LESSON 01

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HISTORICAL ROOTS OF EXPERIMENTAL PSYCHOLOGY

Before formal psychology was introduced, philosophers performed studies that lead to the beginning contributions of psychology. They investigated the basic psychological processes. In 350 B.C., Aristotle and Plato wrote interesting ideas about memory, perception, etc. However, in 1880, there were no professors in psychology, no undergraduate programs in psychology, and very few Ph.D.s in the world working in the field that we today call psychology.

According to the received view (Boring, 1950), scientific psychology began in Germany as a physiological psychology born of a marriage between the philosophy of mind, on the one hand, and the experimental phenomenology that arose within sensory physiology on the other. Philosophical psychology, concerned with the epistemological problem of the nature of knowing mind in relationship to the world as known, contributed fundamental questions and explanatory constructs; sensory physiology and to a certain extent physics contributed experimental methods and a growing body of phenomenological facts.

Kant's point of view

Until the middle of the 19th century, psychology was widely regarded as a branch of philosophy. Immanuel Kant (1724-1804), for instance, famously declared in his *Metaphysical Foundations of Natural Science* (1786) that a scientific psychology "properly speaking" (a phrase in which much is buried) is an impossibility. He then proceeded to produce what looks to modern eyes very much like an empirical (if not "properly" scientific) psychology in his *Anthropology* Kant, who denied the possibility that psychology could become an empirical science on two grounds. First, since psychological processes vary in only one dimension, time, they could not be described mathematically. Second, since psychological processes are internal and subjective, Kant also asserted that they could not be laid open to measurement.

Emergence of experimental psychology

Ibn al-Haytham

Born in Basra in 965, **Abu Ali al-Hasan ibn al-Hasan ibn al-Haytham** was the first person to test hypotheses with verifiable experiments, developing the modern scientific method more than two hundred years before European scholars learned of it—by reading his books. According to the majority of the historians al-Haytham was the pioneer of the modern scientific method. With his book he changed the meaning of the term optics and established experiments as the norm of proof in the field. His investigations are based not on abstract theories, but on experimental evidences and his experiments were systematic and repeatable.

Roshdi Rashed wrote the following on Ibn al-Haytham:

"His work on optics, which includes a theory of vision and a theory of light, is considered by many to be his most important contribution, setting the scene for developments well into the 17th century. His contributions to geometry and number theory go well beyond the archimedean tradition. And by promoting the use of experiments in scientific research, al-Haytham played an important part in setting the scene for modern science." Ibn al-Haytham's scientific method was very similar to the modern scientific method and consisted of the following procedures:

1. Observation
2. Statement of problem
3. Formulation of hypothesis
4. Testing of hypothesis using experimentation
5. Analysis of experimental results
6. Interpretation of data and formulation of conclusion
7. Publication of findings

Herman Helmholtz

Hermann von Helmholtz (1821-1894), conducted studies of a wide range of topics that would later be of interest to psychologists.

- Natural scientist who studied sensation
- Investigated color vision, hearing, and speed of nerve condition
- Provided foundation for modern perception research
- Defined problems of visual and auditory perception that experimental psychologists would study, including Trichromatic theory of color, Unconscious Inference theory of perception, and established a theory of music perception that lasted 100 years

Ernst Weber

He taught anatomy and physiology at the University of Leipzig. His work is on the physiology of sense organs. He worked on skin and muscular sensations. He was originally not interested in psychology but his work contributed a lot in making psychology a science.

Important contributions

- Experimental determination of the accuracy of the two-point discrimination of the skin; that is, the distance btw two points that must be spanned before subjects report felling two distinct sensations
- **Two-point threshold;** the point at which the two separate source of stimulation can be distinguished
- First demonstrator of a threshold
- **Just noticeable difference;** smallest difference that can be detected btw two physical stimuli; to report whether one felt heavier than the other
- Subject could make such discrimination much more accurately when they lifted the weights themselves than when the experimenter placed the weights in their hands

- Suggested that discrimination among sensation depends not on the absolute difference btw two weights but on their relative difference or ratio

Gustav Theodor Fechner

He is considered as the father of psychophysics and experimental psychology. He studied and remained at University of Leipzig

Herbart answered the first of Kant's objections by conceiving of mental entities as varying both in time and in intensity and showing that the change in intensity over time could be mathematically represented. Fechner then answered the second objection by developing psychophysical procedures that allowed the strength of a sensation to be scaled. Wundt combined these notions, joined them to the methods of sensory physiology and experimental phenomenology and, in 1879, created the Leipzig laboratory.

One such contribution, as we have already noted, was Kant's defining the prerequisites that would need to be met for psychology to become an empirical science.

It is in the work of Gustav Theodor Fechner (1801-1887) that we find the formal beginning of experimental psychology. Before Fechner, as Boring (1950) tells us, there was only psychological physiology and philosophical psychology. It was Fechner "who performed with scientific rigor those first experiments which laid the foundations for the new psychology and still lie at the basis of its methodology"

Fechner was born in Gross-Sächen, Prussia. At the age of 16 he enrolled in medicine at the University of Leipzig where he studied anatomy under Weber. No sooner had he received his medical degree, however, than his interest began to shift toward physics and mathematics. By 1824, he was lecturing in physics and in 1834, with over 40 publications to his credit, including an important paper on the measurement of direct current, he was appointed Professor of Physics at Leipzig.

Fechner's psychological interests began to manifest themselves toward the end of the 1830s in papers on the perception of complementary and subjective colors. In 1840, the year in which an article on subjective afterimages appeared,

Between 1851 and 1860, Fechner worked out the rationale for measuring sensation indirectly in terms of the unit of just noticeable difference between two sensations, developed his three basic psychophysical methods (just noticeable differences, right and wrong cases, and average error) and carried out the classical experiments on tactual and visual distance, visual brightness, and lifted weights that formed a large part of the first of the two volumes of the

Wilhelm Wundt

In 1875, Wundt founded a laboratory specifically dedicated to original research in experimental psychology in 1879, the first laboratory of its kind in the world.

Wilhelm Wundt, who is often considered the father of experimental psychology, for introducing a mathematical and quantitative approach to experimental psychology in the 19th century. Wundt was the first to call himself a "psychologist", and was also the first research/experimental psychologist. He established the first psychology laboratory in Leipzig and he founded the structuralist school of psychology. His disciples carried on his work, most prominent among them is Titchner.

Titchner

Contribution

- Established an association of experimental Psychology called the Experimentalists (1904) which is still in existence today as the Society of Experimental Psychologists.
- Was an influence in American Psychology bringing a strict empirical, Wundtian approach to experimental psychology.
- Created a system of Structural Psychology later termed Structuralism a study of the elemental structures of Consciousness based on introspection.
- Trained 56 doctoral students of which over a third were Women, many rising as prominent Psychologists.
- Attempted to eliminate stimulus error in the experience of the stimulus.

- Sought to reduce experience to its basic elements.
- Initiated change in his system abandoning the elemental approach and considering a phenomenological approach to the study of consciousness in 1923.

The methods of psychology: as psychology was defined as the study of experience, and as an outside observer cannot gather information on subjective experience, Wundt turned to introspection as the tool for gathering data. Researchers were trained with specific criteria for becoming skilled introspectors.
They attempt to study the mental world with introspection, the tool that Descartes thought most appropriate for the mental realm. It attempted to use that data to fit into the mechanical realm of science. This early attempt to cut across Cartesian dualism was not successful. Introspectors could not agree on the data, and thus the scientific necessity of confirming results in other laboratories could not be met.
Introspection (from Lat. *introspicere,* to look within) in psychology, is the process of examining the operations of one's own mind with a view to discovering the laws which govern psychic processes. The introspective method has been adopted by psychologists from the earliest times, more especially by Hobbes, Locke, Berkeley, Hume, and English psychologists of the earlier school. It possesses the advantage that the individual has fuller knowledge of his own mind than that of any other person, and is able therefore to observe its action more accurately under systematic tests. On the other hand it has the obvious weakness that in the total content of the psychic state under examination there must be taken into account the consciousness that the test is in progress. This consciousness necessarily arouses the attention, and may divert it to such an extent that the test as such has little value. Such psychological problems as those connected with the emotions and their physical concomitants are especially defective in the introspective method; the fact that one is looking forward to a shock prepared in advance constitutes at once an abnormal psychic state, just as a nervous person's heart will beat faster when awaiting a doctor's diagnosis. The purely introspective method has of course always been supplemented by the comparison of similar psychic states in other persons, and in modern psycho-physiology it is of comparatively minor importance.

"A view of the inside or interior; a looking inward; specifically, the act or process of self-examination, or inspection of one's own thoughts and feelings; the cognition which the mind has of its own acts and states; self-consciousness; reflection. "I was forced to make introspection into my own mind." *Dryden*
Some psychologists claimed that introspection was unreliable and that the subject matter of scientific psychology should be strictly operationalzed in an objective and measurable way. This then led psychology to focus on measurable behavior rather than consciousness or sensation. Cognitive psychology accepts the use of the scientific method, but rejects introspection as a valid method of investigation for this reason. It should be noted that Herbert Simon and Allen Newell identified the 'thinking-aloud' protocol, in which investigators view a subject engaged in introspection, and who speaks his thoughts aloud, thus allowing study of his introspection.

stimulus error .introspection is wholly unreliable; for if we compare the observer's reports with the stimuli actually exposed, we find that he may see what was not there at all, may fail to see much of what was there, and may misrepresent the little that he really perceived; introspection adds, subtracts, and distorts.

Modern psychology began with the adoption of experimental methods at the end of the nineteenth century: Wilhelm Wundt established the first formal laboratory in 1879; universities created independent chairs in psychology shortly thereafter; and William James published the landmark work *Principles of Psychology* in 1890. In *A History of Modern Experimental Psychology,* George Mandler traces the evolution of modern experimental and theoretical psychology from these beginnings to the "cognitive revolution" of the late twentieth century

Hermann Ebbinghaus
Hermann Ebbinghaus (January 24, 1850–February 26, 1909) was a German psychologist who pioneered experimental study of memory, and discovered the forgetting curve and the learning curve.
Ebbinghaus was born in Barmen. At age 17, he entered the University of Bonn. His first and foremost interest was psychology. His studies were interrupted in 1870 by the Franco-Prussian War. He enlisted in the Prussian army. He resumed his studies and received a Ph.D. in 1873.

In 1885, he published his groundbreaking *Über das Gedächtnis* ("On Memory", later translated to English as *Memory. A Contribution to Experimental Psychology*) in which he described experiments he conducted on himself to describe the process of forgetting.
He was professor of philosophy at the University of Berlin, and later in Breslau (now Wroclaw, Poland). He died of pneumonia in Breslau at the age of 59.
His contributions are multiple. His famous work on memory helped to initiate experimental psychology. He pioneered precise experimental techniques used in the research on learning. In addition to his research and lecturing, he established two psychology laboratories in Germany, and co-founded the *Zeitschrift für Physiologie und Psychologie der Sinnesorgane* (*Journal of the Physiology and Psychology of the Sense Organs*), an important early psychology journal.
Herman Ebbinghaus was the first to experimentally investigate the properties of human memory. Influenced by the British Empiricists, Ebbinghaus assumed that the process of committing something to memory involved the formation of new associations and that these associations would be strengthened through repetition. To observe this process, he devised a set of items to be committed to memory that would have no previous associations, the so-called **nonsense syllables**. These consist of a sequence of consonant, vowel, and consonant (*CVC*) that does not spell anything in one's language -- in English, CAJ would be an example. Ebbinghause constructed lists of perhaps 20 of these items and then proceeded to memorize these lists systematically. He would read the first item, say it to himself, then go on to the next item, repeat it to himself, and so on, spending the same amount of time on each item. One complete run through the list constituted a single repetition.
After some number of repetitions, Ebbinghaus would attempt to recall the items on the list. It turned out that his ability to recall the items improved as the number of repetitions went up, rapidly at first and then more slowly, until finally the list was mastered. This was the world's first **learning curve**.
To test retention, Ebbinghaus practiced a list until he was able to repeat the items correctly two times in a row. He then waited varying lengths of time before testing himself again. Forgetting turned out to occur most rapidly soon after the end of practice, but the rate of forgetting slowed as time went on and fewer items could be recalled. This curve represented the the first **forgetting curve**.
One of the important memory phenomena discovered by Ebbinghaus is the **overlearning** effect. You can of course continue to practice memorizing a list beyond that required to produce two perfect recalls. For example, if it required 10 repetitions to memorize the list, then you might continue for an additional ten repetitions -- this would be "100% overlearning." The effect of overlearning is to make the information more resistant to disruption or loss. For example, the forgetting curve for overlearned material is shallower, requiring more time to forget a given amount of the material.
Ebbinghaus was the first to discover the **serial position curve** -- the relation between the serial position of an item (its place in the list) and the ability to recall it. Items near the beginning of the list are easier to recall than those in the middle (the *primacy effect*). Those near the end of the list are also earier to recall than those in the middle (the *recency effect*.) These two effects together yield a curve that is roughly U - shaped.
The normal serial position curve shows that items in the middle of a list are the most difficult to commit to memory. However, this disadvantage can be reduced or eliminated by making the item distinctive, so that it stands out from the other middle-list items. For example, the item could be printed in red when the rest of the items are printed in black. The contrasting color draws attention to the item, and it receives more processing.

Defining the experimental psychology

Experimental psychology approaches psychology as one of the natural sciences, and therefore assumes that it is susceptible to the experimental method. Many experimental psychologists have gone further, and have assumed that all methods of investigation other than experimentation are suspect

Nature of experimental psychology

Experimental psychology is a science its nature is scientific
Important Characteristics

Use of scientific methods

Experimental psychology uses the experimental methods for study.

Factuality

Psychology studied the facts of behavior. A psychologist is detached and objective in his observations and experiments. Psychology is not related with values but facts.

Universality

The laws of experimental psychology have been found to be correct at every time and place under the same conditions. The general principles of experimental psychology are universal, whatever difference may be in the psychology of different individuals for example the psychological fact that human beings and animals are emotionally disturbed by any impediment in the satisfaction of their impulses, is applicable everywhere.

Discovers the cause-effect relationship:

Experimental psychology not only obverses behavior, but also finds out cause-effect relationship in it, e.g., it has discovered why and in what circumstances a D.L. is constant. These findings have been put to use and found correct. Thus experimental psychology discovers the "how" of behavior together with its "what".

Predicts behavior

By discovering the cause-effect relationship, experimental psychology also predicts behavior and these predictions are generally correct. Thus, in the modern progressive countries, appoints to different Governments posts are made by relying on the predictions made on the basis of psychological tests. On the basis of psychological tests, it is predicted that such and such person will be a good solider and so and so a good administrator; and generally this proves true in actual experience.

Scope of experimental psychology

Experimental psychology studies external behavior as well as the internal processes of the different stages of human development. Only those phenomenon fall outside its field which can not be studied in controlled situations. But the scope of experimental psychology is gradually widening with the invention of new tools and instruments for experiments. The most important areas covered by experimental psychology include psychophysics, animal psychology, learning psychology, psychology of individual differences, child psychology, educational psychology, clinical p[psychology and industrial psychology etc.

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LESSON 02

SENSATION AND PERCEPTION

In this chapter we focus on the field of psychology that is concerned with the nature of the information our body takes in through its senses and with the way we interpret such information. We will explore both sensation, the' stimulation of the sense organs and perception, the sorting out, interpretation, analysis, and integration of stimuli involving our sense organs and brain. .

To a psychologist interested in understanding the causes of behavior, sensation and perception are fundamental topics, since our behavior is so much a reflection of how we react to and interpret stimuli from the world around us. Indeed, questions ranging from what processes enable us to see and hear, to how we know whether sugar or lemon is sweeter, to how we distinguish one person from another all fall into the realm of sensation and perception.

Although perception clearly represents a step beyond sensation, in practice it is sometimes difficult to distinguish the precise boundary between the two. Indeed, psychologists, and philosophers, as well have argued for years over the distinction. The primary difference is that sensation can be thought of as an organism's first, encounter with a raw sensory stimulus, while perception is the process by which the stimulus is interpreted, analyzed, and integrated with other sensory information. If, for example, we were considering sensation, we might ask about the loudness of a ringing fire alarm. On the other 'hand, if we were considering perception, we might ask whether someone recognizes the ringing sound as an alarm and identifies, its meaning .

Sensing the word around us

Most of us have been taught at one time or another that there are just five senses: sight, sound, taste, smell and touch this enumeration is too modest, since human sensory capabilities go well beyond the basic five senses. It is well established, for example. that we are sensitive not merely to touch, but to a considerably wider set of stimuli-pain, pressure, temperature, and vibration, to name a few. In addition, the ear is responsive to information that allows us not only to hear but to keep our balance as well. Psychologists now believe that there are at least a dozen distinct senses, all of which arc interrelated.

To consider how psychologists understand the senses, and, more broadly, sensation and perception we first need a basic working vocabulary. In formal terms, if any passing source of physical energy activates a sense organ, the energy is known as a stimulus. **A stimulus**, then, is energy that produces a response in a sense organ.

Stimuli vary in both type and intensity. Different types of stimuli activate different sense organs. For instance, we can differentiate light stimuli, which activate our sense of sight and allow us to see the colors of a tree in autumn, from sound stimuli which, through our sense of hearing, permit us to hear the sounds of an orchestra. Each sort of stimulus that is capable to activating a sense organ can also be considered in terms of its strength, or *i1ltensity.* Questions such as how intense a light stimulus needs to be before it is capable of being detected or how much perfume a person must wear before it is noticed by others relate to stimulus intensity.

The issue of how the intensity of a stimulus influences Our sensory responses is considered a branch of psychology known as psychophysics. Psychophysics is the study of the relationship between the physical nature of stimuli and the sensory responses that they evoke.

Sensory Adaptation

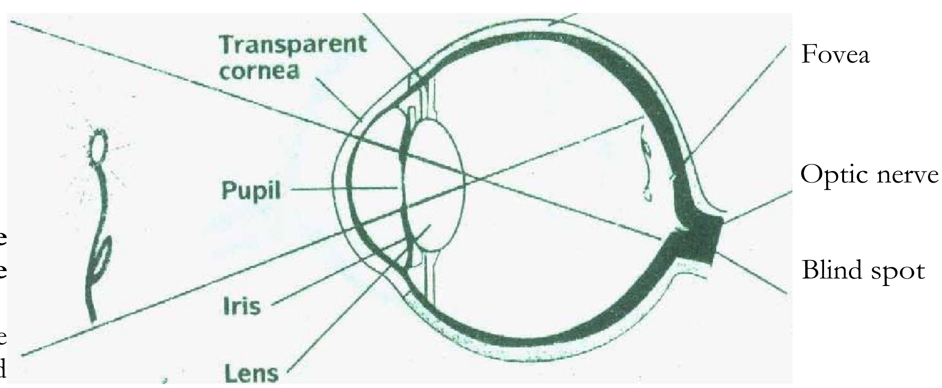
It is the capacity following prolonged exposure to stimuli. Adaptation occurs as people get used to a stimulus and change their frame of reference. Consequently they do not respond to the stimulus in the way they did earlier. One example of adaptation is the decrease in sensitivity that occurs after frequent exposure to a stimulus. If for example you were to repeatedly hear a loud tone, it would begin to sound softer after a while. This apparent decline in sensitivity to sensory stimuli is due to the inability of the sensory nerve receptors to constantly fire off messages to the brain. Because these receptor cells are most responsive to changes in stimulation, constant stimulation is not effective in producing a reaction.

