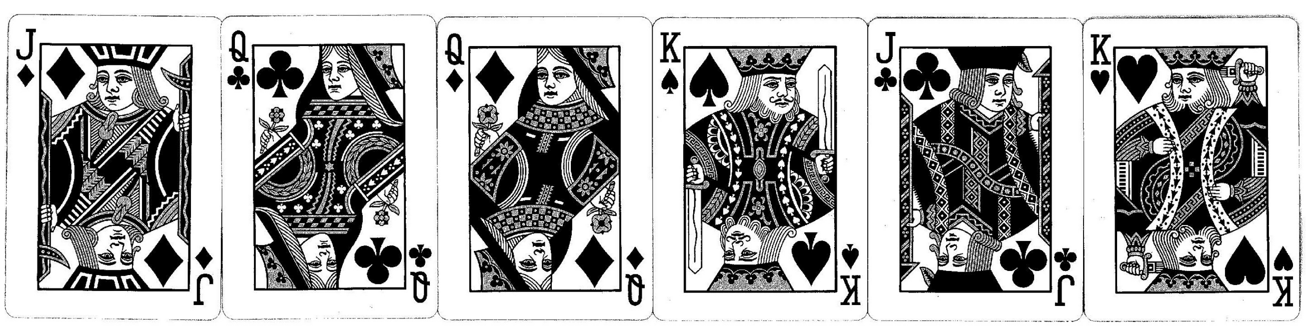
words, that you would cut at that line, that a randomly designated student would then choose one word from the top readable line, and that you had a precognition of what that chosen word would be. Amazingly, your precognition is correct.

The trick is simple. First, you must get the designated student to read a newspaper line containing a few small words and one big word, thus determining his or her choice. But how? Simply precut a newspaper column at that point, and then hold the column upside down, thus preserving the top line when the cut is made. The part you hold at the top should be two columns wide for the first couple inches, and one column wide for the remainder of its length. This will reinforce the perception that the column is being held right side up. (Of course, you should not stand too close to the first row of students.)

4. Still another way to demonstrate precognition (and also review the principle of change blindness covered in the text discussion of Sensation and Perception) involves a popular card trick. Create a PowerPoint slide (or computer screen image) with pictures of the six playing cards below:



As you turn your back to the class and close your eyes, have a volunteer pick one of the six cards and point to it for the class to see. (This should all be done quite rapidly). Then announce to the class that you knew what card would be picked and now will make it disappear. Quickly present the cards below on (on PowerPoint or a computer screen).



Source of both sets of cards: From Stanley Coren, Lawrence M. Ward, and James T. Enns, *Sensation and perception,* 6th Edition. Copyright © 2003 John Wiley and Sons, Inc. Reproduced by permission.

Magically, the card has disappeared. Of course, all of the cards have changed but the overwhelming majority of observers will have encoded the first display simply as face cards, not the specific combinations of face and suit. Although you may not want to reveal the secret of the trick, doing so will enable you to review the fascinating literature on change blindness.

5. For a quick yet dramatic demonstration of mental telepathy, have a volunteer or each student in your class choose a number (of course, keeping it to themselves) between 1 and 10. They should then multiply it by 9. If the result has more than one

digit, students should add them together. Next they should subtract 5. Now they should find the letter in the alphabet that corresponds to the result with A = 1, B = 2, C = 3, D = 4, etc. (Regardless of the beginning number, these calculations will end in the number "4" and thus the letter "D.") Having found the appropriate letter, they should pick a country that begins with the letter. They should pick an animal that begins with the second letter of the country. Finally, they should write down that animal's color. Have them concentrate on the color as you read their minds. Finally, after several seconds, announce to your class that the color is gray. (The country will be Denmark, and the animal an elephant or possibly an eel—there will be few if any exceptions to these obvious associates to "D" and "E").

6. This mental telepathy trick requires an accomplice stationed near a telephone. The effect is spectacular, however, and worth the effort.

   Have three volunteers leave the room, while someone in the room blindly picks a card from a shuffled deck and shows the card to you and the rest of the class. Explain to the class that you know someone who claims to have psychic ability. To put him and the class to the test, you will all focus on that card and attempt to "send" it to the would-be psychic. Now call back the volunteers, who are ignorant of the card, and tell them to call a designated phone number and to ask for (select a name from the chart on the next page). "Tell him you are in an ESP experiment with me and ask what card we have selected." Your accomplice will have a copy of this chart and will, of course, be able to name the card for each of your volunteers (e.g., "I think I see a three of diamonds"), who will return and announce it to the amazed class.

	Clubs	**Spades**	**Diamonds**	**Hearts**
2	Allen	Dale	Henry	Pete
3	Andy	Dan	Jerry	Phil
4	Art	Dave	Jeff	Randy
5	Barry	Dick	Jim	Ron
6	Bill	Donald	Joel	Russ
7	Bob	Doug	John	Scott
8	Brad	Dwayne	Keith	Steve
9	Brian	Ed	Ken	Ted
10	Bruce	Eric	Larry	Terry
Jack	Chuck	Fred	Leonard	Tim
Queen	Clark	Gary	Mark	Tom
King	Craig	George	Mike	Wayne
Ace	Curt	Harold	Paul	Wes

	Clubs	**Spades**	**Diamonds**	**Hearts**
2	Ann	Eileen	Linda	Rachel
3	Audrey	Esther	Marsha	Sarah
4	Barbara	Gayle	Mary	Sharon
5	Beth	Gloria	Margaret	Shelley
6	Bonnie	Janet	Molly	Susan
7	Cheryl	Jodi	Marilyn	Teresa
8	Colleen	Jane	Nancy	Tamara
9	Carla	Jill	Pamela	Vicki
10	Debbie	Kim	Polly	Virginia
Jack	Dawn	Karen	Patricia	Vivian
Queen	Diane	Kristin	Phyllis	Wendy
King	Ellen	Lila	Rebecca	Yolanda
Ace	Elizabeth	Lois	Robin	Zelda