Adaptation occurs with all the senses for example, try to stare unblinkingly at the period at the end of this sentence. (You actually won't be able to do it very well because of involuntary tiny movements of your eye.) But if you could stare long enough, the spot would eventually disappear as the visual neurons lost their

ability to fire.
Judgments of sensory stimuli are also affected by the context in which the judgments are made. Carrying five acrobats seems insignificant to the strongman who has just carted an elephant around the circus floor. The reason is that judgments are made, not in isolation from other stimuli, but in terms of preceding sensory experience.

Vision: Shedding light on the eye

The stimuli that register as light in our eyes are actually electromagnetic radiation waves to which our bodies' visual apparatus happens to be sensitive and capable of responding. Electromagnetic radiation is measured in wavelengths. The size of each wavelength corresponds to different types of energy. The range of wavelengths that humans are sensitive to-called the *visual spectrum is* actually relatively small. Many nonhuman species have different capabilities. For instance, some reptiles and fish see longer wavelengths than humans, while certain insects see shorter wavelengths than humans.
Light Waves coming from some object outside the body first encounter the only organ that is capable of re-sponding to the visual spectrum: the eye. Strangely enough, most of the eye is not involved with responding directly to light. Instead, its function is to shape the entering image into a form that can be used by the neurons that will serve as messengers to the brain. The neurons themselves take up a relatively small percentage of the total eye. In other words most of the eye is a mechanical device, analogous in many respects to a camera without film. At the same time, it is important to realize the limitations of this analogy. Vision involves processes that are far more complex and sophisticated than any camera is capable of mimicking. Once the image reaches the neuronal receptors of the eye, the analogy ends, for the processing of the visual image in the brain is more reflective of a computer than a camera.



Illuminating the Structure of the Eye

The ray of light we are tracing as it is reflected off the flower first travels through the *cornea,* a transparent, protective window that allows light to pass through. After moving through the cornea, the light traverses the pupil, a dark hole in the center of the iris which is the colored part of the eye. It ranges in humans from a light blue to a dark brown. The size of the pupil opening depends on the amount of light in the environment the dimmer the surroundings, the more the pupil opens in order to allow more light to enter.
Why shouldn't the pupil be opened all the way all the time, thereby allowing the greatest amount of light into the eye? The answer has to do with the basic physics of light. A small pupil greatly increases the range of distances at which objects are in focus. With a wide-open pupil, the image is relatively small, and details are harder to discern. The eye takes advantage of bright light by decreasing the size of the pupil and thereby becoming more discerning. In dim light the pupil expands to enable us to view the situation better-but at the expense of visual detail. Perhaps one reason that candle light dinners arc often thought of as romantic is that the dimness of the light prevents from seeing the details of a lover's face.
Once light passes through the pupil, it enters the *iris* which is located directly behind the pupil. The lens acts to bend the rays of light so that they are properly focused on the rear of the eye. The lens focuses light by changing its own thickness, a process called accommodation. The kind of accommodation that occurs depends on the location of the object in relation to the viewer's body. Distant objects require a relatively flat

lens. In this case, the muscles controlling the lens relax, allowing the lens to flatten. In contrast, close objects are viewed best through a rounded lens, Here, then, the muscles contract, relieving tension and permitting the lens to become rounder.

Having traveled through the pupil and lens, OUT image of the flower finally reaches its ultimate destination in the eye-the retina. Here the electromagnetic energy of light is converted into messages that the brain can use. It is important to note that because of the physical properties of light, the image has reversed itself in traveling through the lens, and it reaches the retina upside down (relative to its original position). Although it might seem that this reversal would cause difficulties in understanding and moving about the world, this is not the case.

The retina is actually a thin layer of nerve cells at the back of the eyeball. There are two kinds of light-sensitive receptor cells found in the retina.

The names they have been given describe their shapes: rods which are cylindrical, and cones, which are short and thick. The rods and cones are distributed unevenly through out the retina. The greatest concentration of cones is found on the *fovea* (fovea is a particularly sensitive region of the retina).

The sensitivity of cones declines just outside the fovea. Because the fovea covers only a small portion of the eye, there are fewer cones (about 7 million) than there are rods (about 125 million).

The rods and cones are not only structurally dissimilar, but they play distinctly different roles in vision. Cones are primarily responsible for the vision in sharp light while rods are related to vision in dimly lit situations and are largely insensitive to color and to details as sharp as that of cones are capable of recognizing.

Adaptation

Light adaptation

This occurs when we move from the dark into bright light. The bright light momentarily dazzles us and all we see is white light because the sensitivity of the receptors is set to dim light. Rods and cones are both stimulated and large amounts of the photopigment are broken down instantaneously, producing a flood of signals resulting in the glare.

Adaptation occurs in two ways: The sensitivity of the retina decreases dramatically. Retinal neurons undergo rapid adaptation inhibiting rod function and favoring the cone system within about one minute the cones are sufficiently excited by the bright light to take over. Visual accuracy and color vision continue to improve over the next ten minutes. During light adaptation retinal sensitivity is lost.

Dark adaptation

Dark adaptation is essentially the reverse of light adaptation. It occurs when going from a well light area to a dark area. Initially blackness is seen because our cones cease functioning in low intensity light. Also, all the rod pigments have been bleached out due to the bright light and the rods are initially nonfunctional. Once in the dark, rhodopsin regenerates and the sensitivity of the retina increases over time (this can take approximately one hour). During this adaptation process reflexive changes occur in the pupil size.

Sending the Message from the Eye to the Brain

When the light energy strikes the rods and cones it starts a chain of events that transform light into neural impulses that can be transferred to brain. Before the neural message reaches the brain some initial alteration of visual information take place. Rods contain *rhodopsin,* a complex reddish-purple substance whose composition changes chemically when energize by light

The substance found in cone receptors is different, but the principles are similar. Stimulation of the nerve cells in the eye triggers a neural response that is transmitted to other nerve cells, called *bipolar cells* and *ganglion cells,* leading to the brain.

Bipolar cells receive information directly from the rods and cones. This information is then communicated to the ganglion cells. Ganglion cells collect and summarize visual information, which is gathered and moved out of the back of the eyeball through a bundle of ganglion axons called the optic nerve. Because the opening for the optic nerve pushes through the retina, there are no rods or cones in the area, which creates a blind spot. Normally however, this absence of nerve cells does not interfere with vision, because you automatically compensate for the missing part of your field of vision

Once beyond the eye itself, the neural signals relating to the image move through the optic nerve. As the optic nerve leaves the eyeball, its path does not take the most direct route to the pan of the brain right

behind the eye. Instead, the optic nerves from each eye meet at a point roughly between the two eyes-called the optic chiasm where each optic nerve then splits.
When the optic nerves split, the nerve impulses coming from the right' half of each retina are sent to the right side of the brain, and the impulses arriving from the left half, of each retina are sent to the left side of the brain. Because the image on the retinas is reversed and upside down, however, those images corning from the right half of each retina actually originated in the field of vision to the person's left, and images coming from the left half of each retina originated in the field of vision to the person's right. In this way, our nervous system ultimately produces the phenomenon that each half of the brain is associated with the functioning of the opposite side of the body.
Color vision theories

Color Vision Theories
1 Trichromatic Theory - this theory indicates that we can receive 3 types of colors (red, green, and blue) and that the cones vary the ratio of neural activity (Like a projection T.V.). The ratio of each each color to the other then determines the exact color that we see.
2 Opponent-Process Theory - color perception depends on the reception of pairs of antagonist colors. Each receptor can only work with one color at a time so the opponent color in the pair is blocked out. Pairs = red-green, blue-yellow, black- white (light-dark).
DOES COLOR EXIST? People just assume that because we see colors that they actually exist in the world. In other words, that when they see the color red, that red is a real, physical, tangible, "thing". But is it, or is color just a matter of our perception? If we had different types of nervous systems, we would see things differently (literally) and so wouldn't we think those other things we saw were the real "things"?

Color blindness
For most people who are color-blind, the world looks quite dull. Red fire engines appear yellow green grass, seems yellow, and the red colors of a traffic light all look yellow. In fact, in the most common form of color blind all red and green objects are seen as yellow. There are other forms of color blindness as well, but they are quite rare. In yellow-blue blindness, people can not tell the difference between yellow and blue, and in the most extreme case all individual perceive no color at all. To such a person the world looks something like the picture on a black and television screen
One of the most frequent causes of blindness is a restriction of the impulses across the optic nerve. *Glaucoma,* which strikes between 1 and 2 percent of those over age 40, occurs when pressure in the fluid of the eye begins to build up, either because it cannot be properly drained or because too much of it is produced. When this first begins to happen, the nerve cells that communicate information about peripheral vision are constricted, leading to a decline in the ability to see anything outside a narrow circle directly ahead. This is called *tunnel vision.* Eventually, the pressure can become so great that all the nerve cells are contracted, leading to total blindness. Fortunately, if detected early enough, glaucorpa is highly treatable, either through medication that reduces the pressure in the eye or through surgery

LESSON 03

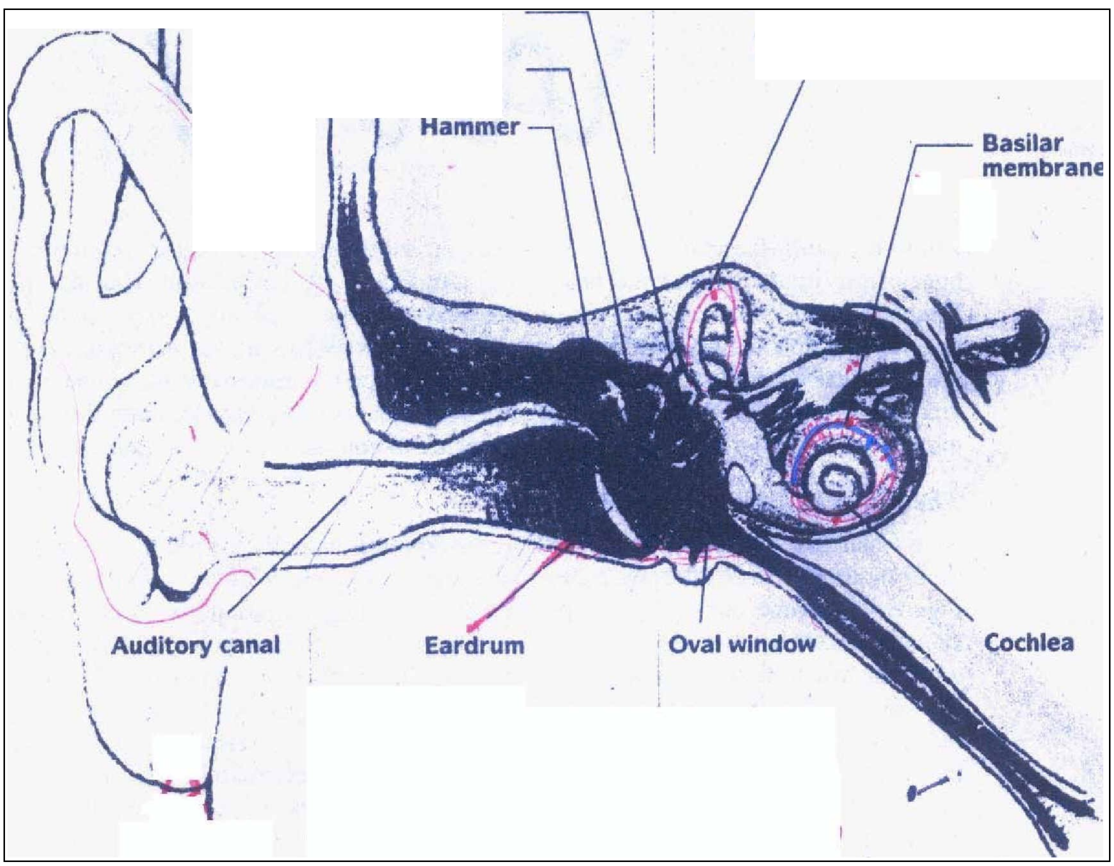
HEARING AND THE OTHER SENSES

A major problem for space travelers is related to a basic sensory process centered in the ear: the sense of motion and balance. This sense allows people to navigate their bodies through the world and maintain an upright position without falling. Along with hearing, the process by which sound waves are translated into understandable and meaningful forms, the senses of motion and balance represent the major functions of the ear.

Sensing Sound

Although many of us think primarily of the *outer ear* when we consider hearing, this part functions simply as a reverse megaphone, designed to collect and bring sounds into the internal portions of the ear (see Figure). However, the location of the outer ears on different sides of the head helps with ***sound localization**,* the process by which we identify the origin of a sound. Wave patterns in the air enter each ear at a slightly different time, permitting the brain to use the discrepancy to locate the place from which the sound is originating. In addition, the two outer ears delay or amplify sounds of particular frequencies to different degrees (Middlebrooks & Green, 1991; Yost, 1992; Konishi, 1993),

Sound is the movement of air molecules brought about by the vibration of an object. Sounds travel through the air in wave patterns similar in shape to those made by a stone thrown into a still pond. Sounds, arriving at the outer ear in the form of wave vibrations, are funneled into the auditory canal*,* a tube like passage that leads to the eardrum. The eardrum is aptly named because it operates like a miniature drum, vibrating when sound waves hit it. The more intense the sound, the more the eardrum vibrates.
(Fig.1-03)

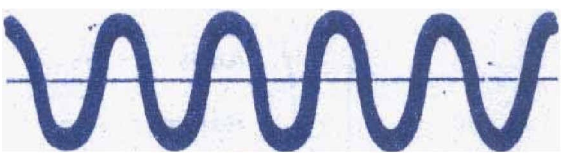


These vibrations are then transmitted into the *middle ear,* a tiny chamber containing just three bones called, because of their shapes, the *hammer,* the *anvil,* and the *stirrup.* These bones have one function i.e. to transmit vibrations to the *oval window,* a thin membrane leading to the inner ear. Because of their shape the hammer, anvil, and stirrup do a particularly effective job. Because they act as a set of levers, they not only transmit vibrations but actually increase their strength. Moreover, since the opening into the middle ear (the eardrum) is considerably larger than the opening out of it (the oval window), the force of sound waves on the oval window becomes amplified. The middle ear, then, acts as a tiny mechanical amplifier, making us aware of sounds that would otherwise go unnoticed.

The *inner ear* is the portion of the ear that changes the sound vibrations into a form that allows them to be transmitted to the brain. It also contains the organs that allow us to locate our position and determine how we are moving through space. When sound enters the inner ear through the oval window, it moves into the cochlea, a coiled tube filled with fluid that look something like a snail. Inside the cochlea is the basilar membrane, a structure that runs through the center of the cochlea, dividing it into an upper and a lower chamber. The basilar membrane is covered with hair cells. When these hair cells are bent by the vibrations entering the cochlea, a neural message is transmitted to the brain.

Low frequency (few peaks and v.alleys per second)

High frequency (numerous peaks and valleys per . second)



(Fig.2-03)

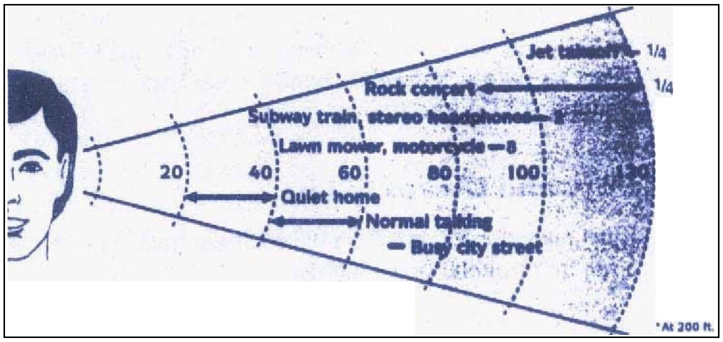
Although sound typically enters the cochlea via the oval window there is an additional method of entry: bone conduction. Because the ear rests on a maze of bones within the skull, the cochlea is able to pick up subtle vibrations that travel across the bones from other parts of the head (Lenhardt et aI., 1991; Carlsson, Hakansson, & ingdahl, 1995), For instance, one of the ways you hear your own voice is through bone conduction. This explains why your sound different to yourself than to other people who hear your voice. (Listen to yourself on a tape recorder sometime to hear what you *really* sound like!) The sound of your voice reaches you both through the air and via bone conduction and therefore sounds richer to you than to everyone else.

The Physical Aspects of Sound

As we mentioned earlier, what we refer to as sound is actually the physical movement of air molecules in regular, wavelike patterns caused by the vibration of an object (see Figure). Sometimes it is even possible to view these vibrations, as in the case of a stereo speaker that has no enclosure. If you have ever seen one, you know that, at least when the lowest notes are playing, you can see the speaker moving in and out. What is less obvious is what happens next: The speaker pushes air molecules into waves with the same pattern as its movement. These wave patterns soon reach your ear, although their strength has been weakened considerably during their travels. All other stimuli that produce sound work in essentially the same fashion, setting off wave patterns that move through the air to the ear. Air or some other medium such as water is necessary to make the vibrations of object reach us. This explains why there can be no sound in a vacuum.

We are able to see the stereo speaker moving when low notes played because of a primary characteristic of sound called frequency. Frequency is the number of wave crests that occur in a second. With very low frequencies there are relatively few, and therefore slower, up and-down wave cycles per second. These are visible to the naked eye as vibrations in the speaker. Low frequencies are translated into a sound that is low in pitch. Pitch is the characteristic that makes sound "high" or" low," For example, the lowest frequency that humans are capable of hearing is 20 cycles per second. Higher frequencies translate into higher pitch. At the upper end of the sound spectrum, people can detect sounds with frequencies as high as 20,000 cycles per second.

While sound frequency allows us to enjoy the sounds of the high notes of a piccolo and the bass notes of a tuba, *intensity* is a feature of wave patterns that allows us to distinguish between loud and soft sounds. **Intensity** refers to the difference between the peaks and valleys of air pressure in a sound wave as it travels through the air, Waves with small peaks and valleys produce soft sounds while those that are relatively large produce loud sounds.
We are sensitive to a broad range of sound intensity. The loudest sounds we are capable of hearing



(Fig.3-03)

are about 10 million times as intense as the very weakest sound we can hear. This range is measured in *decibels,* which can be used to place everyday sounds along a continuum (see Figure3-03). When a sound gets higher than 120 decibels, it become painful to the human ear. Exposure to such high level can eventually result in hearing loss, as the hair cells of the basilar membrane lose their elasticity and bend and flatten, Such a loss of hearing is often permanent, although recent finding have shown that hair' cell have the potential to repair themselves following damage

Sorting Out Theories of Sound

How are our brains able to sort out wavelengths of different frequencies and intensities? One clue comes from studies of the basilar membrane, the area within the cochlea that translates physical vibrations into neural impulses. It turns out that sounds affect different, areas of the basilar membrane, depending on the frequency of the sound wave. The part of the basilar membrane nearest the oval window is most sensitive to high frequency sounds, while the part nearest the cochlea's inner end is most sensitive to low-frequency sounds. This finding has led to the place theory of hearing, which says that different areas of the basilar membrane respond to different frequencies. On the other hand place theory does not tell the full story of hearing, since very low frequency sounds trigger neurons across such a wide area of the basilar membrane that no single site is involved. Consequently, an additional explanation for hearing has been proposed: frequency theory. **The frequency theory of hearing** suggests that the entire basilar membrane acts like a microphone, vibrating as a whole in response to a sound. According to this explanation, the nerve receptors send out signals that are lied directly to the frequency (the number of wave crests per second) of the sounds to which we are exposed, with the number of nerve impulses being a direct function of the sound's frequency. Thus the higher the pitch of a sound (and therefore the greater the frequency of its wave crests), the greater the number of nerve impulses that are transmitted up the auditory nerve to the brain.

According to most contemporary research, both place theory and frequency theory explain at least some of the processes involved in hearing but neither explanation alone provides the full story (Levine & Shefner, 1991; Hartmann, 1993; Luce, 1993; Hirsh & Watson, 1996). Specifically, place theory provides a better explanation for the sensing of high-frequency sounds whereas frequency theory explains what happens when low-frequency sounds are encountered. Medium-frequency sounds appear "to incorporate both processes.

After an auditory message leaves the ear, it is transmitted to the auditory cortex of the brain through a complex series of neural connections, as the message is transmitted; it is communicated through neurons that respond 10 specific types of sounds. Within the auditory cortex itself, there are neurons that respond selectively to very specific sorts of sound features, such as clicks or whistles. Some neurons respond only to a specific pattern of sounds, such as a steady tone but not an intermittent one. Furthermore specific neurons transfer information about a sound's location through their particular pattern of firing (Abissar et aL, 1992; Middlebrooks et al., 1994).

Balance: The Ups and Downs of Life

Several structures of the ear are related more to our sense of balance than hearing (Kelly, 1991). The semicircular canals of the inner ear consist of three tubes containing fluid that sloshes through them when the head moves, signaling rotational or angular1movemehl to the brain. The pull on our bodies caused by the acceleration of forward, backward, or up-and-down motion, as well as the constant pull of gravity, is sensed by the otoliths, tiny, motion-sensitive crystals within the semicircular canals. When we move, these crystals shift like sands on a windy beach. The brain's inexperience in interpreting messages from the weightless otoliths is the cause of the space sickness commonly experienced by two-thirds of all space travelers (Flam, 1991; Werss.1992; Clarke, Teiwes, & Scherer, 1993; Mittelstaedt & Glasauer, 1993; Stem & Koch, 1996.).

Smell and Taste

Smell

While there are few instances in which the sense of smell provides such drama, it is clear that our lives would be considerably less interesting if we could not smell freshly mowed hay sniff a bouquet of flowers, or enjoy the aroma of an apple pie baking. Although many animals have keener abilities to detect odors than we do, since a greater proportion of their brains is devoted to the sense of smell than ours, we are still able to detect more than 10,000, separate smells. We also remember smells, and long forgotten events and memories can be brought back with the mere whiff of an odor associated with the memory.

Results of "sniff tests" have shown that women generally have a better sense of smell than men (Engen, 1987; Ship & Weiffenbach, 1993: Segal et aI., 1995). People also seem to have the ability to distinguish males from females on the basis of smell alone. In one experiment, blindfolded students sniffed a sweating hand held one-half inch from their nose. The findings showed that male and female hands could be distinguished from one another with better than 80 percent accuracy (Wallace, 1977). Similarly, experimental participants, asked to sniff the breath of a male or female volunteer who was hidden from view, were able to distinguish the sex of the donor at better than chance levels (Doty et at., 1982).

Our understanding, of the mechanisms that underlie the sense of smell is just beginning to emerge. We do know that the sense of smell is sparked when the molecules of a substance enter the nasal passages and meet olfactory cells. The receptor cells of the nose, which are spread across the nasal cavity. More, than 1,000 separate types of receptor cells have been identified so far. Each of these cells is so specialized that it responds only to a small band of different, odors. The responses of the separate olfactory cells are then transmitted to the brain, where they are combined into recognition of a particular smell

There's increasing evidence that smell may also act as an involuntary means of communication for humans. It has long been known that animals release pheromones chemicals that produce n reaction in other members of the species permitting them to send such messages as sexual availability. For instance, certain substances in the vaginal secretions of female monkeys contain pheromones that stimulate sexual interest in male monkeys.

Although it seems reasonable that humans might also communicate through the release of pheromones, the evidence is still scanty. Women's vaginal secretions contain chemicals similar to those found in monkeys, but in humans the smells do not seem to be related to sexual activity. On the other hand, the presence of these substances might explain why women who live together for long periods of time tend to show similarity in the timing of their menstrual cycles. In addition, women are able to identify their babies solely on the basis of smel1 just a few hours after birth. Finally, studies of women's reactions to androsterone, a component of male sweat find that most women respond negatively to the smell except at specific times during their monthly menstrual cycles when they are most likely to become pregnant. At those times the smell doesn't seem to bother them. Apparently, androsterone acts as if it were a pheromone, helping to increase the chances that a female ready to conceive is likely to be receptive to sexual activity

Taste

Unlike smell, which employs more than 1,000 separate types of receptor cells, the sense of taste seems to make do with only a handful of fundamental types of receptors. Most researchers believe that there are just four basic receptor cells, which specialize in either sweet, sour, salty, or bitter flavors. Every other taste is simply a combination of these four basic qualities, in the same way that the primary colors blend into a vast variety of shades and hues (Mclaughlin & Margolskee, 1994).

The receptor cells for taste are located in *taste buds,* which are distributed across the tongue. However, the distribution is uneven, and certain areas of the tongue are more sensitive to particular fundamental tastes than others (Bartoshuk, 1971). The tip of the tongue is most sensitive to sweetness. For example, a granule of sugar placed on the rear of the tongue will hardly seem sweet at all. Similarly, only the sides of the tongue are very sensitive to sour tastes, and the rear specializes in bitter tastes.

The different taste areas on the tongue correspond to different locations in the brain. Neurons responding to sour and bitter tastes are located on one end of the area of the cortex corresponding to taste, where as sweet tastes stimulate neurons on the opposite end of the cortex. In contrast, salty tastes stimulate neurons that are distributed across the entire taste area of the brain (Yamamoto, Yuyama, & Kawamura, 1981).

There are significant differences between various individuals' sense of taste, determined largely by genetic factors. Some people, dubbed "super taster," are highly sensitive to taste; they have twice as many taste receptors as "nontasters, ' who are relatively insensitive to taste. Supertasters find sweets sweeter, cream creamier and spicy dishes spicier and weaker concentrations of flavor are enough to satisfy their cravings they may have. On the other hand, because they aren't so sensitive to taste, nontasters may seek out relatively sweeter and finer foods in order to maximize the taste. As a consequence, they may be prone to obesity.

The Skin Senses: Touch, Pressure, Temperature, and Pain

In fact, all our skin senses-touch, pressure, temperature, and pain-plays critical role in survival, making us aware of potential danger to Our bodies. Most of these senses operate through nerve receptor cells located at various depths throughout the skin. These cells are not evenly distributed. When we consider receptors sensitive to touch, for example, some areas, such as the fingertips, have many more cells and as a consequence are notably sensitive. In contrast, areas with fewer cells, such as the middle of the back, are considerably less sensitive to touch

Probably the most extensively researched skin sense is pain, and with good reason: People consult physicians and take medication for pain more than for any other symptom or condition. Some 120 million people in the United States have problems with persistent or recurrent pain, and at any given moment, some 2 million of them are unable to function normally. Back pain, migraine headaches, and arthritis pain alone produce medical bills in the neighborhood of some $40 *billion* each year (Langreth, 1996).

As with our other senses, the perception of pain is a simple matter of a direct response to certain kinds of stimulation. Some kinds of pain, such as that experience in childbirth, are moderated by the joyful nature of the situation. At the same time, even a minor stimulus can produce the perception of strong pain, if it occurs in the context of an anxiety-tinged visit to the dentist. Clearly, then pain is a perceptual response that depends heavily on our emotions and thoughts

Some or' the contradictions involved in our responses to stimulation capable of eliciting pain are explained by gate control theory. **The gate-control theory of pain** suggests that particular nerve receptors lead to specific areas of the brain related to pain. When these receptors are activated because of some injury or problem with a part of the body, a "gate" to the brain is opened, allowing us to experience the sensation of pain.

However, another set of neural receptors is able, when stimulated, to close the "gate" to the brain, thereby reducing the experience of pain. The gate may be shut in two different ways. First, other impulses can overwhelm the nerve pathways relating to pain, which are spread throughout the brain (Talbot et al., 1991; Kakigi, Matsuda, & Kuroda, 1993). In this case, non painful stimuli compete with and sometimes displace the neuronal message of pain, thereby shutting off the painful stimulus. This explains why rubbing the skin around an injury helps reduce pain. The competing stimuli from the rubbing may overwhelm the painful ones. Similarly, scratching is able to relieve itching (which is technically classified as a kind of pain stimulus).

Psychological factors account for the second way in which a gate may be shut (Turk, 1994). Depending on an 'individual's current emotions, interpretation of events, and previous experience, the brain may close a gate by sending a message down the spinal cord to an injured area, producing a reduction in or relief from pain. Thus soldiers who are injured in battle may experience no pain the surprising situation in more than half of all combat injuries. The lack of pain probably occurs because a soldier experiences such relief at still being alive that the brain sends a signal to the injury site to shut down the pain gate.

Thousands of people awaken every day facing chronic pain, a condition that can dramatically alter one's life. While many cases of chronic pain cannot be cured, treatment is available for persons afflicted with pain that can greatly increase their quality of life.

Gate-control theory may also explain cultural differences in the experience of pain. Some of these variations are astounding. For example, in India people who participate in the "hook-swinging" ritual to celebrate the power of the gods, have steel hooks embedded under the skin and muscles of their backs. During the ritual, they swing from a pole, suspended by the hooks. What would seem likely to induce excruciating pain instead produces a state of celebration and near-euphoria. In fact, when the hooks are later removed, the wounds heal quickly, and after two weeks almost no visible marks remain (Kosambi. 1967).
Gate-control theory suggests that the lack of pain is due to a message from the participant's brain which shuts down the pain pathways. Gate-control theory may also explain the effectiveness of **acupuncture***,* an ancient Chinese technique in which sharp needles are inserted into various parts of the body. The sensation from the needles may close the gateway to the brain, reducing the experience of pain. It is also possible that the bodys own painkillers, the endorphins as well as positive and negative emotions may play a role in opening and closing the gate.

LESSON 04

PERCEPTION

Perceptual Organization
Constructing Our View of the World

Consider the vase shown in Figure below for a moment. Is it a vase'! Take another look, and instead you may see the profile of two people.

Now that an alternative interpretation has been pointed out you will probably shift back and forth between the two interpretations. Reason for these reversals is this: Because each figure is two dimensional, the usual means we employ for distinguishing the *figure* (the object being perceived) from the *ground* (the background or spaces within the object) do not work.

The fact that we can look at the same figure in more than one way illustrates an important point. We do not just passively respond to visual stimuli that happen to fall on our retinas. Instead, we actively try to organize and make sense of what we see.

We turn now from a focus on the initial response to a stimulus (sensation) to what our mind make of that, stimulus. Perception is a constructive process by which we go beyond the stimuli that are presented to us and attempt to construct a meaningful situation

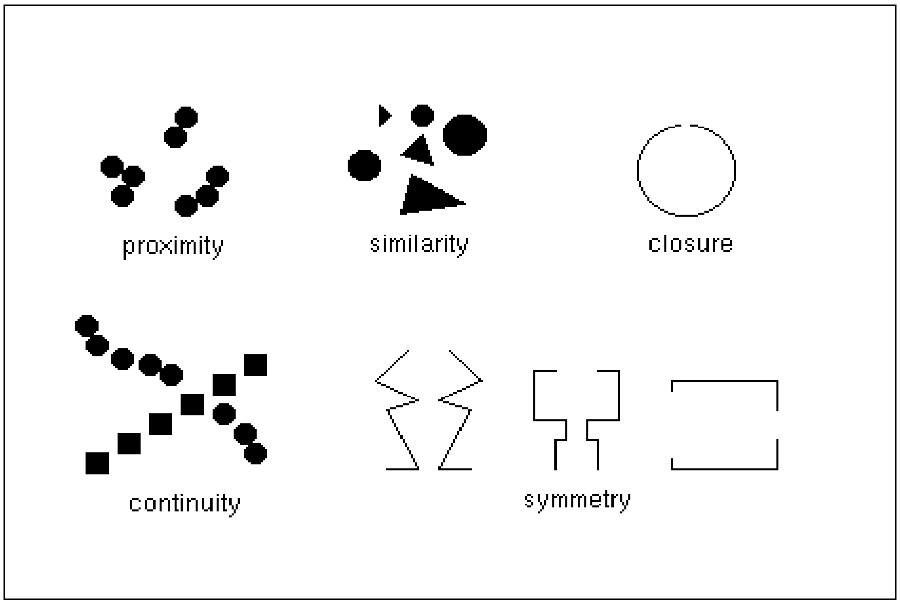
The Gestalt Laws of Organization

Some of the most basic perceptual processes operate according to a series of principles that describe how we organize bits and pieces of information into meaningful wholes. These are known as gestalt laws of organization, set forth in the early 1900s by a group of German psychologists who studied patterns, or *gestalts* ('Wertheimer, 1923). They discovered a number of important principles that are valid for visual (as well as auditory) stimuli:

Gestalt principles of Organization

Most common principles of gestalt theory are;

Proximity



The law of proximity says that items which are close together in space or time tend to be perceived as belonging together or forming an organized group.

Similarity

This law says that same things are considered one thing. Similar items tend to be organized together.

Good continuation

The tendency to perceive a line that starts in one way as continuation in the same way.

Closure

It refers to perceptual processes that organize the perceived world by filling in gaps in stimulation.

Good Form

It is a type of closure. We fill in the gaps perceive form rather than disconnected lines.

Symmetry

It says that there is a tendency to organize things to make a balanced or symmetrical figure that includes all the parts.

Feature Analysis: Focusing on the Parts of the Whole

A more recent approach to perception, feature analysis considers how we perceive a shape, pattern, object, or scene by reacting first to the individual elements that make it up. These individual components are then used to understand the overall nature of what we perceive. Feature analysis begins with the evidence that individual neurons in the brain are sensitive to specific spatial configurations, such as angles, curves, shapes, and edges

The presence of these neurons suggests that any stimulus can be broken down into a series of component features for example, the letter "R" is a combination of a vertical line, a diagonal line, and a half circle

According to feature analysis, when we encounter a stimulus such as a letter our brain's perceptual processing system initially responds to its component parts. Each of these parts is, compared with information about components that is stored in memory. When the specific components we perceive match up with particular components that we have encountered previously, we are able to identify the stimulus (Spilltnanll & Wt.mer, 1990; Uman, 1996).

In short

In this model, Stimuli are thought of as combination of elemental or primitive features.

- The features for alphabets may consist of horizontal lines _
- vertical lines **I**
- Lines at approx 45 degree angle **/**
- And curves **(**

Like alphabet **T** has two line one vertical and other is horizontal line both make alphabet **T.** All letters are consisted on these four patterns. Our mind analyzes letters according to these features.

Example

Many other details are unimportant

So,

A A *A* A A A A A A

All of the above can be recognized as the same letter. Even they are in different shapes and different styles. In the feature model we do not need a template for each letter but only for every feature, this would be a great saving. We have 26 letters small and capital. If letters have many features in common, subjects are prone to confuse them.

By these four features we can store all 26 letters. English model is also applicable in Urdu letters with the addition of Dot (nukta). Urdu writing is much more complex than English. Urdu reading is also difficult as well.

The feature model has a number of advantages over the template models.

First, since the features are simpler, it is easier to see how the system might try to correct for the kinds of difficulties caused by templates model.

A second advantage of the feature combination scheme is that it is possible to specify those relationships among features that are most critical to the pattern.

Top down and bottom up processing

In **top-down** processing, perception is guided by higher-level knowledge, experience, expectations, and motivations. we are able to figure out the meanings of the sentence with the missing letters because of our prior reading experience, and because written English contains redundancies. Not every letter of each word is necessary to decode its meaning. Moreover, your expectations played a role in your' being able to read the sentence. You were probably expecting a statement that had *something* to do with psychology, and not the lyrics to a Grateful Dead song.

Top-down processing cannot occur on its own. Even though top-down processing allows us to fill in the gaps in ambiguous and out-of-context stimuli, we would be unable to perceive, the meaning of such stimuli without bottom-up processing. Bottom-up processing consists of recognizing and processing information about the individual components of the stimuli. We would make no headway in our recognition of the sentence without being able to perceive the individual shapes that make up the letters. Some perception, then, occurs at, the level of the patterns and features of each of the separate letters.

It should be apparent that top-down and bottom-up processing occur simultaneously, and interact with each other, in our perception of the world around us (Kimchi. 1992; Egetll & Yantis, 1997). It is bottom-up processing that permits us to process the fundamental characteristics of stimuli, whereas top-down processing allows us to bring our experience to bear on perception. And as we learn more about the complex processes involved in perception, we are developing a better understanding, of how our brain continually interprets information from our senses and permit us to make responses appropriate to the environment (Rees, Frith, & Lavie. 1997).

Perceptual consistency

Imagine if every time an object changed we had to completely reprocess it. The next time you walk toward a building, you would have to re-evaluate the size of the building with each step, because we all know as we get closer, everything gets bigger. The building which once stood only several inches is now somehow more than 50 feet tall.

Luckily, this doesn't happen. Due to our ability to maintain constancy in our perceptions, we see that building as the same height no matter what distance it is. **Perceptual constancy** refers to our ability to see things differently without having to reinterpret the object's properties. There are typically three constancies discussed, including size, shape, brightness.

Size constancy refers to our ability to see objects as maintaining the same size even when our distance from them makes things appear larger or smaller. This holds true for all of our senses. As we walk away from our radio, the song appears to get softer. We understand, and perceive it as being just as loud as before. The difference being our distance from what we are sensing.

Everybody has seen a plate shaped in the form of a circle. When we see that same plate from an angle, however, it looks more like an ellipse. **Shape constancy** allows us to perceive that plate as still being a circle even though the angle from which we view it appears to distort the shape.

Brightness constancy refers to our ability to recognize that color remains the same regardless of how it looks under different levels of light. That deep blue shirt you wore to the beach suddenly looks black when you walk indoors. Without color constancy, we would be constantly re-interpreting color and would be amazed at the miraculous conversion our clothes undertake.

Depth Perception: Translating 2-D to 3-D

As sophisticated as the retina is the images projected onto it are flat and two-dimensional. Yet the world around us is three dimensional, and we perceive it that way.
How do we make the transformation from 2-D to 3-D?

The ability to view the world in three dimensions and to perceive distance, a skill, known as depth perception, is due largely, to the fact that we havae two eyes. Because there is a certain distance between the eyes, a slightly different image reaches each retina. The brain then integrates these two images into one composite view. But it does not ignore the difference in images, which is known as **binocular disparity** 'This disparity allows the brain to estimate the distance of an object from us.

You can get sense of binocular disparity for yourself. Hold a pencil at arm's length and look at it first with one eye and then with the other. There is little difference between the two views relative to the background. Now bring the pencil just 6' inches away from your face, and try the same thing. This time you will perceive a greater difference between the two views.

The fact that the discrepancy between the images in the two eyes varies according to the distance of objects that we view provides us with a means of determining distance. If we view two objects, and one is considerably closer to us than another, the retinal disparity will be relatively large and we will have a greater sense of depth between the two. On the other hand, if the two objects are at similar' distance from us, the retinal disparity will be' minor, and we wi11 perceive them as being at similar distance from us.

Filmmakers, whose medium compels them to project image in just two dimensions; have Filmmakers,tried to create the illusion of depth perception by using two cameras, spaced slightly apart, to produce slightly different images, each destined for different eye. In a 3-D movie, the two images are, projected simultaneously, this produces a double image, unless special glasses are worn to allow each image to be viewed by, the eye for which it is intended. The special glasses-familiar to moviegoers since the first 3-D movie, *Bawana Devil,* appeared in 1952-provide a genuine sense 'of depth. Similar techniques are being developed to show 3-D movies on television.