7. Daryl Bem, who uses a variety of psychic stunts to confound, convince, and then deflate, provides yet another easy demonstration of psi power. He selects a class registration card at random from a fishbowl. From the number alone, he recites a description of the student. While the card is indeed picked at random, he reports the number of another student selected in advance and thoroughly researched with the help of a roommate accomplice. Of all his tricks, this is the one he explains because "even magicians consider it a cheap swindle." Explaining one trick may serve to convince students that what they've seen is not ESP. In general, however, there are at least three good reasons for leaving students in the dark. First, these demonstrations will be discussed back in the dorms, where some of your future students reside. Second, you would lose the point of the demonstration—that even someone who lacks the skills of an amateur magician can fool them with simple tricks. "Consider how much easier it would be for a skilled pseudo-psychic to do so. I want to leave you with the puzzlement experienced by audiences of stage 'psychics,' yet knowing that there can be simple explanations for seemingly bewildering feats." Third, these are magic tricks, and the magician's code of ethics mandates nondisclosure.
8. Most of us are susceptible to the gambler's fallacy, that is, the tendency to see links between events that are actually independent. Keith Stanovich uses this as the basis for a convincing demonstration of mental telepathy. Ask a student volunteer to prepare a list of 200 numbers by "randomly" selecting from the numbers one, two, and three over and over again. The prepared list is kept out of your view. Announce that you will demonstrate your "psychic powers" by reading the volunteer's mind. Before starting, ask what level of performance would provide evidence of mental telepathy. Virtually all will immediately understand that since 33 percent hits could be expected by chance, a larger proportion, probably at least 40 percent, is necessary before the claim for psychic power is supported. Have the volunteer concentrate on the first number. Guess a number, then have the volunteer tell the class and you the correct choice. Have the class keep a careful record of hits and misses. On the second trial, simply pick one of the two numbers that the volunteer did not announce as the correct first choice. Following this procedure will ensure success of greater than 33 percent simply because people tend to alternate numbers in order to produce a "representative" sequence. That is, people alternate too much in producing "random" numbers and generate few, if any, runs. By explaining the results, you will teach students a lesson about randomness as well as how easy it is to fake "psychic powers."
9. Although this demonstration of "psychokinesis" involves a bit of risk and requires some practice, it is dramatic (and not painful) when successful. Holding your hand out, palm down, you can hold a lighted match (the wooden stick ones are most easily observable in class) to the inside of your palm without getting burned. Fake hard concentration for mind over matter. More important, keep the flame close (your palm is in the flame so the flame is spread out) and *keep it moving*!!!

Cornell, J. (1984, March). The Merlin of psi psychology does his magical thing. *Psychology Today,* 32–33.

Stanovich, K. (2004). *How to think straight about psychology* (7th ed.). Boston: Allyn & Bacon.

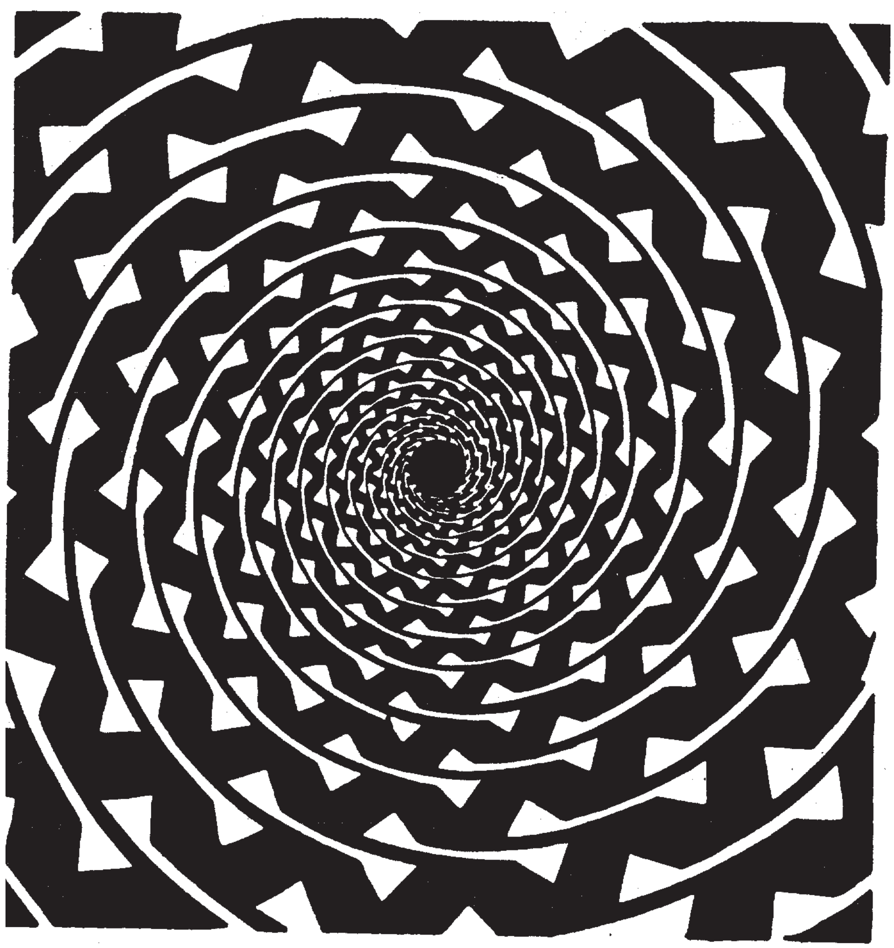
Student Project/Classroom Exercise: Testing for ESP

Students may enjoy testing their roommates or other volunteers for ESP. Handout 18 contains the ESP symbols from the well-known Zener cards used in J. B. Rhine's parapsychological research. These can be reproduced on heavy stock paper and then cut for use in demonstrating telepathy, precognition, and clairvoyance. Typically, Rhine used 25 cards, with each symbol represented five times. Thus, by guessing alone, one should average five correct answers. Have students volunteer to be experimenter or research participant. For telepathy, the experimenter shuffles the deck and then attempts to mentally communicate to the participant the symbol appearing on each card. In a test of precognition, the participants foretell the order in which the symbols will appear before the experimenter shuffles the deck. With clairvoyance, participants "sense" the order in which the symbols appear in a shuffled deck.

While the cards and procedures may seem far removed from the dramatic performances of psychics, they are more scientific tests of ESP. They reduce, perhaps eliminate, the possibility of cheating on these tests of statistical significance and also make performance evaluation more precise. Finally, such tests of ESP are easily replicated with different participants or with the same participant at different times.

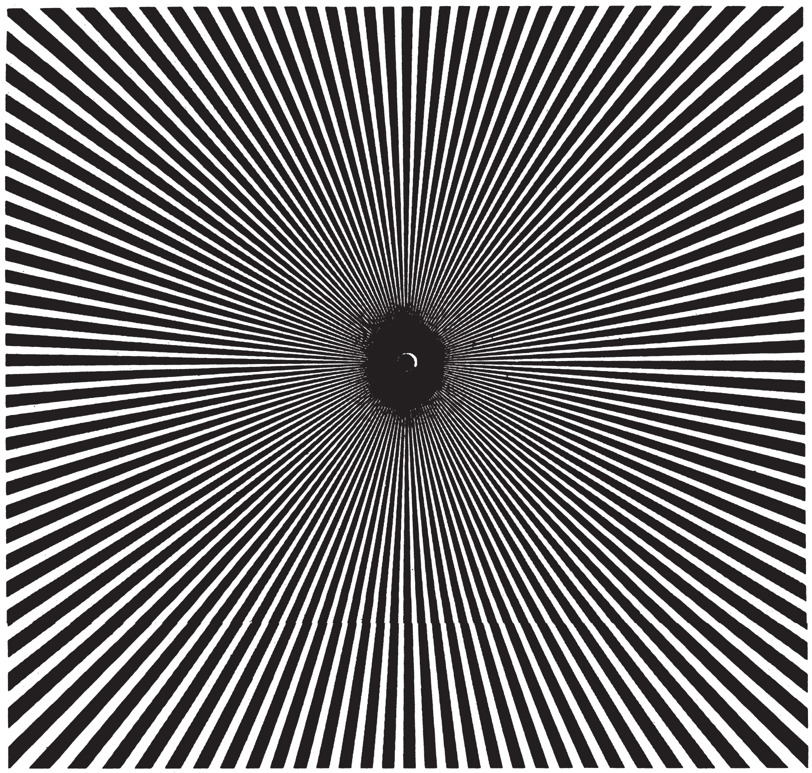
A simple classroom test of ESP involves flipping a coin. This test also provides an important lesson in probability. As you flip a coin 20 times, have students guess each outcome before you flip (precognition), after you flip (clairvoyance), or after you mentally send the result (telepathy). Have them keep a written tally of their successes. Then report the results on the board. The distribution of total correct guesses will approximate the binomial distribution around an average of 10. Retest the ESP "stars" and again report the results on the board. Of course, some will continue to beat chance, but with all such "gifted" performers the "decline effect" will eventually prevail. Alternatively, in a test of psychokinesis you might have all students in your class stand and flip a coin in an attempt to get heads. Everyone should flip at the same time, and everyone who succeeds should remain standing. If only chance is operating, around half the students should sit down after the first flip. Those standing should continue flipping until they get tails. In a class of 32, the number of students standing will go from 16 to 8 to 4 to 2 to 1. Ask the class if the last person standing after five successful flips has ESP.