In some cases certain cues permit us to obtain the sense of depth and distance with just one eye these cues are known as monocular cues. One monocular cue, motion parallax, is the change in the position of an object on retina as the head moves from side to side. The brain is able to calculate the distance of the object by the amount of change in the retinal image.

Movement perception

It is process through which humans and other animals orient themselves to their own or others' physical movements. Most animals, including humans, move in search of food that itself often moves; they move to avoid predators and to mate. Animals must perceive their own movements to balance themselves and to move effectively; without such perceptual functions the chances for survival would be sharply reduced

Visual cues to movement

The eye is by far the most effective organ for sensing movement. Some animals are especially sensitive to visual stimuli that move in specific ways. For instance, electrical patterns from the eye of a frog show that some elements in the organ respond only when the stimulus is about the size of a fly moving in the insect's range of speed. Generally the eyes of lower animals seem to respond selectively to what is of importance to survival. In these animals the eye's retina does much of the visual processing. This is an economical arrangement since the animal tends to respond only to essential stimuli, the brain having little to do but relay signals to the motor system. It is an inflexible mechanism, however; higher animals process visual information in more elaborate ways, the brain being more heavily involved. Thus, some cells in the visual area of the cat's brain respond only to moving stimuli, sets of movement-detector cells functioning specifically for each direction across the field of view. Features of human visual experience also suggest that movement detectors exist in the human brain.

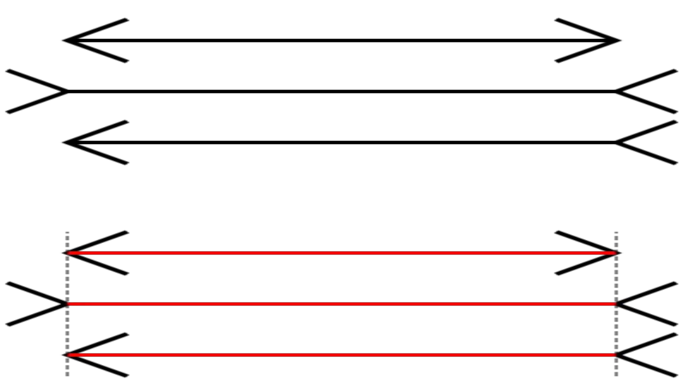
Perceptual Illusions: The Deceptions of Perceptions

Perceptual illusions and ambiguous figures were of special interest to the Gestaltists. Artists have also been fascinated by these perceptual phenomena. Perceptual illusions and ambiguous figures are of special interest in the investigation of thinking because:

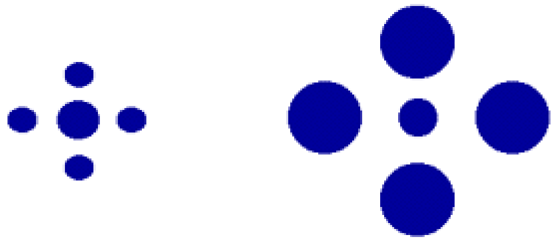
Illusions seem to indicate that our mind does not always accurately represent the perceptual input. For the Gestaltist, this suggested that the mind was "actively" involved in **interpreting** the perceptual input rather than passively recording the input.

Müller-Lyer Illusion

The **Müller-Lyer illusion** is an optical illusion consisting of nothing more than an arrow. When viewers are asked to place a mark on the figure at the mid-point, they invariably place it more towards the "tail" end. Another variation consists of two arrow-like figures, one with both ends pointing in, and the other with both ends pointing out. When asked to judge the lengths of the two lines, which are equal, viewers will typically claim that the line with inward pointing arrows is longer. One possible explanation is that one sees the lines as three-dimensional, such as the outgoing and ingoing corners of a room. Another possible explanation is that the line with arrows pointing inwards may simply appear longer because the arrows themselves extend past the line.



Ebbinghaus Illusion

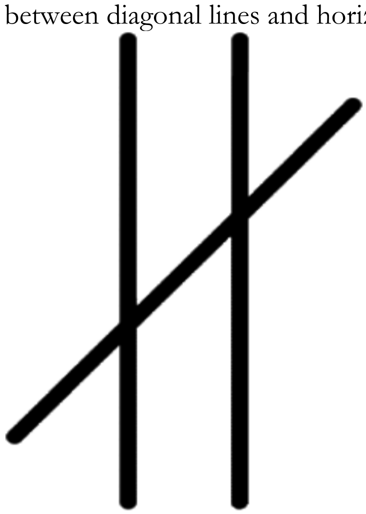


A B

You probably perceive the middle circle as smaller in the figure B than the circle in the center of the figure A. They are actually the same size.

Poggendorff Illusion

This illusion was discovered in 1860 by physicist and scholar JC Poggendorff, editor of Annalen der Physik und Chemie, after receiving a letter from astronomer F. Zöllner. In his letter, Zöllner described an illusion he noticed on a fabric design in which parallel lines intersected by a pattern of short diagonal lines appear to diverge (Zöllner's illusion). Whilst pondering this illusion, Poggendorff noticed and described another illusion resulting from the apparent misalignment of a diagonal line; an illusion which today bears his name. The Poggendorff Illusion is an optical illusion that involves the brain's perception of the interaction between diagonal lines and horizontal and vertical edges.



LESSON 05

PSYCHOPHYSIC

ONE of the oldest problems in psychology is the relation between variations in physical stimulation and reported experience. Historically, this field of investigation has often been tied to such philosophical issues as the mind-body problem and the nature and meaning of "subjective experience:' Today psychologists are content to leave the solution of philosophical problems to the philosopher, but there still remains a large area of research of great theoretical as well as practical importance. What are the lawful relationships between the measurable characteristics of the stimulus, on the one hand, and the reportable attributes of sensory experience, on the other'? It is to this question that the division of experimental psychology known as *psychophysics* addresses itself. Psychophysics is indeed the earliest branch of experimental psychology. The theoretical value of psychophysics lies in the fact that it provides one important experimental approach to the study of the sensory processes and of judgment. As for its practical value, the knowledge gained by the methods of psychophysics has received increasingly wide application in such fields as personnel selection and equipment design.

History

Many of the classical techniques and theory of psychophysics were formulated in 1860 when Gustav Theodor Fechner published *Elemente der Psychophysik*. He coined the term "psychophysics", and described research relating physical stimuli with how they are perceived and set out the philosophical foundations of the field. Fechner wanted to develop a theory that could relate matter to the mind, by describing the relationship between the world and the way it is perceived Fechner's work formed the basis of psychology as a science. Wilhelm Wundt, the founder of the first laboratory for psychological research, built upon Fechner's work.

Psychophysicists usually employ experimental stimuli that can be objectively measured, such as pure tones varying in intensity, or lights varying in luminance. All the senses have been studied: vision, hearing, touch (including skin and enteric perception), taste, smell, and the sense of time. Regardless of the sensory domain, there are three main topics in the psychophysical classification scheme: absolute thresholds, discrimination thresholds, and scaling.

What is Psychophysics?

Psychophysics is concerned with describing how an organism uses its sensory systems to detect events in its environment. This description is functional, because the processes of the sensory systems are of interest, rather than their structure (physiology).

OR

Study of quantitative relations between psychological events and physical events or, more specifically, between sensations and the stimuli that produce them.

Physical science permits, at least for some of the senses, accurate measurement on a physical scale of the magnitude of a stimulus by determining the stimulus magnitude that is just sufficient to produce.

Psychophysics is a sub discipline of psychology dealing with the relationship between physical stimuli and their subjective correlates, or percepts

The Basic Problems of Psychophysics

In studying the relation between the characteristics of the stimulus and the attributes of experience, certain specific experimental questions are asked

Detection of minimal stimuli: What is the minimum of stimulation required for the detection of a stimulus? What kind of stimulus is needed? How intense must it be in order that a subject may reliably distinguish between its presence and absence? Obviously the minimum amount of stimulation required will vary with the conditions of testing. To be barely detectable, a tone has to be less intense in a sound-treated room than in a noisy one, and, similarly, a weaker light is needed in a dark room than in a well lit one. But for each condition of testing and for each subject, such a minimum value of a given stimulus can be estimated.

Detection of minimal stimulus differences: that is the minimal difference, qualitative or quantitative needed between two stimuli so that they can be reliably recognized as different by a subject? For example, how different do two light stimuli have to be in wave length for a detectable difference in hue? How great a difference in intensity of light is required for a discrimination of brilliance? Again, the minimum value of the difference will vary from one testing situation to another and from one subject to another.

Judgment of relation among stimuli: The experimental problems of psychophysics are not limited to the study of stimuli and stimulus differences that are barely detectable. The judgment of stimuli well above the minimum needed for discrimination defines another important area of investigation. Under what conditions, for example, are two stimuli judged to be equal or as standing in a certain relation to one another? What is the extent of order when subjects attempt to equate two stimuli with respect to quality or quantity? How reliably can subjects respond to a stimulus as being half as intense or twice as intense as another stimulus? These are just a few illustrations of the problems which arise in connection with judgment of relations among stimuli

The Basic Concepts of Psychophysics

Sensitivity

The organism is equipped with a number of receptor organs specialized to respond to particular energy changes in the environment. The receptors of the eye are responsive to light within a certain range of wave lengths, the receptors of the ear to sound waves within a certain range of frequencies, and so on. The action of these receptor organs constitutes an important link in the chain of responses which occurs between the application of the stimulus and the subject's response. The capacity of the receptor organs and other reaction systems in the organism to respond selectively and differentially to physical stimulation we designate as *sensitivity*. The laws governing sensitivity are inferred, with the aid of psychophysical procedures, from the variations in response resulting from variations in stimulation. Our experimental measurements allow us to distinguish two types of sensitivity: *absolute* and *differential*.

Absolute sensitivity defines the limits of the organism's capacity to respond to stimulation. It is inversely related to the minimum stimulus which can be detected reliably by a subject. Differential sensitivity defines the organism's capacity to respond to differences, both qualitative and quantitative, between stimuli. It is inversely related to the minimum difference between stimuli needed for reliable discrimination Thresholds. Some stimuli are so weak that they always fail to evoke an effective response in the organism; others are so intense that they never fail to produce a reaction. The line separating these two kinds of stimuli-those never yielding responses and those always yielding responses-can never be sharply drawn; rather, the transition from one to the other is gradual and continuous.
Suppose we wish to measure a subject's absolute sensitivity to sound. We begin with a very weak sound which the subject fails to hear on repeated trials. We then increase the intensity of the sound. At this second level of stimulation the subject may sometimes hear the sound and sometimes fail to hear it. When we increase the intensity even further, the subject may hear the sound more frequently than before but still miss it part of the time. Finally, we may increase the intensity of stimulation to a level at which the subject never fails to report the presence of the sound. Clearly, then, there is no *one* stimulus value which represents the minimum necessary for a response. For purposes of measurement, it is generally agreed to consider as *the absolute threshold* that stimulus value which yields a response 50 percent of the time, i.e. on half the test trials. It is essential to understand that the absolute threshold is not a *fixed* point on the stimulus scale but rather is inherently variable in time. A single value representing the absolute threshold must necessarily be a statistical concept
Similar considerations apply to estimates of a subject's differential sensitivity? The *differential threshold* is defined as that stimulus difference which gives rise to a judgment of *different* 50 percent of the time. *For* example if we present a subject with two tones differing only very little in intensity he will fail to report a difference most of the time. As we increase the intensity difference between the two sounds so as to obtain a judgment of *different* on half the trials this difference defines the differential threshold. There are many variations in the experimental and statistical procedures for the determination of the absolute and differential thresholds, but they an have the same general purpose: to make as good as possible an estimate

of that stimulus value which will yield a given judgment presence vs. absence, same vs. different on half the trials of a series.

Point of Subjective Equality

One fundamental category of relational judgment is *sameness* vs. *difference*. Sometimes stimuli whose physical characteristics are identical may give rise to a judgment of *different,* and stimuli which differ physically may be judged same. Thus, there is no necessary correspondence between physical equality of stimuli and judgments of sameness, nor is there a necessary correspondence between physical differences and judgments of different. For this reason, experiments on discrimination often include an estimate of the *point of subjective equality*. Suppose we present a subject with pairs of stimuli, one member of the pair being fixed and the other member varying from trial to trial, sometimes being equal to the first stimulus, sometimes larger sometimes smaller. The subject is required to make a judgment of *same* or *different* in response to each pair. In such all experiment the point of subjective equality is defined by that comparison stimulus which is most likely to result in a judgment of *same*. Under many experimental conditions the stimuli most likely to be judged *same* are physically equal ones. Sometimes, however, two stimuli which differ by a certain amount are more likely to be judged *same* than physically equal ones,

Thresholds

A threshold (or limen), is the point of intensity at which the participant can just detect the presence of, or difference in, a stimulus. Stimuli with intensities below the threshold are considered not detectable, however stimuli at values close to threshold will often be detectable some proportion of the time. Due to this, a threshold is considered to be the point at which a stimulus, or change in a stimulus, is detected some proportion *p* of the time.

There are two kinds of thresholds: absolute and difference. An absolute threshold is the level of intensity of a stimulus at which the subject is able to detect the presence of the stimulus some proportion of the time (a *p* level of 50% is often used). An example of an absolute threshold is the number of hairs on the back of one's hand that must be touched before it can be felt - a participant may be unable to feel a single hair being touched, but may be able to feel two or three as this exceeds the threshold.

A difference threshold is the magnitude of the *difference* between two stimuli of differing intensities that the participant is able to detect some proportion of the time (again, 50% is often used). To test this threshold, several difference methods are used. The subject may be asked to adjust one stimulus until it is perceived as the same as the other, may be asked to describe the magnitude of the difference between two stimuli, or may be asked to detect a stimulus against a background.

Absolute and difference thresholds are sometimes considered similar because there is always background noise interfering with our ability to detect stimuli, however study of difference thresholds still occurs, for example in pitch discrimination tasks.

Absolute Thresholds

Just when does a stimulus become strong enough to be detected by our sense organs? The answer to this question requires an understanding of the concept of absolute thresholds. An absolute threshold is the smallest intensity of a stimulus that must be present for it to be detected. Consider the following examples of absolute thresholds for the various senses:

Hearing: The licking of a watch can be heard 20 feet away under quiet conditions
Taste: Sugar can be discerned when 1 teaspoon is dissolved in 2 gallons of water.
Smell: Perfume can be detected when one drop is present in a three-room apartment.
Touch: A bee's wing falling from a distance of 1 centimeter can be felt on the cheek

Such thresholds permit our sensory apparatus to detect a wide range of sensory stimulation. In fact, the capabilities of our senses are so fine-tuned that we might have problems if they were any more sensitive. For instance, if our ears were just slightly more acute, we would be able to hear the sound of air molecules in our ears knocking into our eardrum-a phenomenon that would surely prove distracting and might even prevent us from hearing sounds outside our bodies.

Of course, the absolute thresholds we have been discussing are measured under ideal conditions. Normally our senses cannot detect stimulation quite as well because of the presence of noise. *Noise* as defined by psychophysicists, is background stimulation
that interferes with the perception of other stimuli. Hence, noise refers not just to auditory stimuli the most obvious example, but also to stimuli that affect the other senses. Picture a talkative group of people crammed into a small, crowded, smoke~ filled room at a party. The din of the crowd makes it hard to hear individual voices; and the smoke makes it difficult to see, or eyen taste, the food. In this case, the smoke and crowded

Signal detection theory (SDT)

Detection theory, or signal detection theory, is a means to quantify the ability to discern between signal and noise. Much of the early work in detection theory was done by radar researchers. Detection theory was used in 1966 by John A. Swets and David M. Green for Psychophysics. Green and Swets criticized the traditional methods of Psychophysics for their inability to discriminate between the real sensitivity of subjects and their (potential) response biases.
Detection theory has applications in many fields such as diagnostics of any kind, quality control, telecommunications, and psychology. The concept is similar to the signal to noise ratio used in the sciences, and it is also usable in alarm management, where it is important to separate important events from background noise.
According to the theory, there are a number of psychological determiners of how we will detect a signal, and where our threshold levels will be. Experience, expectations, physiological state (e.g. fatigue) and other factors affect thresholds. For instance, a sentry in wartime will likely detect fainter stimuli than the same sentry in peacetime.
Signal detection theory (SDT) is used when psychologists want to measure the way we make decisions under conditions of uncertainty, such as how we would perceive distances in foggy conditions. SDT assumes that the decision maker is not a passive receiver of information, but an active decision-maker who makes difficult perceptual judgments under conditions of uncertainty. In foggy circumstances, we are forced to decide how far an object is away from us based solely upon visual stimulus which is impaired by the fog. Since the brightness of the object, such as a traffic light, is used by the brain to discriminate the distance of an object, and the fog reduces the brightness of objects, we perceive the object to be much further away than it actually is .To apply signal detection theory to a data set where stimuli were either present or absent, and the observer categorized each trial as having the stimulus present or absent, the trials are sorted into one of four categories:

	Respond "Absent"	Respond "Present"
Stimulus Present	Miss	Hit
Stimulus Absent	Correct Rejection	False Alarm

Based on the proportions of these types of trials, numerical estimates of sensitivity can be obtained with statistics like the sensitivity index d' and A', and response bias can be estimated with statistics like β.

Just Noticeable Differences

Suppose you wanted to choose the six best apple from a supermarket display-the biggest, reddest, and sweetest apples. One approach would be to systematically compare one apple with another until you were left with a few so similar that you could not tell the difference between them. At that point it wouldn't matter which ones you chose.
Psychologists have discussed this comparison problem in terms of the difference threshold, the smallest detectable difference between two stimuli, also known as a just noticeable difference. They have found that the stimulus value that constitutes a just noticeable difference depends on the initial intensity of the stimulus for instance, you may have noticed that the light change when you switch a three way bulb from 75 - to 100 watts appears greater than when you switch from IOO to 125 watts, even though the voltage increase is the same in both cases. Similarly, when the moon is visible during the late afternoon, it appears relatively dim-yet against a dark night sky, it seems quite bright.
The relationship between changes in the original value of a stimulus and the degree to which the change will be noticed forms one of the basic laws of psychophysics: Weber's law. Weber's law states that a just noticeable difference is a constant proportion of the intensity of an initial stimulus. Therefore, if a I-pound increase in a l0 pound weight

produces a just noticeable difference, it would take a 10-pound increase to produce a noticeable difference if the initial weight were 100 pounds. In both cases, the same proportional increase is necessary to produce a just noticeable difference-I: 10 = 10:100. (Actually, Weber found the true proportional increase in weight that produces a just noticeable difference to be between 2 and 3 percent.) Similarly, the just noticeable difference distinguishing changes in loudness between sounds is larger for sounds that are initially loud than for sounds that are initially soft. This principle explains why a person in a quiet room is more apt to be startled by the ringing of a telephone than a person in a room that is already noisy. In order to produce the same amount of reaction in a noisy room, a telephone ring might have to approximate the loudness of cathedral bells Weber's law seems to hold up for all sensory stimuli, although its predictions are less accurate at extremely high or extremely low levels of stimulation (Sharpe et al, 1989; MacLeod & Willen, 1995). Moreover, the law helps explain psychological phenomena that lie beyond the realm of the senses. For example, imagine that you own a house you would like to sell for $150,000. You might be satisfied if you received an offer of $145,000 from a potential buyer, even though the offer is $5,000 less than the asking price. On the other hand, if you were selling your car and asking $10,000 for it, an offer of $5,000 less than your asking price would probably not make you happy,. Although the absolute amount of money is the same in both cases, the psychological value of the $5.000 is very different.

Classic Methods of experimentation

Psychophysical experiments have traditionally used three methods for testing subjects' perception in stimulus detection and difference detection experiments: the method of limits, the method of constant stimuli, and the method of adjustment.

Method of limits

Wilhelm Wundt invented the method of limits. The subject reports whether he or she detects the stimulus. In ascending method of limits, some property of the stimulus starts out at a level so low that the stimulus could not be detected, and then this level is gradually increased until the participant reports that they are aware of it. For example, if the experiment is testing the minimum amplitude of sound that can be detected, the sound begins too quietly to be perceived, and is made gradually louder. In the descending method of limits, this is reversed. In each case, the threshold is considered to be the level of the stimulus property at which the stimuli is just detected.

In experiments, the ascending and descending methods are used alternately and the thresholds are averaged. A possible disadvantage of these methods is that the subject may become accustomed to reporting that they perceive a stimulus and may continue reporting the same way even beyond the threshold (the error of habituation). Conversely, the subject may also anticipate that the stimulus is about to become detectable or undetectable and may make a premature judgment (the error of expectation).

To avoid these potential pitfalls, Georg von Bekesy introduced the staircase method in 1960 in his study of auditory perception. In this method, the sound starts out audible and gets quieter after each of the subject's responses, until the subject does not report hearing it. At that point, the sound is made louder at each step, until the subject reports hearing it, at which point it is made quieter in steps again. This way the experimenter is able to "zero in" on the threshold.

Method of constant stimuli

Instead of being presented in ascending or descending order, in the method of constant stimuli the levels of a certain property of the stimulus are not related from one trial to the next, but presented randomly. This prevents the subject from being able to predict the level of the next stimulus, and therefore reduces errors of habituation and expectation. The subject again reports whether he or she is able to detect the stimulus.

Method of adjustment

Also called the method of average error, the method of adjustment asks the subject to control the level of the stimulus, instructs them to alter it until it is just barely detectable against the background noise, or is the same as the level of another stimulus.

LESSON 06

LEARNING

Definition of learning

Learning is a process that depends on experience and leads to long term changes in behavior potential. Behavior potential designates the possible behavior of an individual, not actual behavior. The main assumption behind all learning psychology is that the effects of the environment, conditioning, reinforcement, etc. provide psychologists with the best information from which to understand human behavior.

As opposed to *short term* changes in behavior potential (caused e.g. by fatigue) learning implies *long term* changes. As opposed to long term changes caused by *aging and development*, learning implies changes related directly to *experience*.

What actually happens when an organism learns is not an easy question. Those who are interested in a science of behavior will insist that learning is a change in behavior, but they tend to avoid explicit references to responses or acts as such. "Learning is adjustment, or adaptation to a situation." But of what stuff are adjustments and adaptations made? Are they data, or inferences from data? "Learning is improvement" but improvement in what? And from whose point of view? "Learning is restoration of equilibrium." But what is in equilibrium and how is it put there? "Learning is problem solving." But what are the physical dimensions of a problem or of a solution? Definitions of this sort show an unwillingness to take what appears before the eyes in a learning experiment. An organism meets a criterion of ten successful trials; but an arbitrary criterion is at variance with our conception of the generality of the learning process.

This is where theory steps in. If it is not the time required to get out of a puzzle box that changes in learning, but rather the strength of a bond, or the conductivity of a neural pathway, or the excitatory potential of a habit, then problems seem to vanish. Getting out of a box faster and faster is not learning; it is merely performance. The learning goes on somewhere else, in a different dimensional system. And although the time required depends upon arbitrary conditions, often varies discontinuously, and is subject to reversals of magnitude, we feel sure that the learning process itself is continuous, orderly, and beyond the accidents of measurement. Nothing could better illustrate the use of theory as a refuge from the data.

But we must eventually get back to an observable datum. If learning is the process we suppose it to be, then it must appear so in the situations in which we study it. Even if the basic process belongs to some other dimensional system, our measures must have relevant and comparable properties. But productive experimental situations are hard to find, particularly if we accept certain plausible restrictions. To show an orderly change in the behavior of the *average* rat or ape or child is not enough, since learning is a process in the behavior of the individual. To record the beginning and end of learning or a few discrete steps will not suffice, since a series of cross-sections will not give complete coverage of a continuous process. The dimensions of the change must spring from the behavior itself; they must not be imposed by an external judgment of success or failure or an external criterion of completeness. But when we review the literature with these requirements in mind, we find little justification for the theoretical process in which we take so much comfort.

The energy level or work-output of behavior, for example, does not change in appropriate ways. In the sort of behavior adapted to the Pavlovian experiment (respondent behavior) there may be a progressive increase in the magnitude of response during learning. But we do not shout our responses louder and louder as we learn verbal material, nor does a rat press a lever harder and harder as conditioning proceeds. In operant behavior the energy or magnitude of response changes significantly only when some arbitrary value is differentially reinforced when such a change is what is learned.

The emergence of a right response in competition with wrong responses is another aspect frequently used in the study of learning. The maze and the discrimination box yield results which may be reduced to these terms. But a behavior-ratio of right *vs.* wrong cannot yield a continuously changing measure in a single experiment on a single organism. The point at which one response takes precedence over another cannot give us the whole history of the change in either response. Averaging curves for groups of trials or organisms will not solve this problem.

Increasing attention has recently been given to latency, the relevance of which, like that of energy level, is suggested by the properties of conditioned and unconditioned reflexes. But in operant behavior the relation to a stimulus is different. A measure of latency involves other considerations, as inspection of any case will show. Most operant responses may be emitted in the absence of what is regarded as a relevant stimulus. In such a case the response is likely to appear before the stimulus is presented. It is no solution to escape this embarrassment by locking a lever so that an organism cannot press it until the stimulus is presented, since we can scarcely be content with temporal relations that have been forced into compliance with our expectations. Runway latencies are subject to this objection. In a typical experiment the door of a starting box is opened and the time that elapses before a rat leaves the box is measured. Opening the door is not only a stimulus; it is a change in the situation that makes the response possible for the first time. The time measured is by no means as simple as latency and requires another formulation. A great deal depends upon what the rat is doing at the moment the stimulus is presented. Some experimenters wait until the rat is facing the door, but to do so is to tamper with the measurement being taken. If, on the other hand, the door is opened without reference to what the rat is doing, the first major effect is the conditioning of favorable waiting behavior. The rat eventually stays near and facing the door. The resulting shorter starting-time is not due to a reduction in the latency of a response, but to the conditioning of favorable preliminary behavior.

Habituation and Sensitization

When a ringing bell is presented to a cat, it may evoke a turning of the head toward the sound source. If that same stimulus is repeated over and over again, the probability and magnitude of this orienting response decrease. This phenomenon is called *habituation.* If a mouse now runs in front of the cat and then the bell is rung again, the cat may reorient to the bell. This phenomenon is called *dishabituation.* By recording electrical activity in the first central synapse in the auditory system or using another stimulus that elicits an orienting response of the same size, it can be shown that habituation cannot be explained by either sensory adaptation or muscle fatigue (Thompson and Spencer, 1966).

Habituation has been the subject of a great deal of empirical investigation because practically every organism displays habituation, even those with very primitive nervous systems (Harris, 1943). In reviewing this literature, Thompson and Spencer (1966, pp. 18-19) enumerated nine parametric features of habituation and dishabituation that can be seen in a variety of organisms:

1. Given that a particular stimulus elicits a response, repeated applications of the stimulus result in decreased response (habituation). The decrease is usually a negative exponential function of the number of stimulus presentations.
2. If the stimulus is withheld, the response tends to recover over time (spontaneous recovery).
3. If repeated series of habituation training and spontaneous recovery are given, habituation becomes successively more rapid (this might be called potentiation of habituation).
4. Other things being equal, the more rapid the frequency of stimulation, the more rapid and/or more pronounced is habituation.
5. The weaker the stimulus, the more rapid and/or more pronounced is habituation. Strong stimuli may yield no significant habituation.
6. The effects of habituation training may proceed beyond the zero or asymptotic response level (i.e., additional habituation training given after the response has disappeared or reached asymptote will result in slower recovery).
7. Habituation of response to a given stimulus exhibits stimulus generalization to other stimuli.
8. Presentation of another (usually strong) stimulus results in recovery of the habituated response (dishabituation).
9. Upon repeated applicatio.....

Why Learning Occurs

We may define learning as a change in probability of response but we must also specify the conditions under which it comes about. An effective class-room demonstration of the Law of Effect may be arranged in the following way.

A pigeon, reduced to 80 per cent of its *ad lib* weight, is habituated to a small, semi-circular amphitheatre and is fed there for several days from a food hopper, which the experimenter presents by closing a hand switch. The demonstration consists of establishing a selected response by suitable reinforcement with food. For example, by sighting across the amphitheatre at a scale on the opposite wall, it is possible to present the hopper whenever the top of the pigeon's head rises above a given mark. Higher and higher marks are chosen until, within a few minutes, the pigeon is walking about the cage with its head held as high as possible. In another demonstration the bird is conditioned to strike a marble placed on the floor of the amphitheatre. This may be done in a few minutes by reinforcing successive steps. Food is presented first when the bird is merely moving near the marble, later when it looks down in the direction of the marble, later still when it moves its head toward the marble, and finally when it pecks it. Anyone who has seen such a demonstration knows that the Law of Effect is no theory. It simply specifies a procedure for altering the probability of a chosen response.

But when we try to say *why* reinforcement has this effect, theories arise. Learning is said to take place because the reinforcement is pleasant, satisfying, tension reducing, and so on. The converse process of extinction is explained with comparable theories. If the rate of responding is first raised to a high point by reinforcement and reinforcement then withheld, the response is observed to occur less and less frequently thereafter. One common theory explains this by asserting that a state is built up which suppresses the behavior. This "experimental inhibition" or "reaction inhibition" must be assigned to a different dimensional system, since nothing at the level of behavior corresponds to oppose processes of excitation and inhibition. Rate of responding is simply increased by one operation and decreased by another. Certain effects commonly interpreted as showing release from a suppressing force may be interpreted in other ways. Disinhibition, for example, is not necessarily the uncovering of suppressed strength; it may be a sign of supplementary strength from an extraneous variable. The process of spontaneous recovery, often cited to support the notion of suppression, has an alternative explanation, to be noted in a moment.

Let us evaluate the question of why learning takes place by turning again to some data. Since conditioning is usually too rapid to be easily followed, the process of extinction will provide us with a more useful case. A number of different types of curves have been consistently obtained from rats and pigeons using various schedules of prior reinforcement. By considering some of the relevant conditions we may see what room is left for theoretical processes.

Learning theory

What is learning? Is it a change in behavior or understanding? Is it a process? Here we survey some common models.

I want to talk about learning. But not the lifeless, sterile, futile, quickly forgotten stuff that is crammed in to the mind of the poor helpless individual tied into his seat by ironclad bonds of conformity! I am talking about LEARNING - the insatiable curiosity that drives the adolescent boy to absorb everything he can see or hear or read about gasoline engines in order to improve the efficiency and speed of his 'cruiser'. I am talking about the student who says, "I am discovering, drawing in from the outside, and making that which is drawn in a real part of me." I am talking about any learning in which the experience of the learner progresses along this line: "No, no, that's not what I want"; "Wait! This is closer to what I am interested in, what I need"; "Ah, here it is! Now I'm grasping and comprehending what I need and what I want to know!" Carl Rogers 1983: 18-19

For all the talk of learning amongst educational policymakers and practitioners, there is a surprising lack of attention to what it entails. In Britain and Northern Ireland, for example, theories of learning do not figure strongly in professional education programmes for teachers and those within different arenas of informal education. It is almost as if it is something is

unproblematic and that can be taken for granted. Get the instructional regime right, the message seems to be, and learning (as measured by tests and assessment regimes) will follow. This lack of attention to the nature of learning inevitably leads to an impoverishment of education. It isn't simply that the process is less effective as a result, but what passes for education can actually diminish well-being.
Here we begin by examining learning as a product and as a process. The latter takes us into the arena of competing learning theories - ideas about how learning may happen. We also look at Alan Roger's (2003) helpful discussion of task-conscious or acquisition learning, and learning-conscious or formalized learning.

Learning as a product
Pick up a standard psychology textbook - especially from the 1960s and 1970s and you will probably find learning defined as a change in behavior. In other words, learning is approached as an outcome - the end product of some process. It can be recognized or seen. This approach has the virtue of highlighting a crucial aspect of learning - change. It's apparent clarity may also make some sense when conducting experiments. However, it is rather a blunt instrument. For example:

- Does a person need to perform in order for learning to have happened?
- Are there other factors that may cause behavior to change?
- Can the change involved include the potential for change? (Merriam and Caffarella 1991: 124)

Questions such as these have led to qualification. Some have looked to identifying relatively permanent changes in behavior (or potential for change) as a result of experiences (see behaviorism below). However, not all changes in behavior resulting from experience involve learning. It would seem fair to expect that if we are to say that learning has taken place, experience should have been used in some way. Conditioning may result in a change in behavior, but the change may not involved drawing upon experience to generate new knowledge. Not surprisingly, many theorists have, thus, been less concerned with overt behavior but with changes in the ways in which people 'understand, or experience, or conceptualize the world around them' (Ramsden 1992: 4) (see cognitivism below). The focus for them, is gaining knowledge or ability through the use of experience.
The depth or nature of the changes involved is likely to be different. Some years ago Säljö (1979) carried out a simple, but very useful piece of research. He asked a number of adult students what they understood by learning. Their responses fell into five main categories:

1. Learning as a quantitative increase in knowledge. Learning is acquiring information or 'knowing a lot'.
2. Learning as memorizing. Learning is storing information that can be reproduced.
3. Learning as acquiring facts, skills, and methods that can be retained and used as necessary.
4. Learning as making sense or abstracting meaning. Learning involves relating parts of the subject matter to each other and to the real world.
5. Learning as interpreting and understanding reality in a different way. Learning involves comprehending the world by reinterpreting knowledge. (quoted in Ramsden 1992: 26)

As Paul Ramsden comments, we can see immediately that conceptions 4 and 5 in are qualitatively different from the first three. Conceptions 1 to 3 imply a less complex view of learning. Learning is something external to the learner. It may even be something that just happens or is done to you by teachers (as in conception 1). In a way learning becomes a bit like shopping. People go out and buy knowledge - it becomes their possession. The last two conceptions look to the 'internal' or personal aspect of learning. Learning is seen as something that you do in order to understand the real world.

'Knowing that' and 'knowing how'

A man knowing little or nothing of medical science could not be a good surgeon, but excellence at surgery is not the same thing as knowledge of medical science; not is it a simple product of it. The surgeon must indeed have learned from instruction, or by his own inductions and observations, a great number of truths; but he must also have learned by practice a great number of aptitudes. (Ryle 1949: 48-49)

Learning how or improving ability is not like learning that or acquiring information. Truths can be imparted, procedures can only be inculcated, and while inculcation is a gradual process, imparting is relatively sudden. It makes sense to ask at what moment someone became apprised of a truth, but not to ask at what moment someone acquired a skill. (Ryle 1949: 58)

In some ways the difference here involves what Gilbert Ryle (1949) has termed 'knowing *that*' and 'knowing *how*'. The first two categories mostly involve 'knowing that'. As we move through the third we see that alongside 'knowing that' there is growing emphasis on 'knowing how'. This system of categories is hierarchical - each higher conception implies all the rest beneath it. 'In other words, students who conceive of learning as understanding reality are also able to see it as increasing their knowledge' (Ramsden 1992: 27).

Learning as a process
In the five categories that Säljö identified we can see learning appearing as a process - there is a concern with what happens when the learning takes place. In this way, learning could be thought of as 'a process by which behaviour changes as a result of experience' (Maples and Webster 1980 quoted in Merriam and Caffarella 1991: 124). One of the significant questions that arises is the extent to which people are conscious of what is going on. Are they aware that they are engaged in learning - and what significance does it have if they are? Such questions have appeared in various guises over the years - and have surfaced, for example, in debates around the rather confusing notion of 'informal learning'.
One particularly helpful way of approaching the area has been formulated by Alan Rogers (2003). Drawing especially on the work of those who study the learning of language (for example, Krashen 1982), Rogers sets out two contrasting approaches: task-conscious or acquisition learning and learning-conscious or formalized learning.

Task-conscious or acquisition learning: Acquisition learning is seen as going on all the time. It is 'concrete, immediate and confined to a specific activity; it is not concerned with general principles' (Rogers 2003: 18). Examples include much of the learning involved in parenting or with running a home. Some have referred to this kind of learning as unconscious or implicit. Rogers (2003: 21), however, suggests that it might be better to speak of it as having a consciousness of the task. In other words, whilst the learner may not be conscious of learning, they are usually aware of the specific task in hand.
Learning-conscious or formalized learning: Formalized learning arises from the process of facilitating learning. It is 'educative learning' rather than the accumulation of experience. To this extent there is a consciousness of learning - people are aware that the task they are engaged in entails learning. 'Learning itself is the task. What formalized learning does is to make learning more conscious in order to enhance it' (Rogers 2003: 27). It involves guided episodes of learning.
When approached in this way it becomes clear that these contrasting ways of learning can appear in the same context. Both are present in schools. Both are present in families. It is possible to think of the mix of acquisition and formalized learning as forming a continuum.

At one extreme lie those unintentional and usually accidental learning events which occur continuously as we walk through life. Next comes incidental learning - unconscious learning through acquisition methods which occurs in the course of some other activity... Then there are various activities in which we are somewhat more conscious of learning, experiential activities arising from immediate life-related concerns, though even here the focus is still on the task... Then come more purposeful activities occasions where we set out to learn something in a more systematic way, using whatever comes to hand for that purpose, but often deliberately disregarding engagement with teachers and formal institutions of learning. Further along the continuum lie the self-directed learning projects on which there is so much literature... More formalized and generalized (and consequently less contextualized) forms of learning are the distance and open education programmes, where some elements of acquisition learning are often built into the designed learning programme. Towards the further extreme lie more formalized learning programmes of highly decontextualized learning, using material common to all the learners without paying any regard to their individual preferences, agendas or needs. There are of course no clear boundaries between each of these categories. (Rogers 2003: 41-2)

The focus on process obviously takes us into the realm of learning theories, ideas about how or why change occurs. Here we focus on four different orientations the behaviorist orientation to learning

- The cognitive orientation to learning
- The humanistic orientation to learning
- The social/situational orientation to learning

As with any categorization of this sort the divisions are a bit arbitrary: there could be further additions and sub-divisions to the scheme, and there a various ways in which the orientations overlap and draw upon each other.

The four orientations can be summed up in the following figure:
Four orientations to learning (after Merriam and Caffarella 1991: 138)

Aspect	Behaviourist	Cognitivist	Humanist	Social and situational
Learning theorists	Thorndike, Pavlov, Watson, Guthrie, Hull, Tolman, Skinner	Koffka, Kohler, Lewin, Piaget, Ausubel, Bruner, Gagne	Maslow, Rogers	Bandura, Lave and Wenger, Salomon
View of the learning process	Change in behaviour	Internal mental process (including insight, information processing, memory, perception	A personal act to fulfil potential.	Interaction /observation in social contexts. Movement from the periphery to the centre of a community of practice
Locus of learning	Stimuli in external environment	Internal cognitive structuring	Affective and cognitive needs	Learning is in relationship between people and environment.
Purpose in education	Produce behavioural change in desired direction	Develop capacity and skills to learn better	Become self-actualized, autonomous	Full participation in communities of practice and utilization of resources
Educator's role	Arranges environment to elicit desired response	Structures content of learning activity	Facilitates development of the whole person	Works to establish communities of practice in which conversation and participation can occur.
Manifestations in adult learning	Behavioural objectives Competency -based education Skill development and training	Cognitive development Intelligence, learning and memory as function of age Learning how to learn	Andragogy Self-directed learning	Socialization Social participation Associationalism Conversation

As can seen from the above schematic presentation and the discussion on the linked pages, these approaches involve contrasting ideas as to the purpose and process of learning and education - and the role that educators may take. It is also important to recognize that the theories may apply to different sectors of the acquision-formalized learning continuum outlined above. For example, the work of Lave and Wenger is broadly a form of acquisition learning that can involve some more formal interludes.