HANDOUT 1

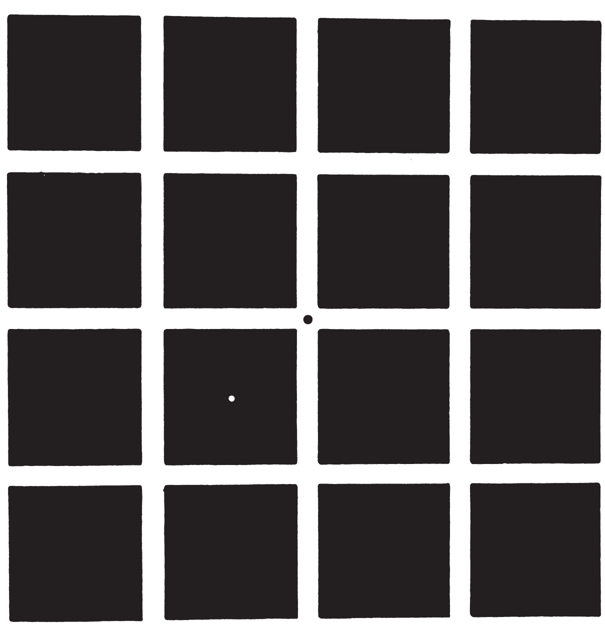


HANDOUT 2

The Perception of Movement

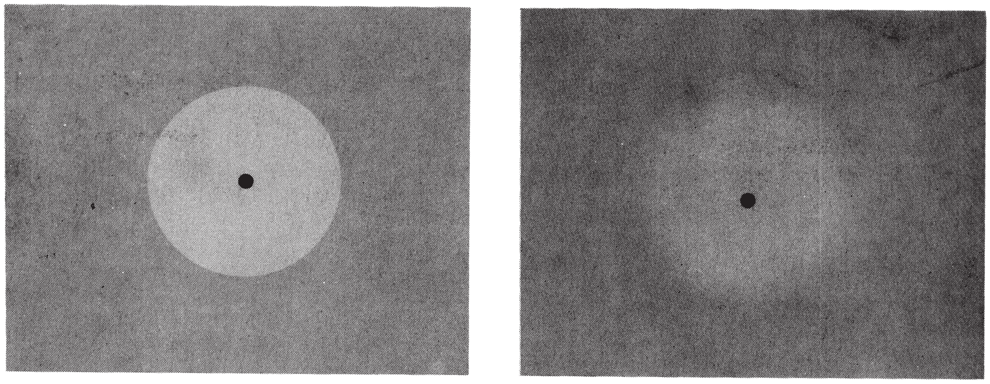


(a)



(b)

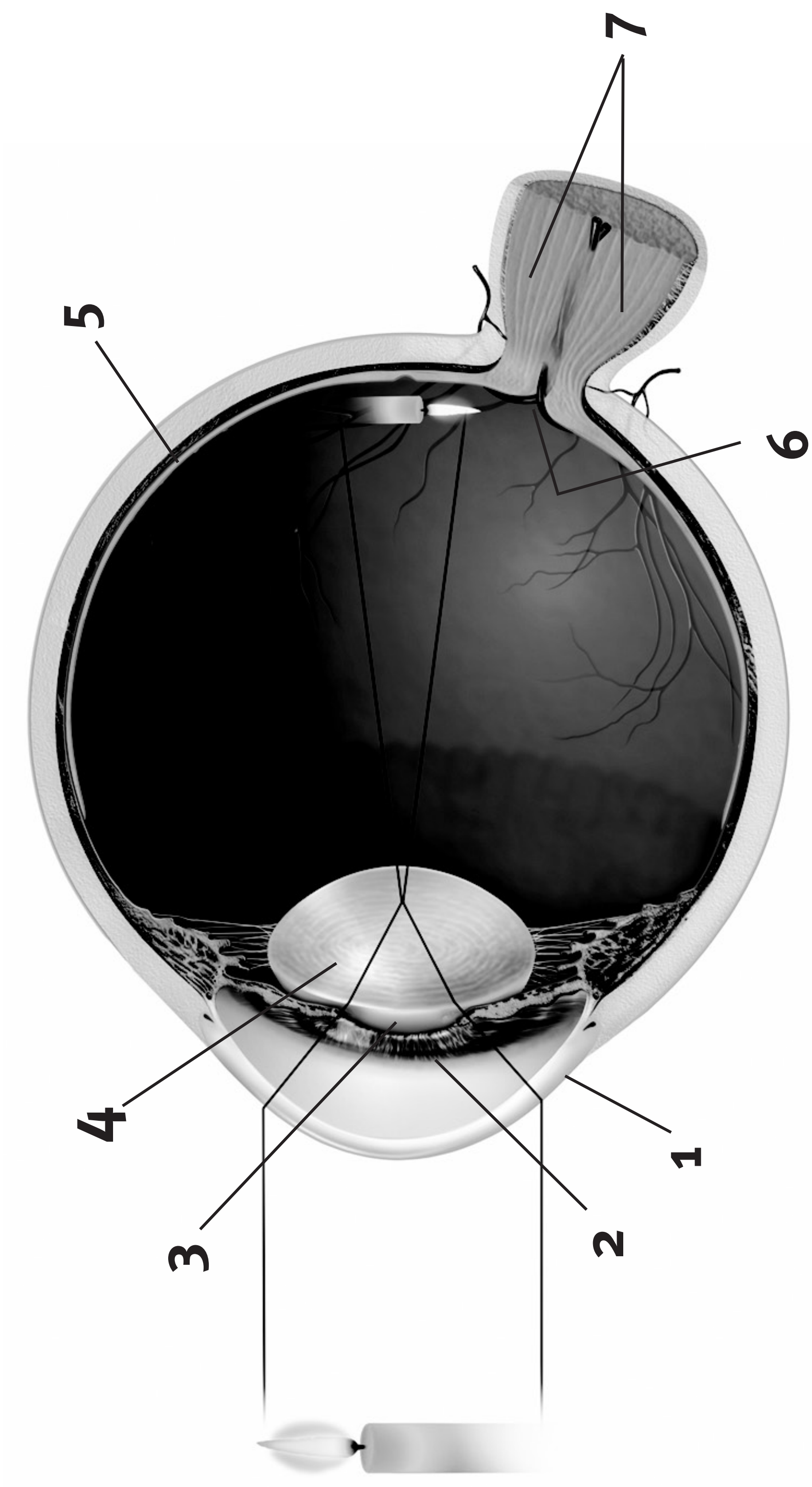
HANDOUT 2 *(continued)*



(c)