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LESSON 07

CLASSICAL CONDITIONING

Classical conditioning, also called associative learning, is based on stimulus-response relationships. A stimulus is an object or situation that elicits a response by one of our sense organs, like how a bright light makes us blink. Associative learning allows us to associate two or more stimuli and change our response to one or more of them as a result of simultaneous experience.
According to classical conditioning, learning occurs when a new stimulus begins to elicit behavior similar to the behavior produced by an old stimulus.

Classical Conditioning was actually discovered accidentally by Ivan Pavlov (1849-1936). Pavlov was a Russian physiologist who discovered this phenomenon while doing research on digestion. His research was aimed at better understanding the digestive patterns in dogs.
During his experiments, he would put meat powder in the mouths of dogs that had tubes inserted into various organs to measure bodily responses. What he discovered was that the dogs began to salivate before the meat powder was presented to them. Then, the dogs began to salivate as soon as the person feeding them would enter the room. He soon began to gain interest in this phenomenon and abandoned his digestion research in favor of his now famous Classical Conditioning study.

Basically, the findings support the idea that we develop responses to certain stimuli that are not naturally occurring. When we touch a hot stove, our reflex pulls our hand back. It does this instinctually, no learning involved. It is merely a survival instinct. But why now do some people, after getting burned, pull their hands back even when the stove is not turned on? Pavlov discovered that we make associations which cause us to generalize our response to one stimulus onto neutral stimuli it is paired with. In other words, hot burner = ouch, stove = burner, therefore, stove = ouch.

Pavlov began pairing a bell sound with the meat powder and found that even when the meat powder was not presented, the dog would eventually begin to salivate after hearing the bell. Since the meat powder naturally results in salivation, these two variables are called the **unconditioned stimulus** (UCS) and the **unconditioned response** (UCR), respectively. The bell and salivation are not naturally occurring; the dog was conditioned to respond to the bell. Therefore, the bell is considered the **conditioned stimulus** (CS), and the salivation to the bell, the **conditioned response** (CR).

Many of our behaviors today are shaped by the pairing of stimuli. Have you ever noticed that certain stimuli, such as the smell of a cologne or perfume, a certain song, a specific day of the year, results in fairly intense emotions? It's not that the smell or the song are the cause of the emotion, but rather what that smell or song has been paired with...perhaps an ex-boyfriend or ex-girlfriend, the death of a loved one, or maybe the day you met you current husband or wife. We make these associations all the time and often don't realize the power that these connections or pairings have on us. But, in fact, we have been classically conditioned.

Ivan Petrovich Pavlov was born in 1849 in Ryazan, Russia, at the beginning of one of the most fertile intellectual eras in Russian history.

In accordance with his father's wishes, he attended the local theological seminary until a growing interest in the natural sciences led him to rebel against his intended career. He went on to obtain a medical degree from the Imperial Medicosurgical Academy in 1879.
He then studied physiology in Germany briefly before being appointed professor of pharmacology at the St. Petersburg Institute of Experimental Medicine in 1890.
He won the Nobel Prize in 1904 for his research on the physiology of digestion. At this time, he began research on conditioned reflexes in dogs, thus becoming the pioneer in classical conditioning. Pavlov spent the rest of his life studying conditioning, which he believed was a useful research method for studying physiology. He engaged in research actively until his death at the age of 87 in 1936.

The Classical Conditioning Procedure

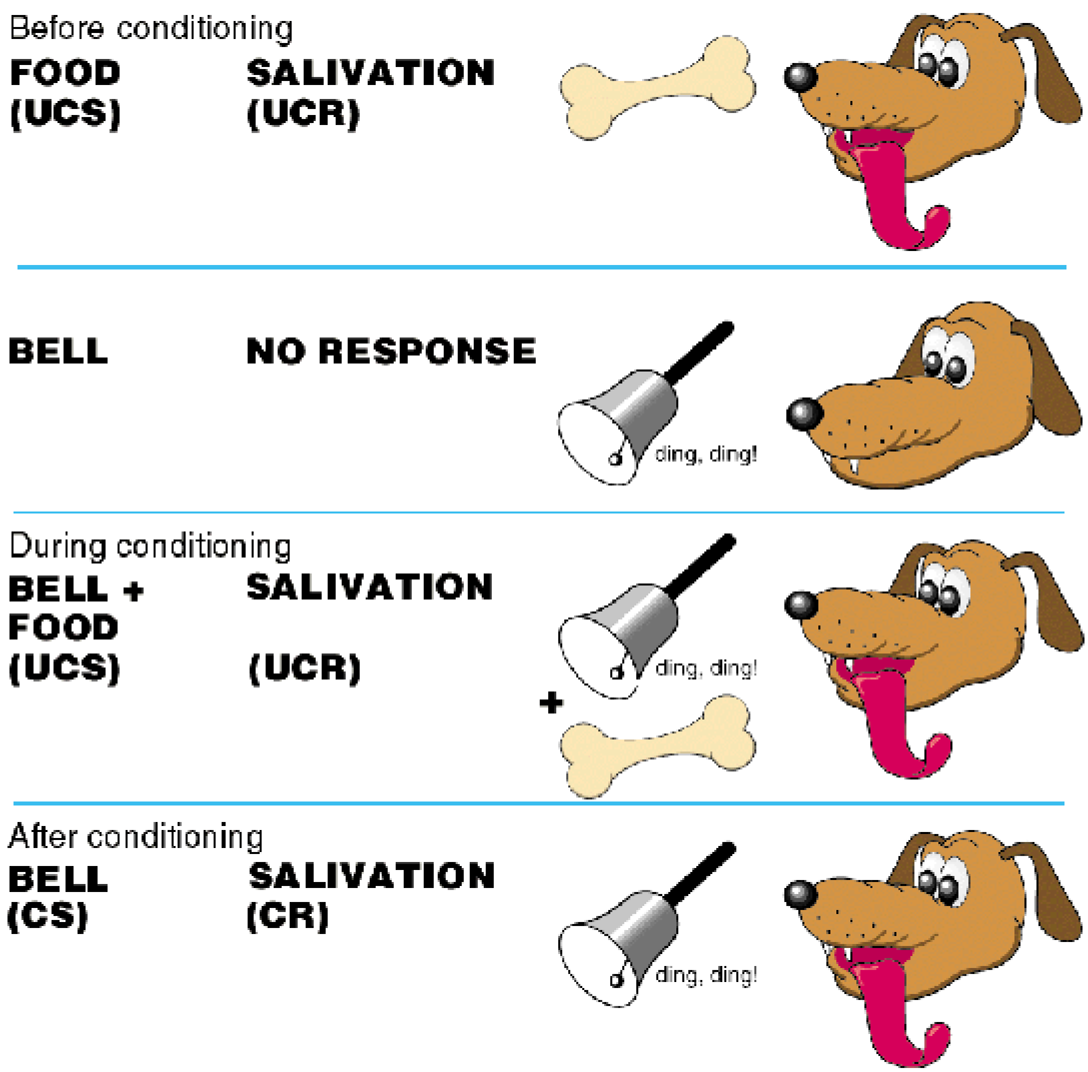
In scientific terms, the procedure for this is as follows:

1 Food is the unconditioned stimulus or UCS. By this, Pavlov meant that the stimulus that elicited the response occurred naturally.

2 The salivation to the food is an unconditioned response (UCR), that is a response which occurs naturally.

3 The bell is the conditioned stimulus (CS) because it will only produce salivation on condition that it is presented with the food.

4 Salivation to the bell alone is the conditioned response (CR), a response to the conditioned stimulus.



Classical conditioning involves learning by association that is associating two events which happen at the same time.

The Conditioned Stimulus

The conditioned stimulus is previously neutral stimulus that, after becoming associated with the unconditioned stimulus, eventually comes to trigger a conditioned response. In our earlier example, suppose that when you smelled your favorite food, you also heard the sound of a whistle. While the whistle is unrelated to the smell of the food, if the sound of the whistle was paired multiple times with the smell, the sound would eventually trigger the conditioned response. In this case, the sound of the whistle is the conditioned stimulus.

The Conditioned Response

The conditioned response is the learned response to the previously neutral stimulus. In our example, the conditioned response would be feeling hungry when you heard the sound of the whistle.
The following are some of the important principles of classical conditioning:

Extinction
If a conditioned stimulus is repeatedly presented without the unconditioned stimulus, then the conditioned response will disappear. This is known as extinction. If a dog learns to associate the sound of a bell with food and then the bell is rung repeatedly, but no food is presented, the dog will soon stop salivating a the sound of the bell.

Stimulus Generalization
A dog who has been conditioned to salivate to the sound of a bell of one tone, may well salivate to a similar sounding bell or a buzzer. Stimulus generalization is the extension of the conditioned response from the original stimulus to similar stimuli.

Discrimination
An animal or person can be taught to discriminate between different stimuli. For example, if a dog is shown a red circle every time he is fed, then he will salivate at the sight of the red circle alone. But initially, the dog may generalise and salivate at circles of any colour. If the dog is only fed when the red circle is presented and not when other colours are shown, he will learn to discriminate between red and the other colours.

Higher Order Conditioning
This is where more than one stimulus is paired and presented; there can be a chain of events that are linked to the same stimulus. It is thought that words may acquire their emotional meaning through higher order conditioning, for example by pairing the words with something that causes emotion, eventually the word alone will have the emotional meaning.

Applications of Classical Conditioning
Classical Conditioning in the Real World
In reality, people do not respond exactly like Pavlov's dogs. There are, however, numerous real-world applications for classical conditioning. Many dog trainers use classical conditioning techniques to help people train their pets.

These techniques are also useful in the treatment of phobias or anxiety problems. Teachers are able to apply classical conditioning in the class by creating a positive classroom environment to help students overcome anxiety or fear. Pairing an anxiety-provoking situation, such as performing in front of a group, with pleasant surroundings helps the student learn new associations. Instead of feeling anxious and tense in these situations, the child will learn to stay relaxed and calm.

The principles of classical conditioning have been used to help improve the human condition. Several examples of therapies involving classical conditioning are provided here.
Mowrer and Mowrer (1938) developed a treatment for enuresis, or bed-wetting. A child with this problem sleeps on a pad into which a wire mesh that is connected to a bell has been sewn. Should the child wet the bed, an electrical circuit is completed causing the bell to ring (US). This in turn awakens the child (UR). After several repetitions of this cycle, in which bed-wetting has caused him to be awakened by the bell, the child begins to associate the sensation of pressure in his bladder (a previously neutral stimulus) with waking up. In a short time, the need to urinate (now a CS) becomes sufficient in itself to awaken the child (now a CR) so he or she can get up and go to the bathroom.

Classical conditioning has been used in predation control. Because they like to eat sheep, coyotes are a problem to sheep farmers. We could kill the coyotes, but this approach would probably not be appropriate. Instead, Gustavson and Gustavson (1985) described a study in which they conditioned some coyotes not to eat the sheep. They took sheep meat (CS) and sprinkled it with a chemical (US) that would produce a stomachache (UR) in the coyotes. After the coyotes ate the treated meat, they avoided the live sheep (CR).

This humane application of conditioned taste aversion might be used to control other predators as well.

Classical conditioning can be used also to help people reduce fears. Counter conditioning involves pairing the stimulus (CS) that elicits fear with a stimulus (US) that elicits positive emotion (UR). For example, a person who is afraid of snakes, but loves strawberry ice cream is shown a snake and then given the ice cream. While the person is busy eating the ice cream, classical conditioning helps associate the snake with good feelings.

Some evidence suggests that classical conditioning may be involved in drug tolerance. After repeatedly taking a drug, it is sometimes necessary to increase the dosage to obtain the same effect. For example, after being given repeated doses of morphine to reduce pain, patients often require larger doses. Siegel and colleagues (1982) argue that cues, such as the needle used to administer the drug, elicit negative feelings that tend to work against the normal effects of the drug. Siegel also suggests that in treating drug addiction, it is necessary to reduce the positive conditioned responses associated with taking the drug. Siegal argued that drug overdose can occur when the drug is taken in a new location that doesn't have all of the associated cues, such as the familiar furniture in a room. Although a lower dose of the drug would have been effective, the individual may take the usual amount, resulting in an overdose.

Classical conditioning appears to be involved both in the formation and elimination of our emotional reactions. You might try to keep a list of the stimuli in your environment that elicit responses from you. Then put to work the principles of classical conditioning to help you understand how you learn the many emotions you experience

In humans, classical conditioning can account for such complex phenomena as a person's emotional reaction to a particular song or perfume based on a past experience with which it is associated. Classical (sometimes called Pavlovian) conditioning is also the basis for many different types of fears or phobias, which can occur through a process called stimulus generalization (a child who has a bad experience with a particular dog may learn to fear all dogs). In addition to causing fears, however, classical conditioning can also help eliminate them through a variety of therapeutic techniques. One is systematic desensitization, in which an anxiety-producing stimulus is deliberately associated with a positive response, usually relaxation produced through such techniques as deep breathing and progressive muscle relaxation. The opposite result (making a desirable stimulus unpleasant) is obtained through **aversion conditioning** therapy, in which a behavior that a person wants to discontinue--often an addiction, such as alcoholism --is paired with an unpleasant stimulus, such as a nausea-producing drug.
Years of learning research have lead to the creation of a highly precise learning theory that can be used to understand and predict how and under what circumstances most any animal will learn, including human beings. Because most behavior is learned according to the principles of instrumental conditioning, learning theory can be used to help people figure out how to change their behaviors.

Behavioral Therapies Based on Classical Conditioning
Classical conditioning is short-term, usually requiring less time with therapists and less effort from patients, unlike humanistic or psychoanalytic therapies. The therapies mentioned in the last paragraph are intended to cause either aversive feelings toward something, or to reduce the aversion altogether. Classical conditioning is based on a repetitive behavior system.
When a behavior that has been strongly reinforced in the past no longer gains a reinforcement, an extinction burst may occur. The animal repeats the behavior over and over again, in a burst of activity, then stops permanently.

Aversion therapy
This is a form of psychological therapy that is designed to eliminate, for example, sexual behavior by associating an aversive stimulus such as nausea with sex. Because the aversive stimulus performs as a US and produces a UR, the association between the stimulus and behavior leads to the same consequences each time. If the treatment has worked, the patient will not have a compulsion to engage in such behaviors again. This sort of treatment has been used to treat alcoholism as well as drug addiction.

Systematic desensitization

Patients might learn that the object of their phobias or fears is not so fearful if they can safely relive the feared stimulus. However, anxiety often obstructs such recovery. This obstruction is overcome by reintroducing the fear-producing object gradually by a process known as reciprocal inhibitions. A person constructs a hierarchy of events leading to the feared situation. This hierarchy is approached step by step and anxiety is relieved at every level. The fear is eventually removed if the therapy is performed correctly.

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LESSON 08

OPERANT CONDITIONING

In late 1890s while Russians physiologist were busy in studying the relationship between stimulus and response an American psychologist named Edward Thorndike was studying the relationship between actions and their consequences. He studied learning in chicks by rewarding them with food for successfully negotiating a maze constructed of books.

At Columbia he conducted research using cat in so-called puzzle boxes which were constructed from wooden shipping crates, In a typical puzzle box study, Thorndike would put a hungry cat in the box and a piece of fish just outside it A sliding latch kept the door to the box closed. The cat could escape by stepping on a pedal that released the latch. At first the cat would perform ineffective actions such as biting the wooden slats or trying to squeeze between them. Eventually the cat would accidentally perform the correct action, thereby releasing the larch, opening the door and gaining access to the fish, Thorndike repeated this for several trials and found that as the trials progressed the cat look less and less time to escape, eventually escaping as soon as it was placed in the box.

The results of his puzzle box studies led Thorndike to develop the law of effect, which states that a behavior followed by' a "satisfying" state of affairs is strengthened and a behavior followed by an "annoying"' State of affairs is weakened. In the puzzle box experiments, behaviors that let the cat reach the fish were strengthened and behaviors that kept the cat in the box were weakened, Because Thorndike studied the process by which behaviors are instrumental ill bringing about certain consequences, the process became known as instrumental conditioning.

Principles of Operant Conditioning

Thorndike's work inspired B. F. Skinner, perhaps the best-known psychologist of the past few decades. Skinner called instrumental conditioning operant conditioning, because animal and people learn to "operate"' on the environment to produce desired consequences instead of just responding reflexively to stimuli. Following in Thorndike's footsteps, Skinner used boxes, now known as Skinner boxes, to study learning in animals, Skinner devoted his career to studying the different kinds of relationships between behaviors and their consequences, which he called behavioral contingencies.

Positive reinforcement

Two centuries ago, while on a fort-building expedition Benjamin Franklin increased the likelihood of attendance at daily prayer meetings by withholding his men's rations of rum until they had prayed (Knapp &. Shodahl.1974). This showed his appreciation of the power of *reinforcement* A *reinforce is* a consequence of a behavior that will increase the likelihood that the behavior will occur again. In positive reinforcement a behavior (for example praying) that is followed by the presentation of a desirable stimulus (for example rum) becomes more likely to occur in the future. Skinner called the desirable stimulus a *positive rein forcer;* you are certainly aware of the effects of positive reinforcement in your own *life.* For example if you find that, studying for exams earns you high grades, you will be more likely to study for exam in future.

A handy approach to determining what will be an effective positive reinforcement is provided by the Prermack principle, named for its discoverer. David Premack (1965). Premack pointed out that a behavior that has higher probability of occurrence will be used as: positive reinforcement for a behavior that has a lower probability. Benjamin Franklin relied on this principle when he used the higher probability behavior of drinking rum to reinforce the lower probability behavior of praying. Parents too use the Premack principle with their children when they make television a positive reinforcement for the completion of homework, keep in mind that, according to the Premack principle something that is reinforcing to one person may not be to anther. Eating jelly might be a positive reinforcement to one person yet repugnant to another.
In **Positive Reinforcement** a particular behavior is strengthened by the consequence of experiencing a positive condition. For example:

A hungry rat presses a bar in its cage and receives food. The food is a positive condition for the hungry rat. The rat presses the bar again, and again receives food. The rat's behavior of pressing the bar is strengthened by the consequence of receiving food.
In **Negative Reinforcement** a particular behavior is strengthened by the consequence of stopping or avoiding a negative condition. For example:
A rat is placed in a cage and immediately receives a mild electrical shock on its feet. The shock is a negative condition for the rat. The rat presses a bar and the shock stops. The rat receives another shock, presses the bar again, and again the shock stops. The rat's behavior of pressing the bar is strengthened by the consequence of stopping the shock.
In **Punishment** a particular behavior is weakened by the consequence of experiencing a negative condition. For example:
A rat presses a bar in its cage and receives a mild electrical shock on its feet. The shock is a negative condition for the rat. The rat presses the bar again and again receives a shock. The rat's behavior of pressing the bar is weakened by the consequence of receiving a shock.
In **Extinction** a particular behavior is weakened by the consequence of not experiencing a positive condition or stopping a negative condition. For example: A rat presses a bar in its cage and nothing happens. Neither a positive nor a negative condition exists for the rat. The rat presses the bar again and again nothing happens. The rat's behavior of pressing the bar is weakened by the consequence of not experiencing anything positive or stopping anything negative.
Classical conditioning forms an association between two stimuli. *Operant* conditioning forms an association between a behavior and a consequence. (It is also called *response-stimulus* or RS conditioning because it forms an association between the animal's response [behavior] and the stimulus that follows [consequence])

Four Possible Consequences
There are four possible consequences to any behavior. They are:
Something Good can start or be presented;
Something Good can end or be taken away;
Something Bad can start or be presented;
Something Bad can end or be taken away.