Source: (a) From Schiffman, SENSATION AND PERCEPTION, 5th edition. Copyright © 2000. Reprinted with permission of John Wiley and Sons, Inc. (b) From F. J. Verheijen, "A Simple after Image Method Demonstrating the Involuntary Multidirectional Eye Movements during Fixation," *Journal of Modern Optics 8*(4). Copyright © 1961 Taylor & Francis Ltd, reprinted by permission of Taylor & Francis Ltd, http://www.tandfonline.com. (c) From E. Bruce Goldstein, *Sensation and Perception.* Copyright © 1989, 1984, 1980 Wadsworth Publishing Company. Reprinted by permission of Cengage Learning, Inc.

HANDOUT 3



HANDOUT 3 *(continued)*

	Structure	**Color chosen**	**Briefly describe what this structure does and provide rationale for color.**
1.			
2.			
3.			
4.			
5.			
6.			
7.			

HANDOUT 4

Color Vision Screening Inventory

For each question you should select the response that best describes you and your behaviors. Circle the letter corresponding to the first letter of one of the following response alternatives:

Never (or almost never)
Seldom
Occasionally
Frequently
Always (or almost always)

Then score your responses as follows: 1 for Never, 2 for Seldom, 3 for Occasionally, 4 for Frequently, and 5 for Always. Add your scores for the 10 questions; if your score is 16 or higher, you have an 81 percent likelihood of failing a standard screening test for color vision. If your score is in this range, you might want to get your color vision tested by your doctor or in a perception laboratory.

1. Do you have difficulty discriminating between yellow and orange?

   N S O F A

2. Do you have difficulty discriminating between yellow and green?

   N S O F A

3. Do you have difficulty discriminating between gray and blue-green?

   N S O F A

4. Do you have difficulty discriminating between red and brown?

   N S O F A

5. Do you have difficulty discriminating between green and brown?

   N S O F A

6. Do you have difficulty discriminating between pale green and pale red?

   N S O F A

7. Do you have difficulty discriminating between blue and purple?

   N S O F A

8. Do the color names that you use disagree with those that other people use?

   N S O F A

9. Are the colors of traffic lights difficult to distinguish?

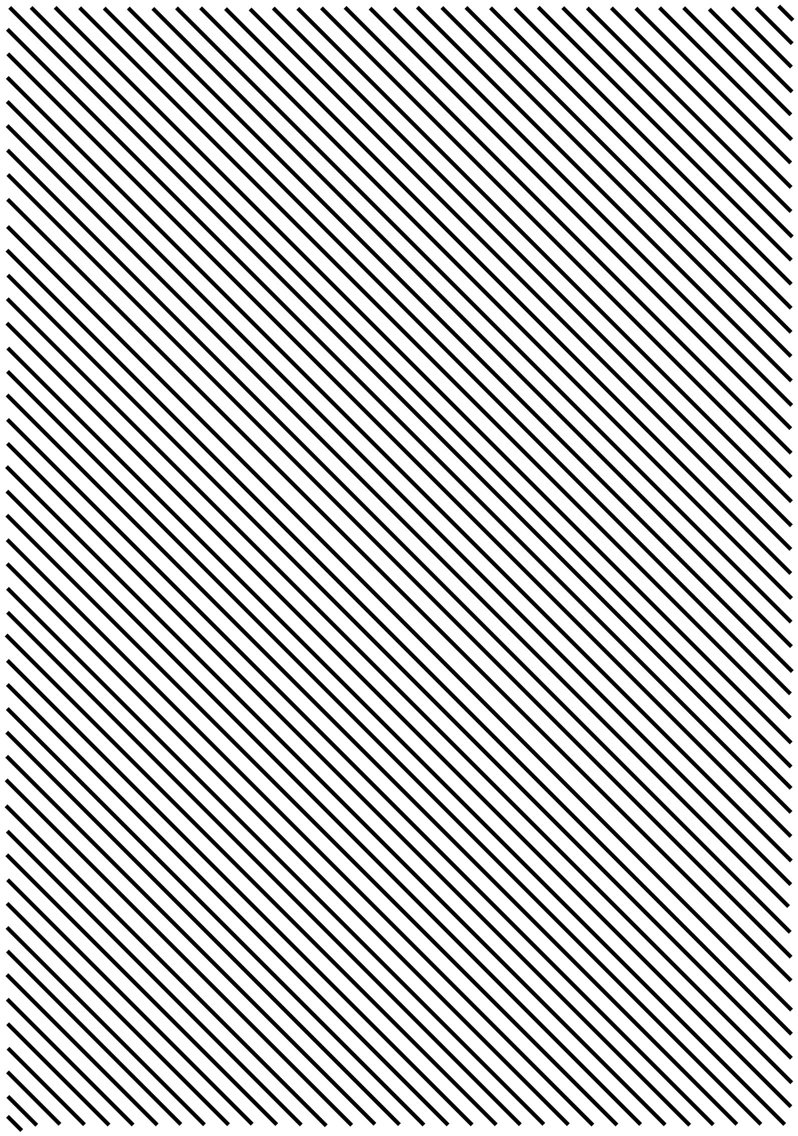
   N S O F A

10. Do you tend to confuse colors?

    N S O F A

HANDOUT 5

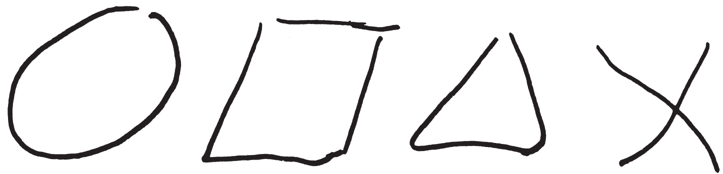
HANDOUT 6



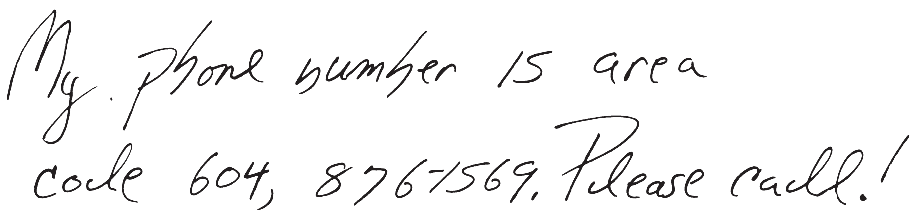
Source: From B. F. Skinner, "A Paradoxical Color Effect," *The Journal of General Psychology 7*(2). Copyright © 1932 Taylor & Francis Ltd, reprinted by permission of Taylor & Francis Ltd, http://www.tandfonline.com.

HANDOUT 7

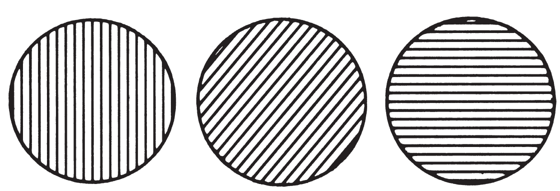
1.



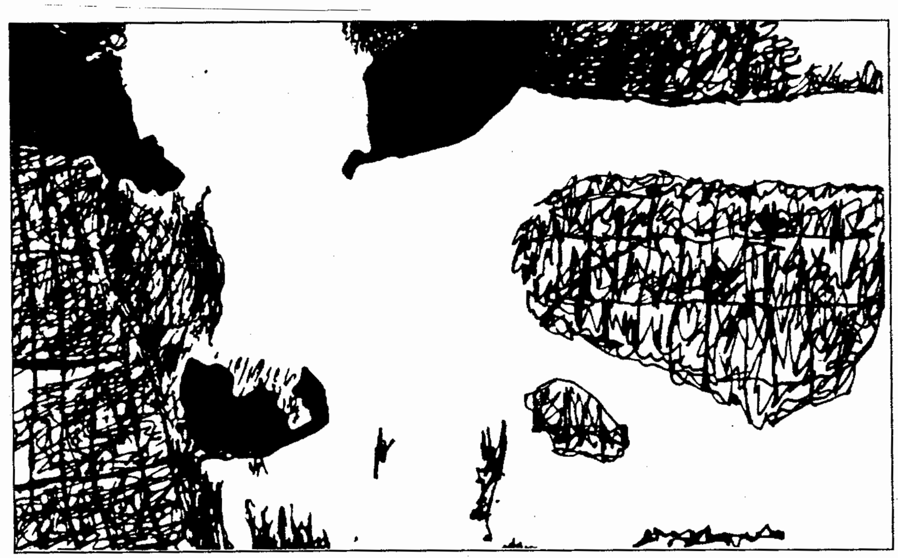
2.

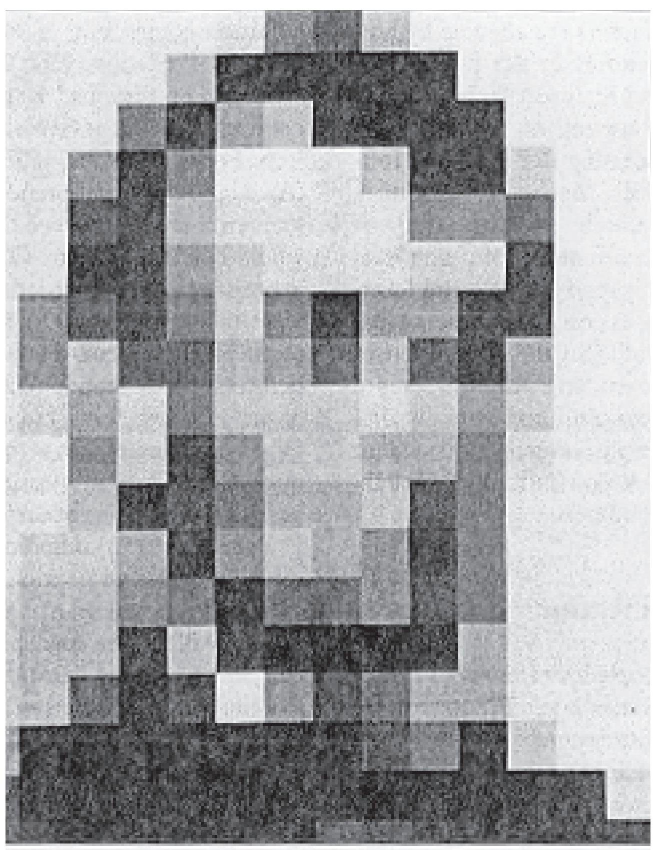


3.



HANDOUT 8



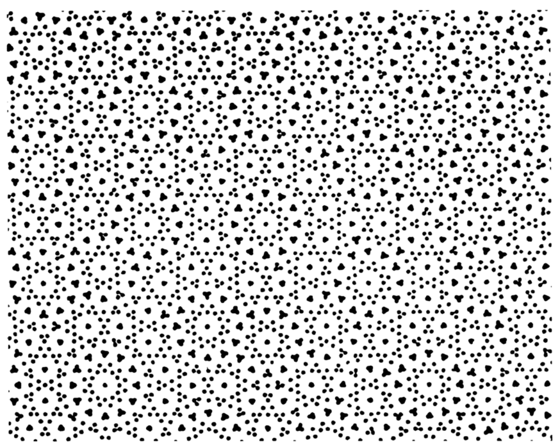


Source: From Stanley Coren, Lawrence M. Ward, and James T. Enns, *Sensation and perception,* 6th Edition.

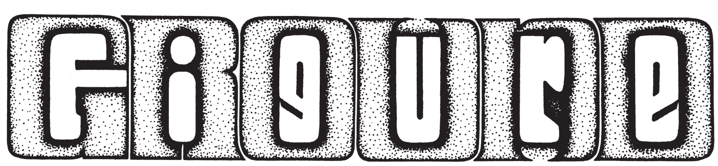
HANDOUT 9

1.

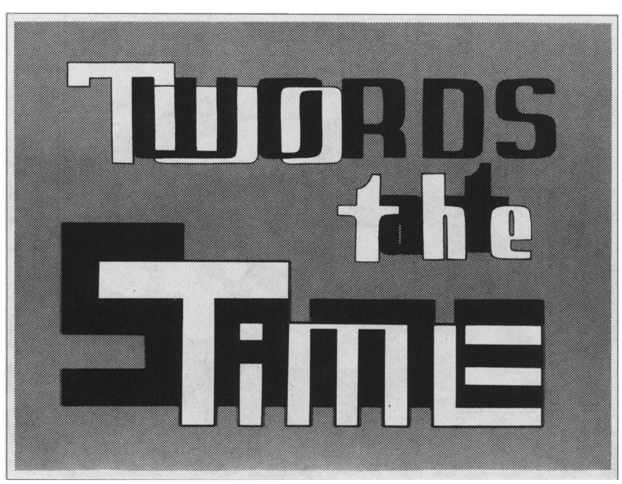
2.



3.



(a)



(b)

HANDOUT 9 *(continued)*

4.