Consequences have to be immediate, or clearly linked to the behavior. With verbal humans, we can explain the connection between the consequence and the behavior, even if they are separated in time. For example, you might tell a friend that you'll buy dinner for them since they helped you move, or a parent might explain that the child can't go to summer camp because of her bad grades. With very young children, humans who don't have verbal skills, and animals, you can't explain the connection between the consequence and the behavior. For the animal, the consequence has to be immediate.
Technical Terms
The technical term for "an event started" or "an item presented" is *positive*, since it's something that's *added* to the animal's environment.
The technical term for "an event ended" or "an item taken away" is *negative*, since it's something that's *subtracted* from the animal's environment.
Anything that *increases* a behavior - makes it occur more frequently, makes it stronger, or makes it more likely to occur - is termed a *rein forcer*. Often, an animal (or person) will perceive "starting Something Good" or "ending Something Bad" as something worth pursuing and they will repeat the behaviors that seem to cause these consequences. These consequences will increase the behaviors that lead to them, so they are *rein forcers*. These are consequences the animal will work to attain, so they strengthen the behavior.
Anything that *decreases* a behavior - makes it occur less frequently, makes it weaker, or makes it less likely to occur - is termed a *punisher*. Often, an animal (or person) will perceive "ending something Good" or "starting Something Bad" as something worth avoiding, and they will not repeat the behaviors that seem to cause these consequences. These consequences will decrease the behaviors that lead to them, so they are *punishers*.
Applying these terms to the Four Possible Consequences, you get:
Something Good can start or be presented, so behavior increases = Positive Reinforcement (R+)
Something Good can end or be taken away, so behavior decreases = Negative Punishment (P-)

Something Bad can start or be presented, so behavior decreases = Positive Punishment (P+)
Something Bad can end or be taken away, so behavior increases = Negative Reinforcement (R-)
or:

	Reinforcement (behavior increases)	Punishment (behavior decreases)
Positive (something added)	Positive Reinforcement: Something added increases behavior	Positive Punishment Something added decreases behavior
Negative (something removed)	Negative Reinforcement Something removed increases behavior	Negative Punishment Something removed decreases behavior

Remember that these definitions are based on their actual effect on the behavior in question: they must reduce or strengthen the behavior to be considered a consequence and be defined as a punishment or reinforcement. Pleasures meant as rewards but that do not strengthen a behavior are indulgences, not reinforcement; aversive meant as a behavior weakened but which do not weaken a behavior are abuse, not punishment.

Schedules of Reinforcement

A schedule of reinforcement determines how often a behavior is going to result in a reward. There are five kinds: fixed interval, variable interval, fixed ratio, variable ratio, and random.

A fixed interval means that a reward will occur after a fixed amount of time for example, every five minutes. Paychecks work on this schedule - every two weeks I got one.

A variable interval schedule means that reinforcers will be distributed after a varying amount of time. Sometimes it will be five minutes, sometimes three, sometimes seven and sometimes one.

A fixed ratio means that if a behavior is performed X number of times, there will be one reinforcement on the Xth performance. For a fixed ratio of 1:3, every third behavior will be rewarded. This type of ratio tends to lead to lousy performance with some animals and people, since they know that the first two performances will not be rewarded, and the third one will be no matter what. Some assembly-line production systems work on this schedule - the worker gets paid for every 10 widgets she makes. A fixed ratio of 1:1 means that every correct performance of a behavior will be rewarded.

A variable ratio schedule means that reinforcers are distributed based on the average number of correct behaviors. A variable ratio of 1:3 means that *on average*, one out of every three behaviors will be rewarded. It might be the first. It might be the third. It might even be the fourth, as long as it averages out to one in three This is often referred to as a *variable schedule of reinforcement* or VSR (in other words, it's often assumed that when someone writes "VSR" they are referring to a variable *ratio* schedule of reinforcement).

With a random schedule, there is no correlation between the animal's behavior and the consequence. This is how Fate works.

If reinforcement fails to occur after a behavior that has been reinforced in the past, the behavior might extinguish. This process is called *extinction*. A variable ratio schedule of reinforcement makes the behavior less vulnerable to extinction. If you're not expecting to gain a reward every time you accomplish a behavior, you are not likely to stop the first few times your action fails to generate the desired consequence. This is the principle that slot machines are based on. "OK, I didn't win this time, but next time I'm almost *sure* to win!"

When a behavior that has been strongly reinforced in the past no longer gains reinforcement, you might experience what's call extinction *burst*.

In summary, the schedules of consequences are often called schedules of reinforcements because there is only one schedule that is appropriate for administering response cost and punishment: continuous or fixed ratio of one. In fact, certainty of the application of a consequence is the most important aspect of using response cost and punishment. Learners must know, without a doubt, that an undesired or inappropriate target behavior will be followed by removal of a positive/pleasant stimulus or the addition of a negative/aversive stimulus. Using an intermittent schedule when one is attempting to reduce a behavior may actually lead to a strengthening of the behavior, certainly an unwanted end result.

Applications of Operant Conditioning to Education:

Our knowledge about operant conditioning has greatly influenced educational practices. Children at all ages exhibit behavior. Teachers and parents are, by definition, behavior modifiers (if a child is behaviorally the same at the end of the academic year, you will not have done your job as a teacher; children are supposed to learn (i.e., produce relatively permanent change in behavior or behavior potential) as a result of the experiences they have in the school / classroom setting.

Behavioral studies in classroom settings have established principles that help teachers organize and arrange classroom experiences to facilitate both academic and social behavior. Instruction itself has also been the focus of numerous studies, and has resulted in a variety of teaching models for educators at all levels. Programmed instruction is only one such model. Programmed instruction requires that learning be done in small steps, with the learner being an active participant (rather than passive), and that immediate corrective feedback is provided at each step.

Operant conditioning has become a very influential area of psychology, because it has successfully provided practical solutions to many problems in human behavior. Operant principles discovered in the laboratory are now being employed to improve teaching techniques so that even slow or unmotivated students can learn faster and better.

Behavior modification is the application of operant conditioning techniques to modify behavior. It is being used to help people with a wide variety of everyday behavior problems, including obesity, smoking, alcoholism, delinquency, and aggression. For example, people with the eating disorder anorexia nervosa have been helped to gain weight, and animals such as primates have been trained to assist physically disabled individuals by feeding and caring for them. It has been successfully used in child rearing, in school systems, and in mental institutions.

One example of a therapeutic use of behavior modification is the *token economy* method. A classic study was conducted in a mental hospital with psychiatric patients who had difficulty performing expected behaviors (Ayllon & Azrin, 1968). The researchers chose a number of simple grooming behaviors, including face washing, hair combing, teeth brushing, and bed making, and dressing properly. The researchers first recorded baseline, or normally occurring, frequencies of the behaviors. Then they gave the patients a token every time the proper behavior was performed. The tokens could be exchanged for food and personal items at the hospital drugstore. The patients significantly increased the frequency of the desired behaviors when they were reinforced with tokens.

It has even been suggested that the principles of operant conditioning can be used efficiently to control a society. B. F. Skinner, in his 1948 novel, *Walden Two*, presented a utopian society guided by operant conditioning principles. His 1971 book, *Beyond Freedom and Dignity*, caused a controversy by presenting his ideas on how operant conditioning could be utilized in an actual society. Although most people are not willing to accept Skinner's utopian ideal, the principles of operant conditioning are being applied in our everyday lives.

Biological constraints

Behaviorists felt that any behavior could be conditioned in any way--the specific behavior was arbitrary, all that mattered is that it be reinforced properly.

This turned out to be **false**

Animals exhibit what Behaviorists termed **biases** and **misbehaviors**

In their home cages, hamsters wash their face, dig, mark territory, rear, and scrape the walls with their paws

Experimenters rewarded each of these behaviors with food, one at a time

Conditioning occurred for digging, rearing, and scraping -- all behaviors they usually use to get food. However, it did not occur for face washing or marking territory. Thus, hamsters could learn that food-associated activities lead to food, but not the food unassociated activities could lead to food. This showed that operant conditioning is not 'all powerful'--animals bring **expectations** to the Skinner box, and are only receptive to some types of associations!

Cognitive learning

Both classical conditioning and operant conditioning have traditionally been explained by the principle of contiguity __ the mere association of events in time and space. Contiguity has been used to explain the association of Cs and UCS in classical conditioning and the association of behavior and its consequences in operant conditioning. Associationists explanation of learning has been criticized for viewing animal and human learner as passive reactor to external carrots, whips and the stimuli associated with them these critics influenced by the cognitive revolution favor the study of cognitive factor in classical and operant conditioning and as well as study of learning by observation, which has traditionally be ignored by learning researchers.
Cognitive Learning is a term that is often used in the academic arena but more recently it has started to pop up in the business world.
What 'cognition' means is 'to know', gaining knowledge through thought or perception.
Cognitive learning is about enabling people to learn by using their reason, intuition and perception. This technique is often used to change peoples' behavior. But people's behavior is influenced by many factors such as culture, upbringing, education and motivation. Therefore cognitive learning involves understanding how these factors influence behavior and then using this information to develop learning program.
So it is far more subtle than just telling people what you want them to do differently it involves presenting the message in such a way that it allows people to work out the answer themselves. This can be achieved a number of ways
Response consequences – should you reward for demonstrating the right behavior or punish for demonstrating the wrong behavior? Which approach will achieve the required outcomes? In reality there needs to be a combination of both as people will be motivated by different things.
Observation – observation is a very powerful learning tool as it enables us to see whether performing an action is desirable or not without making the mistake ourselves. Also employees will be more likely to demonstrate the right behaviors if they see managers and senior managers doing so.
Symbolism – allows us to create mental pictures and act out scenarios so that we can think through the consequences without actually performing it.
Therefore cognitive awareness involves using cognitive learning techniques which are then used to make informed decisions about how to deal with new or similar situations.
This may sound complicated but in reality its how we learn.
Martin Smith, Managing Director of The Security Company (Int) Ltd has worked within the security industry for more than 30 years. Martin believes raising awareness amongst employees will do far more to improve security than any technical solution can ever hope to achieve.

Latent Learning is a form of learning that is not immediately expressed in an overt response; it occurs without obvious reinforcement to be applied later.
Latent learning is when an organism learns something in its life, but the knowledge is not immediately expressed. It remains dormant, and may not be available to consciousness, until specific events/experiences might need this knowledge to be demonstrated. For instance a child may observe a parent setting the table or tightening a screw, but does not act on this learning for a year; then he finds he knows how to do these things, even though he has never done them before.
In a classical experiment, Tolman and C.H. Honzik (1930), placed three groups of rats in mazes and observed their behavior each day for more than two weeks. The rats in Group 1 always found food at the end of the maze. Group 2 never found food. Group 3 found no food for 10 days, but then received food on the eleventh. The Group 1 rats quickly learned to rush to the end of the maze to find their food. Group 2 rats did not learn to go to the end. Group 3 acted as the Group 2 rats until food was introduced on Day 11. Then they quickly learned to run to the end of the maze and did as well as the Group 1 rats by the next day.

Observational Learning

People and animals don't learn only by conditioning; they also learn by observing others. **Observational learning** is the process of learning to respond in a particular way by watching others, who are called models. Observational learning is also called "vicarious conditioning" because it involves learning by watching others acquire responses through classical or operant conditioning.

Bandura and the Bobo Dolls

The person best known for research on observational learning is psychologist Albert Bandura, who did some landmark experiments showing that children who watched adults behaving aggressively were more likely to behave aggressively themselves. His most famous experiment was the Bobo doll study. Bandura let a group of kindergarteners watch a film of an adult violently attacking an inflatable plastic toy shaped like Bobo the Clown by hitting it, sitting on it, hammering it, and so forth. He then let the children into a room with Bobo dolls. The children precisely imitated the adult's behavior, gleefully attacking Bobo. Their behavior was a type of observational learning.

Observational learning is a powerful means of social learning. It principally occurs through the cognitive processing of information displayed by models. The information can be conveyed verbally, textually, and auditorially, and through actions either by live or symbolic models such as television, movies, and the Internet. Regardless of the medium used to present the modeled activities, the same psychological processes underlie observational learning. These include attention and memory processes directed to establish a conceptual representation of the modeled activity. This representation guides the enactment of observationally learned patterns of conduct. Whether the learned patterns will be performed or not depends on incentive structures and observers' actual and perceived competence to enact the modeled performances. Unlike learning by doing, observational learning does not require enactment of the modeling activities during learning. The complexity of the learning, however, is restricted by the cognitive competence and enactment skills of the learner.

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LESSON 09

MEMORY I

Memory Process: Encoding, Storage and Retrieval

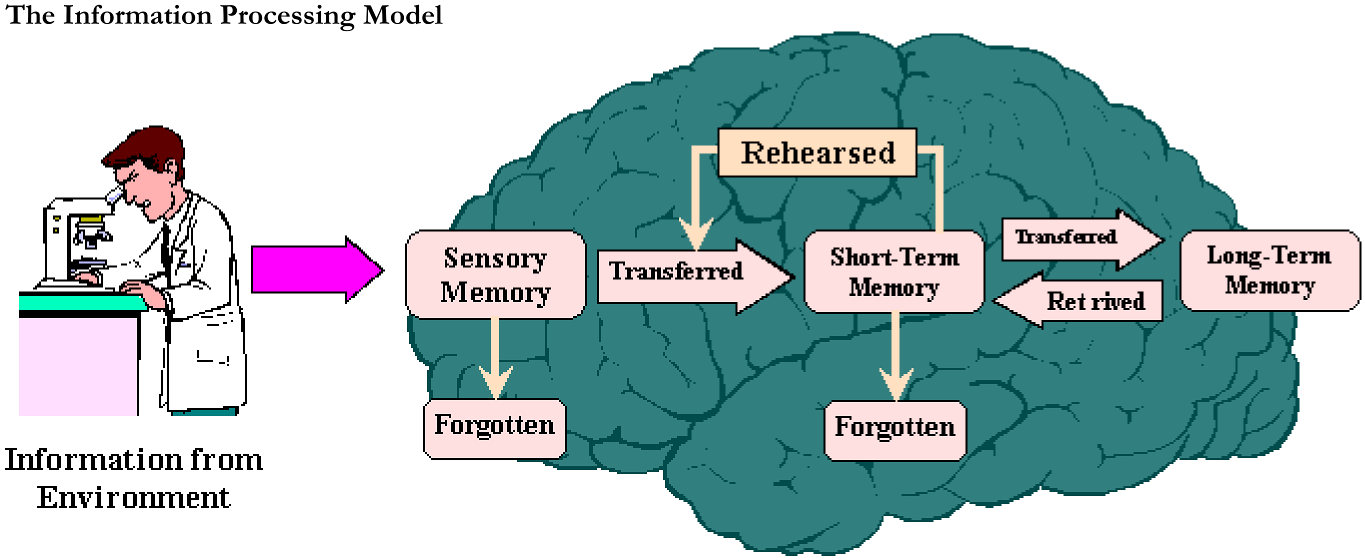
In psychology, **memory** is an organism's mental ability to store, retain and recall information.
Suppose in your entrance test of BS psychology you are asked about the first experimental psychologist. As you track your brain for the answer, several fundamental processes relating to memory come into play. For instance your difficulty in answering the question may be traced to the initial encoding stage of memory. Encoding refer to the process by which information is initially recorded in a form useable to memory. You may never have been exposed to the information related to experimental psychology or if you have expose to it may have simply not registered in a meaningful way.

On the other hand even if you have been expose to the information you may still be unable to recall it because of failure in retention process. Memory specialists speak of the storage the maintenance of the material saved in the memory system. If the material is not stored adequately, it can not be recalled later.

Memory also depends on one last process: retrieval. In retrieval, material in memory storage is located, brought in to awareness and used. Your failure to recall may rest on your inability to retrieve the information that you have learned earlier

In sum, psychologists consider memory as the process by which we encode, store and retrieve information

The Three Systems of Memory: Memory Store Houses
The Information Processing Model



Sensory memory

Sensory memory corresponds approximately to the initial 200 - 500 milliseconds after an item is perceived. The ability to look at an item, and remember what it looked like with just a second of observation, or memorization, is an example of sensory memory. With very short presentations, participants often report that they seem to "see" more than they can actually report. The first experiments exploring this form of sensory memory were conducted by George Sperling (1960) using the "partial report paradigm." Subjects were presented with a grid of 12 letters, arranged into three rows of 4. After a brief presentation, subjects were then played either a high, medium or low tone, cuing them which of the rows to report. Based on these partial report experiments, Sperling was able to show that the capacity of sensory memory was approximately 12 items, but that it degraded very quickly (within a few hundred milliseconds). Because this form of memory degrades so quickly, participants would see the display, but be unable to report all of the items (12 in the "whole report" procedure) before they decayed.

Short term memory
Short-term memory allows one to recall something from several seconds to as long as a minute without rehearsal. Its capacity is also very limited: George A. Miller (1956), when working at Bell Laboratories, conducted experiments showing that the store of short term memory was 7±2 items (the title of his famous paper, "The magical number 7±2"). Modern estimates of the capacity of short-term memory are lower, typically on the order of 4-5 items, and memory capacity can be increased through a process called chunking. For example, if presented with the string:

FBIPHDTWAIBM

People are able to remember only a few items. However, if the same information is presented in the following way:

FBI PHD TWA IBM

People can remember a great deal more letters. This is because they are able to chunk the information into meaningful groups of letters. Beyond finding meaning in the abbreviations above, Herbert Simon showed that the ideal size for chunking letters and numbers, meaningful or not, was three. This may be reflected in some countries in the tendency to remember phone numbers as several chunks of three numbers with the final four-number groups generally broken down into two groups of two.

Working memory is part of short term memory**.** it is a system for temporarily storing and managing the information required to carry out complex cognitive tasks such as learning, reasoning, and comprehension. Working memory is involved in the selection, initiation, and termination of information-processing functions such as encoding, storing, and retrieving data.

One test of working memory is memory span, the number of items, usually words or numbers, that a person can hold onto and recall. In a typical test of memory span, an examiner reads a list of random numbers aloud at about the rate of one number per second. At the end of a sequence, the person being tested is asked to recall the items in order. The average memory span for normal adults is 7 items.

Long term memory
The storage in sensory memory and short-term memory generally has a strictly limited capacity and duration, which means that information, is available for a certain period of time, but is not retained indefinitely. By contrast, long-term memory can store much larger quantities of information for potentially unlimited duration (sometimes a whole life span). For example, given a random seven-digit number, we may remember it for only a few seconds before forgetting, suggesting it was stored in our short-term memory. On the other hand, we can remember telephone numbers for many years through repetition; this information is said to be stored in long-term memory. While short-term memory encodes information acoustically, long-term memory encodes it semantically: Baddeley (1966) discovered that after 20 minutes, test subjects had the least difficulty recalling a collection of words that had similar meanings (e.g. big, large, great, huge).

Short-term memory is supported by transient patterns of neuronal communication, dependent on regions of the frontal lobe and the parietal lobe. Long-term memories, on the other hand, are maintained by more stable and permanent changes in neural connections widely spread throughout the brain. The hippocampus is essential (for learning new information) to the consolidation of information from short-term to long-term memory, although it does not seem to store information itself. Without the hippocampus, new memories are unable to be stored into long-term memory, and there will be a very short attention span. Furthermore, it may be involved in changing neural connections for a period of three months or more after the initial learning. One of the primary functions of sleep is improving consolidation of information, as it can be shown that memory depends on getting sufficient sleep between training and test, and that the hippocampus replays activity from the current day while sleeping.