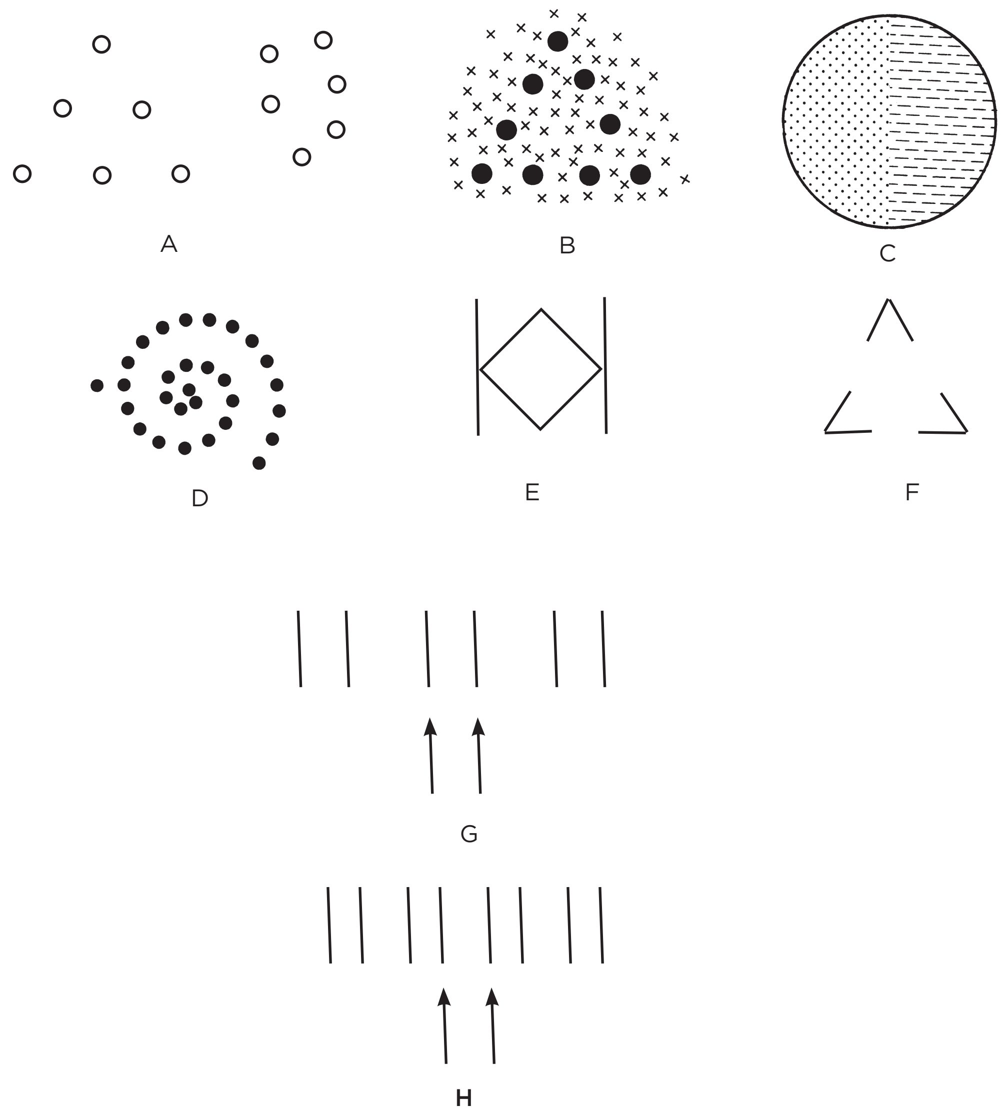
(a)

(b)

(c)

HANDOUT 9 *(continued)*

5.



HANDOUT 10

Depth Perception: Binocular Vision Versus Monocular Vision

Each eye sees objects from two slightly different angles. The brain is able to use retinal disparity and the information about the position of each eye to judge the distance of the object. This demonstration is designed to give you an appreciation of binocular depth cues.

Work in groups of three. One person will be the catcher, one the pitcher, and one the data recorder.

Procedure

1. The pitcher throws the ball to the catcher 10 times. The catcher has both eyes open, but to make it more difficult the catcher uses one hand only to catch the ball. Record the number of balls caught.
2. The pitcher throws the ball to the catcher 10 times but this time the catcher uses one eye only. Record the number of balls caught.

Repeat the procedure with each person serving as the catcher.

Observations

	My Data		Class Data	
	One Eye	Two Eyes	One Eye	Two Eyes
Number caught	________	________	________	________

Source: Adapted from a demonstration in *Blood and guts: A working guide to your own insides* by Linda Allison.

HANDOUT 11

Identifying Cues to Depth and Distance

After viewing the image shown in class, name and define two different monocular cues to depth and distance that are included in the image. Explain how each cue is represented in the image and how it contributes to your perception that some elements of the image are closer to you and some elements are farther away.

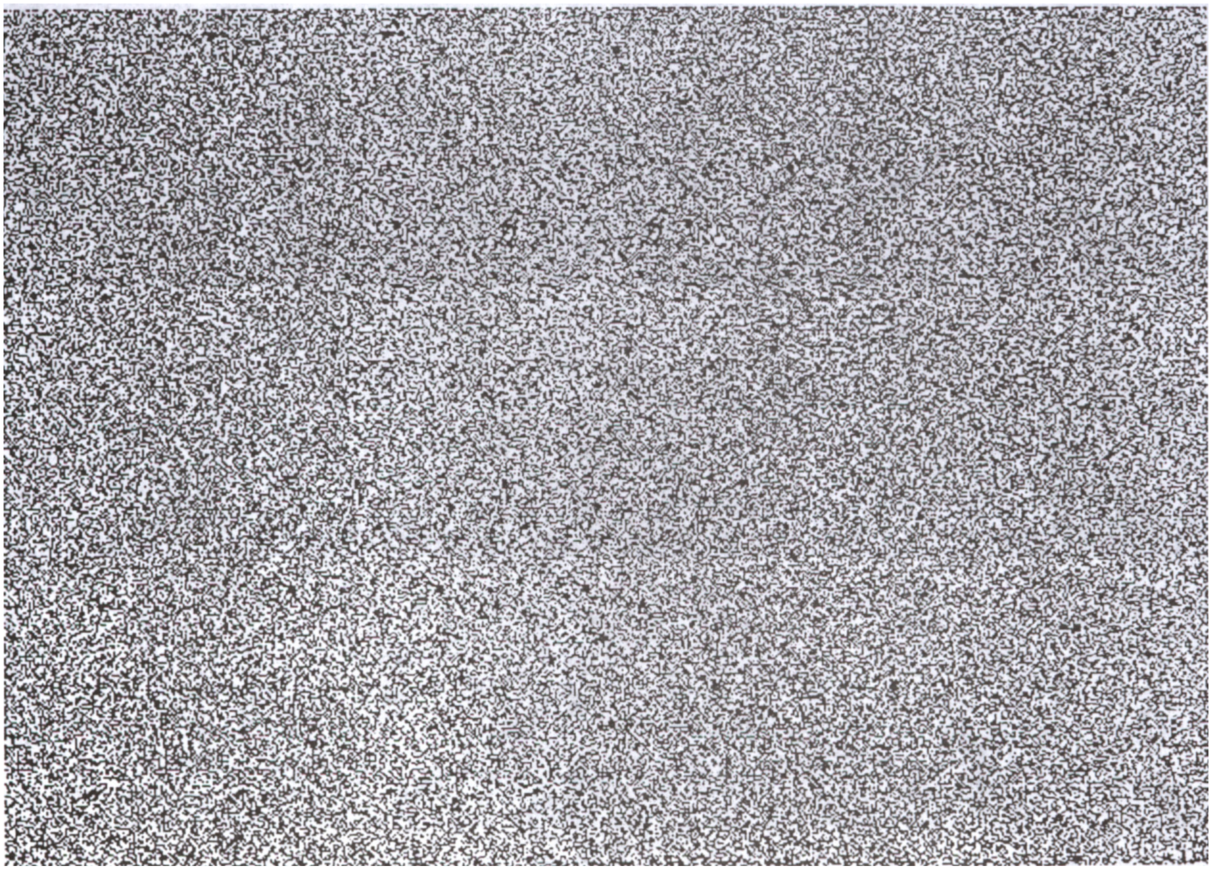
Monocular cue 1:

Monocular cue 2:

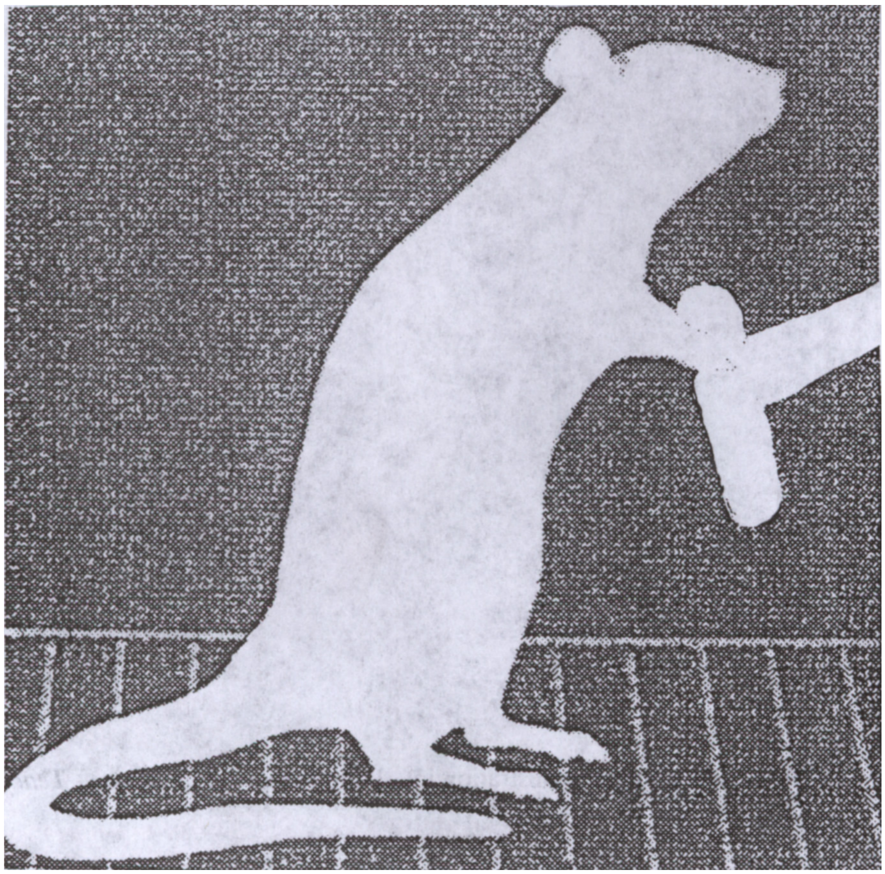
Now, imagine that you were actually present in the scene depicted in the image shown in class. Describe how the binocular cue discussed in the text (retinal disparity) would enable you to perceive some scene elements as closer to you and some as farther away. Explain how that cue would occur and how it would contribute to your perception that some scene elements are closer to you and some are farther away.

Binocular cue:

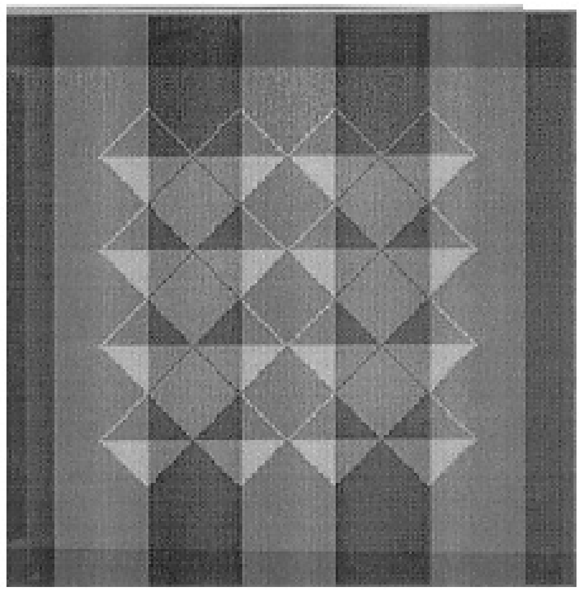
HANDOUT 12a

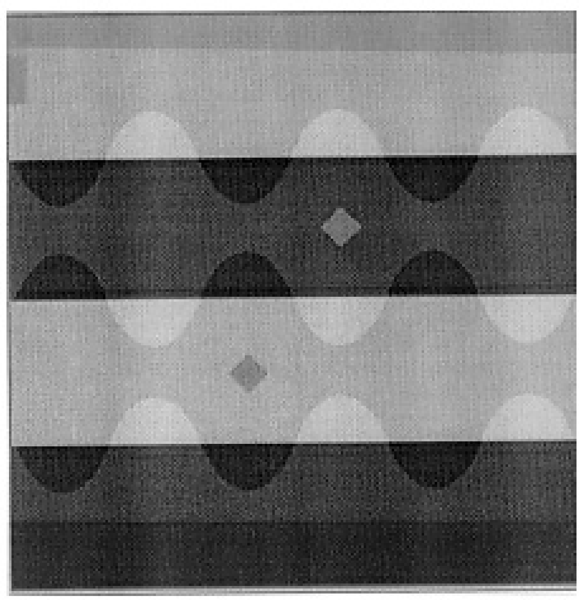


HANDOUT 12b



HANDOUT 13





Source: Reprinted by permission of Dr. Edward H. Adelson, Department of Brain and Cognitive Science, MIT, Cambridge, MA.

HANDOUT 14

Imagine that you are outside on a clear night in which there are no clouds, and there is a bright full moon. Pretend that on a table in front of you are objects that range in size from a BB to a beach ball as follows:

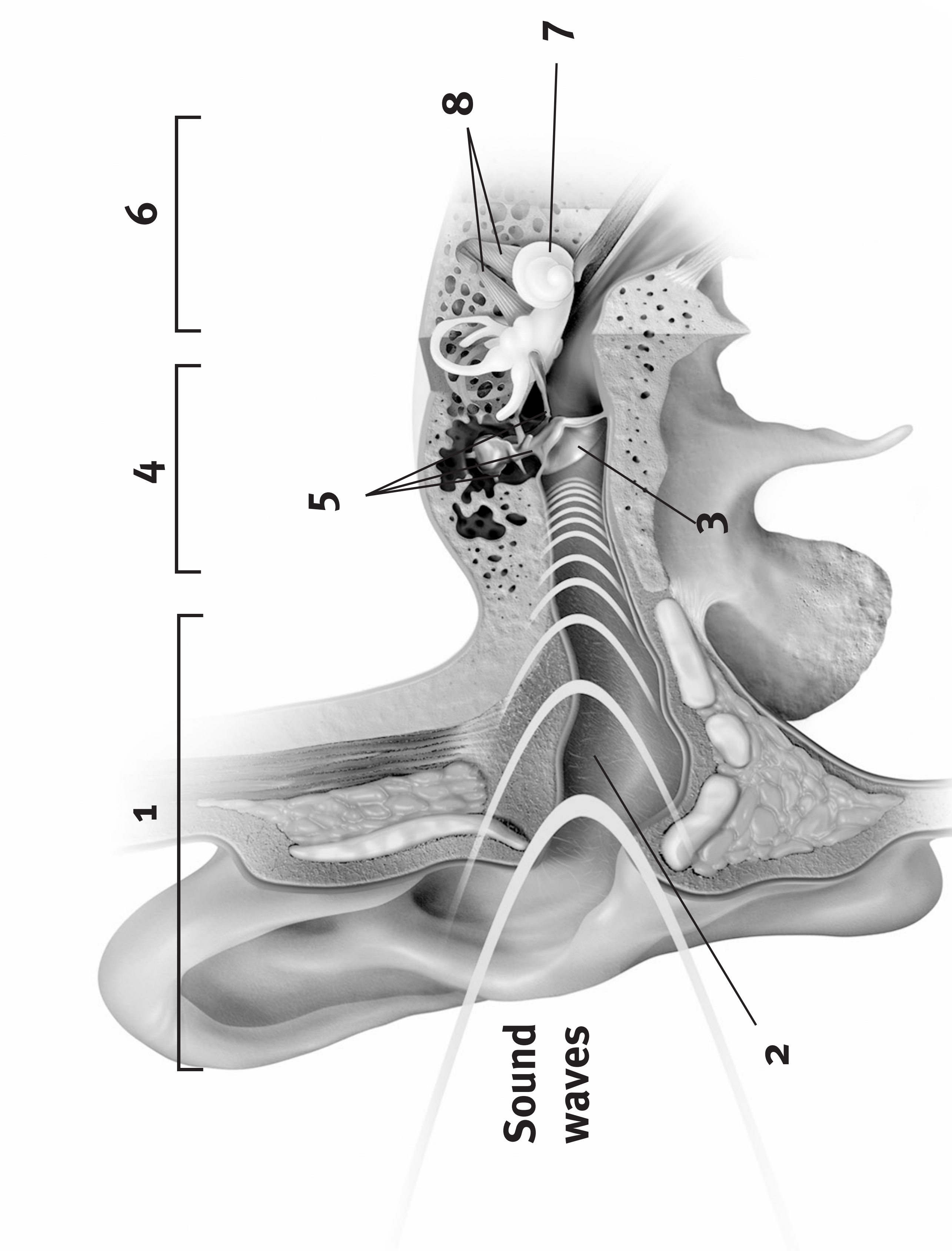
1. BB
2. Pea
3. Dime
4. Penny
5. Nickel
6. Quarter
7. Golf ball
8. Baseball
9. Softball
10. Small salad plate
11. Large dinner plate
12. Frisbee
13. Basketball
14. Beach ball

Please pretend that you are going to pick one of these things that WHEN HELD AT ARM'S LENGTH JUST COVERS UP THE MOON. Imagine that you are picking one that when you hold it in your hand will JUST BARELY COVER UP THE MOON so that you can no longer see it.

_____ Put the number of the object you chose here.

Source: From Mark A. Kunkel, "A Teaching Demonstration Involving Perceived Lunar Size," *Teaching of Psychology 20*(3).

HANDOUT 15



HANDOUT 15 *(continued)*

	Structure	**Color chosen**	**Briefly describe what this structure does and provide rationale for color.**
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			

HANDOUT 16

Revised Reducer–Augmenter Scale

The items in this list refer to events people experience and feelings people have. For each pair of events or feelings, circle the number that best describes your feelings in general or how you feel about a particular event.

Example:

watch TV	1	2	3	4	5	⑥	read a book

The circle around the 6 shows the person would want to read a book much more than watch TV

tennis	1	2	③	4	5	6	baseball

The circle around the 3 shows the person would want to play tennis a little more than baseball.

Please use one circle for each pair of events or feelings.

1.	see an action movie	1	2	3	4	5	6	see a comedy movie
2.	fast blues music	1	2	3	4	5	6	easy listening music
3.	music on too loud	1	2	3	4	5	6	music on too soft
4.	have many pets	1	2	3	4	5	6	have one pet
5.	play hard contact sports	1	2	3	4	5	6	play sports with little contact
6.	get much exercise	1	2	3	4	5	6	get a little exercise
7.	hard rock music	1	2	3	4	5	6	pop rock music
8.	electric guitar solo	1	2	3	4	5	6	nonelectric guitar solo
9.	excitement	1	2	3	4	5	6	calm
10.	be with a crowd	1	2	3	4	5	6	be alone
11.	fast games	1	2	3	4	5	6	slow games
12.	a drum solo	1	2	3	4	5	6	a flute solo
13.	loud music	1	2	3	4	5	6	quiet music
14.	like sports	1	2	3	4	5	6	dislike sports
15.	a hard and fast dance beat	1	2	3	4	5	6	a soft and slow dance beat
16.	crunchy foods	1	2	3	4	5	6	soft foods
17.	drive fast	1	2	3	4	5	6	drive slow
18.	watch football	1	2	3	4	5	6	watch baseball
19.	large family	1	2	3	4	5	6	small family
20.	be the leader of a group	1	2	3	4	5	6	be a small part in a big group
21.	body odors are bad	1	2	3	4	5	6	body odors are good

Source: Reprinted from Rock L. Clapper, "Adult and adolescent arousal preferences: The revised reducer-augmenter scale," *Personality and Individual Differences 11*(11)1115–1122.

HANDOUT 17

Extrasensory Perception Scale

This is a questionnaire in which we are asking your opinion on the existence of psychic or extrasensory abilities. Please read each statement and try to answer as accurately as you can by placing a number in the space provided. Use the following scale:

5 = strongly agree
4 = somewhat agree
3 = neutral or unsure
2 = somewhat disagree
1 = strongly disagree

_____ 1. Some people have the ability to predict the future.

_____ 2. Some people can heal other people's illnesses by just using their minds.

_____ 3. All of the reports of "scientific proof" of psychic phenomena are strictly sensationalism with no factual basis.

_____ 4. The idea of being able to tell the future through the means of palm reading represents the belief of foolish and unreliable persons.

_____ 5. I believe that psychic phenomena are real and should become part of the field of psychology.

_____ 6. Mind reading is not possible.

_____ 7. Dreams can provide information about the future.

_____ 8. Sometimes it is possible for a person to view a scene when the person is not even there by using another sense.

_____ 9. I firmly believe that, at least on some occasions, I can read another person's mind through extrasensory perception.

_____ 10. Through psychic individuals, it is possible to communicate with the dead.

_____ 11. Some animals can read the minds of humans.

_____ 12. The idea of predicting the future is foolish.

_____ 13. A person's thoughts can influence the movement of a physical object.

_____ 14. There is a great deal we have yet to understand about the mind, so it is likely that many phenomena such as ESP will one day be proven to exist.

HANDOUT 18