A major goal of education is to help learners store information in long-term memory and to use that information on later occasions in order to effectively solve problems.

Types of Long Term Memory

There are actually three different types (or aspects or parts) of long-term memory.

Episodic memory refers to our ability to recall personal experiences from our past. When we recount events that happened during our childhood, a ballet we saw last week, or what we ate for breakfast, we are employing our long-term episodic memory. As its name suggests, this aspect of memory organizes information around episodes in our lives. When we try to recall the information, we attempt to reconstruct these episodes by picturing the events in our minds. Episodic memory enables us to recall not only events, but also information related to those events. For example, a baseball coach faced with an unusual situation requiring a rule interpretation might think like this:

"I remember a similar situation in a professional baseball game... When was it...? Last year... Reds vs. Giants... It was a night game, and the Giants had runners on first and second, when a line drive bounced and hit the umpire... What was the call...? I think they gave the batter a single and let the runners advance one base.... But I thought when the ball hit the umpire it remained in play.... Now I remember! If the umpire is in front of the fielders, it's a dead ball and a single. If the umpire would have been behind the fielder, it would have remained in play...." Apparently, recalling memorable episodes enables us to retrieve details that would otherwise be forgotten.

Semantic memory stores facts and generalized information. It contains verbal information, concepts, rules, principles, and problem-solving skills. While episodic memory stores information as images, semantic memory stores information in networks or schemata. Information is most easily stored in semantic memory when it is *meaningful* - that is, easily related to existing, well-established schemata. When we retrieve information from schematic memory, we mentally follow paths like those shown in Figure 6.1. By using information on numerous occasions after it has been initially learned, we solidify the connections among elements of information, make it easier to retrieve when we need to use it, and make it more likely that this information will be available to help us accept and store additional information in the future.

Procedural memory refers to the ability to remember how to perform a task or to employ a strategy. The steps in various procedures are apparently stored in a series of steps, or stimulus-response pairings. When we retrieve information from procedural memory, we retrieve one step, which triggers the next, which triggers the next, etc.

These various parts of long-term memory do not operate in isolation from one another. While it is not clear *how* they work together, it is clear that they are related and overlap. For example, a teacher who is asked to write a letter of recommendation for a former student might wish to retrieve information about the ability of that student compared to other students. To do this, she might first use episodic memory to form an image of that student as a real person performing real activities in her class several years ago, and this image might help her recall specific details of class performance and term papers written by that student. Likewise, a college student writing a paper in a history course on mercantilism might first listen to or read a semantic presentation on the topic, perform an episodic memory search to recall instances in his own life when he himself experienced what the teacher was talking about, recall the semantic definitions of related terms from another course, and continue this process until he felt he could understand and integrate the new information.

There are two major problems related to the use of long-term memory: (1) to transfer the information accurately to long-term memory and (2) to retrieve the information accurately. The primary strategy for transferring information from working memory into long-term memory is referred to as *encoding* or *elaboration*. These terms refer to the process of relating information to other information that is already stored in long-term memory. Piaget and other constructivists have developed detailed theories regarding how information is stored in long-term memory, and some aspects of these schemata theories are described in Chapter 4 of this book. That information should be considered directly compatible with the information presented in this chapter

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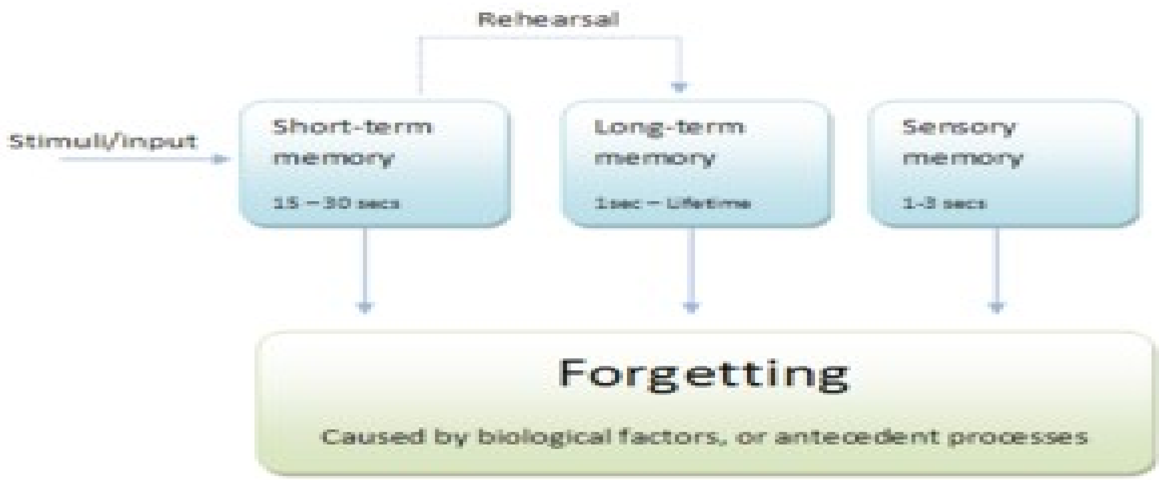
LESSON 10

MEMORY II

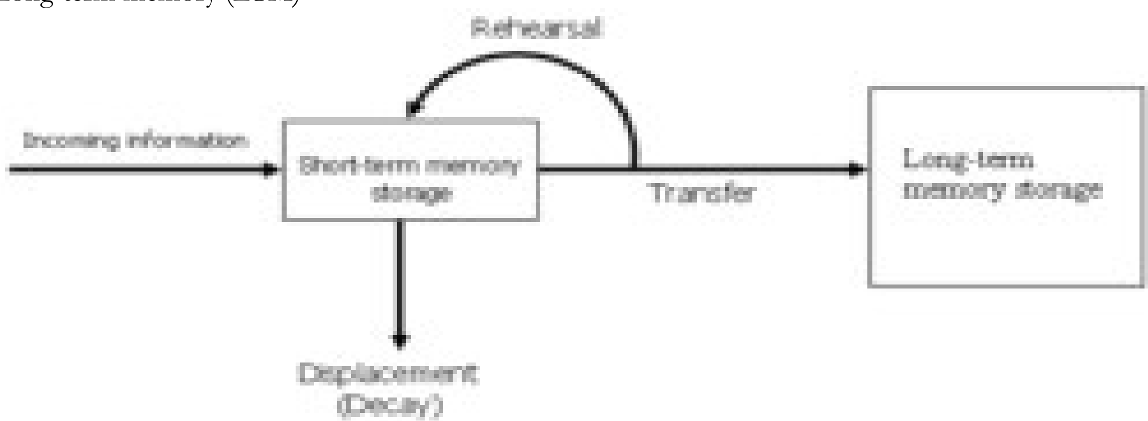
Atkinson-Shiffrin memory model



Note that in this diagram, sensory memory is detached from either form of memory, and represents its devolvement from short term and long term memory, due to its storage being used primarily on a "run time" basis for physical or psychosomatic reference.

The **Atkinson-Shiffrin model**, **Multi-store model** or **Multi-memory model** is a psychological model proposed in 1968 as a proposal for the structure of memory. It proposed that human memory involves a sequence of three stages:

Sensory memory (SM)
Short-term memory (STM)
Long-term memory (LTM)



The original 2-stage model of the Atkinson-Shiffrin memory model; lacking the "sensory memory" stage, which was devised at a later stage in research

The multi-store model of memory is an explanation of how memory processes work. You hear and see and feel many things, but only a small number are remembered. The model was first described by Atkinson and Shiffrin in 1968.

Sensory memory

The sense organs have a limited ability to store information about the world in a fairly unprocessed way for less than a second. The visual system possesses iconic memory for visual stimuli such as shape, size, colour and location (but not meaning), whereas the hearing system has echoic memory for auditory stimuli. Coltheart et al (1974) have argued that the momentary freezing of visual input allows us to select which aspects of the input should go on for further memory processing. The existence of sensory memory has been experimentally demonstrated by Sperling (1960) using a tachistoscope.

Short-term memory

Information is selected by attention from sensory memory, may pass into short term memory (STM). This allows us to retain information long enough to use it, e.g. looking up a telephone number and remembering it long enough to dial it. Peterson and Peterson (1959) have demonstrated that STM last approximately between 15 and 30 seconds, unless people rehearse the material, while Miller (1956) has found that STM has a limited capacity of around 7+/-2 'chunks' of information. STM also appears to mostly encode memory acoustically (in terms of sound) as Conrad (1964) has demonstrated, but can also retain visuospatial images.

Long-term memory

LTM provides the lasting retention of information and skills, from minutes to a lifetime. Long term memory appears to have an almost limitless capacity to retain information, but it could never be measured as it would take too long. LT information seems to be encoded mainly in terms of meaning (semantic memory) as Baddeley has shown, but also retains procedural skills and imagery.
Memory may also be transported directly from sensory memory to LTM if it receives instant attention. Such as the witnessing of a fire in one's home.

Criticisms

Some may argue that the Multi-Store model is much too linear, and does not accommodate for the subdivisions of STM and LTM memory stores -- particularly, its structure does not parallel well within the neurological explanations of where and how memory is stored; the model suggesting that memory would be purposely disregarded by physiological processes and stored in a linear memory sequence --

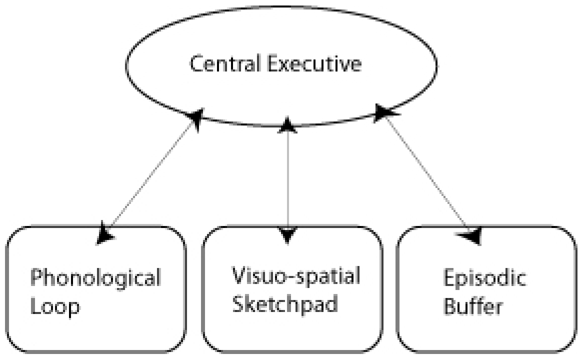
While the model deals with the several forms of memory in its model, it does not take into account the way in which the information is presented, nor does it take into account biological, or internal factors which may interfere with an individual's ability to respond or understand the experiment - including an individual's cognitive ability, or previous experience with learning techniques.

Though there are studies to suggest that some people, such as Clive Wearing have limited memory capacity, it is not enough evidence in itself to suggest that the brain has 3 separate memory stores within its structure. The reasoning is that whilst these cases can be somewhat explained by the multi-store model, other cases such as those of autistic savants, completely disband the theory of repetition and rehearsal within the multi store model, due to their ability to be able to recall precise figures with clarity and lucidity without the need for rehearsal; showing no process of decay, nor any other factors mentioned in the original model.
Had the model included internal factors which influenced each stage of the memory process, it would have been somewhat more credible in explaining such phenomena.

Later Developments

This model provided an important framework for learning and memory theories to evolve from, but a number of problems with it have been cited since. Since each element in the model builds off the one preceding, it cannot explain the rare situations where short-term memory is impaired, but long-term memory is not. According to this model, information that can't make it through short-term memory has no way to become encoded in long-term memory.
Atkinson and Shiffrin also refrain from proposing any mechanisms or processes that might be responsible for encoding memories and transferring them between the three systems. The model is a hypothetical layout of the function of memory systems, but not in any way representative of a physical "map" of memory systems.
Many newer models have been created that can better account for these other characteristics, and a tremendous body of research on the physical layout of memory systems has emerged. As the oldest and simplest model, this is can no longer be considered entirely accurate or comprehensive.
The rehearsal loop also must be included in the transfer of memory into LTM from the STM, it is said that for things to be transferred correctly they must negate the rehearsal loop to ensure full remembrance.

Baddeley's model of working memory



Schematic of Baddeley's Model

Alan Baddeley and Graham Hitch proposed a **Model of Working Memory** in 1974, in an attempt to describe a more accurate model of short-term memory.
Baddeley & Hitch proposed their working memory model as an alternative to the short-term store in Atkinson & Shiffrin's 'multi-store' memory model (1968). This model is later expanded upon by Baddeley and other co-workers and has become the dominant view in the field of working memory. However, alternative models are developing providing a different perspective on the working memory system.
The original model of Baddeley & Hitch was composed of three main components; the *central executive* which acts as supervisory system and controls the flow of information from and to its *slave systems*: the *phonological loop* and the *visuo-spatial sketchpad*. The slave systems are short-term storage systems dedicated to a content domain (verbal and visuo-spatial, respectively). In 2000 Baddeley added a third slave system to his model; the *episodic buffer*.

Baddeley & Hitch's argument for the distinction of two domain-specific slave systems in the older model was derived from experimental findings with dual-task paradigms. Performance of two simultaneous tasks requiring the use of two separate perceptual domains (i.e. a visual and a verbal task) is nearly as efficient as performance of the tasks individually. In contrast, when a person tries to carry out two tasks simultaneously that use the same perceptual domain, performance is less efficient than when performing the tasks individually.

Components

Central executive

The central executive is a flexible system responsible for the control and regulation of cognitive processes. It has the following functions:

- binding information from a number of sources into coherent episodes
- coordination of the slave systems
- shifting between tasks or retrieval strategies
- selective attention and inhibition

It can be thought of as a supervisory system that controls cognitive processes and intervenes when they go astray.

Using the dual-task paradigm, Baddeley and colleagues have found, for instance, that patients with Alzheimer's dementia are impaired when performing multiple tasks simultaneously, even when the difficulty of the individual tasks is adapted to their abilities.
Recent research on executive functions suggests that the 'central' executive is not as central as conceived in the Baddeley & Hitch model. Rather, there seem to be separate executive functions that can vary largely independently between individuals and can be selectively impaired or spared by brain damage.[2]

Phonological loop

The phonological loop (or "articulatory loop") as a whole deals with sound or phonological information. It consists of two parts: a short-term *phonological store* with auditory memory traces that are subject to rapid decay and an *articulatory rehearsal component* that can revive the memory traces.

Any auditory verbal information is assumed to enter automatically into the phonological store. Visually presented language can be transformed into phonological code by silent articulation and thereby be encoded into the phonological store. This transformation is facilitated by the articulatory control process. The phonological store acts as an 'inner ear', remembering speech sounds in their temporal order, whilst the articulatory process acts as an 'inner voice' and repeats the series of words (or other speech elements) on a loop to prevent them from decay. The phonological loop may play a key role in the acquisition of vocabulary, particularly in the early childhood years. It may also be vital for learning a second language.

Five main findings provide evidence for the phonological loop:

The effect of phonological similarity

Lists of words that sound similar are more difficult to remember than words that sound different. Semantic similarity (similarity of meaning) has comparatively little effect, supporting the assumption that verbal information is coded largely phonologically in working memory.

The word length effect

Lists of short words are remembered better than lists of long words. This may be because short words can be articulated faster, so that more words can be silently articulated before they decay. The model assumes that the phonological loop can maintain lists of words (or other verbal material) as long as their articulation duration does not exceed two seconds.

The effect of articulatory suppression

Memory for verbal material is impaired when people are asked to say something irrelevant aloud. This is assumed to block the articulatory rehearsal process, thereby leaving memory traces in the phonological loop to decay.

Transfer of information between codes

With visually presented items, adults usually name and sub vocally rehearse them, so the information is transferred from a visual to an auditory code. Articulatory suppression prevents this transfer, and in that case the above mentioned effect of phonological similarity is erased for visually presented items.

Neuropsychological evidence

A defective phonological store explains the behavior of patients with a specific deficit in phonological short term memory. Aphasic patients with dyspraxia are unable to set up the speech motor codes necessary for articulation, caused by a deficiency of the articulatory rehearsal process.

On the other hand, patients with dysarthria, whose speech problems are secondary, show a normal capacity for rehearsal. This suggests that it is the subvocal rehearsing that is crucial.[

Visuospatial sketchpad

The visuospatial sketchpad is assumed to hold information about what we see. It is used in the temporary storage and manipulation of spatial and visual information, such as remembering shapes and colors, or the location or speed of objects in space. It is also involved in tasks which involve planning of spatial movements, like planning one's way through a complex building. The visuospatial sketchpad can be divided into separate visual, spatial and possibly kinaesthetic (movement) components. It is principally represented within the right hemisphere of the brain.

Logie has proposed that the visuo-spatial sketchpad can be further subdivided into two components:

The visual cache, which stores information about form and color.

The inner scribe, which deals with spatial and movement information. It also rehearses information in the visual cache and transfers information to the central executive.

Three main findings provide evidence for the distinction between visual and spatial parts of the visuospatial sketchpad.

There is less interference between visual and spatial tasks than between two visual tasks or two spatial tasks.

Brain damage can influence one of the components without influencing the other one.

Results from brain-imaging show that working memory tasks with visual objects activate mostly areas in the left hemisphere, whereas tasks with spatial information activate more areas in the right hemisphere.

Episodic buffer

In 2000 Baddeley added a fourth component to the model, called the 'episodic buffer'. This component is a third slave system, dedicated to linking information across domains to form integrated units of visual, spatial, and verbal information with time sequencing (or chronological ordering), such as the memory of a story or a movie scene. The episodic buffer is also assumed to have links to long-term memory and semantical meaning.

The main motivation for introducing this component was the observation that some (in particular, highly intelligent) patients with amnesia, who presumably have no ability to encode new information in long-term memory, nevertheless have good short-term recall of stories, recalling much more information than could be held in the phonological loop.

Validity of the model

The strength of Baddeley's model is its ability to integrate a large amount of findings on short-term and working memory. Additionally, the mechanisms of the slave systems, especially the phonological loop, has inspired a wealth of research in experimental psychology, neuropsychology, and cognitive neuroscience. However, criticisms have been raised, for instance of the phonological-loop component, because some details of the findings are not easily explained by the original Baddeley & Hitch model.

The episodic buffer is seen as a helpful addition to the model of working memory, but it has not been investigated extensively and its functions remain unclear.[18

Memory Retrieval

Encoding and storage are necessary to acquire and retain information. But the crucial process in remembering is retrieval, without which we could not access our memories. Unless we retrieve an experience, we do not really remember it. In the broadest sense, retrieval refers to the use of stored information.

For many years, psychologists considered memory retrieval to be the deliberate recollection of facts or past experiences. However, in the early 1980s psychologists began to realize that people can be influenced by past experiences without any awareness that they are remembering. For example, a series of experiments showed that brain-damaged amnesic patients—who lose certain types of memory function—were influenced by previously viewed information even though they had no conscious memory of having seen the information before. Based on these and other findings, psychologists now distinguish two main classes of retrieval processes: explicit memory and implicit memory.

Explicit Memory

Explicit memory refers to the deliberate, conscious recollection of facts and past experiences. If someone asked you to recall everything you did yesterday, this task would require explicit memory processes. There are two basic types of explicit memory tests: recall tests and recognition tests.

In *recall* tests, people are asked to retrieve memories without the benefit of any hints or cues. A request to remember everything that happened to you yesterday or to recollect all the words in a list you just heard would be an example of a recall test. Suppose you were briefly shown a series of words: *cow, prize, road, gem, hobby, string, weather*. A recall test would require you to write down or say as many of the words as you could. If you were instructed to recall the words in any order, the test would be one of *free recall*. If you were directed to recall the words in the order they were presented, the test would one of *serial recall* or *ordered recall*. Another type of test is *cued recall,* in which people are given cues or prompts designed to aid recall. Using the above list as an example, a cued recall test might ask, "What word on the list was related to *car*?"

In school, tests that require an essay or fill-in-the-blank response are examples of recall tests. All recall tests require people to explicitly retrieve events from memory.

Recognition tests require people to examine a list of items and identify those they have seen before, or to determine whether they have seen a single item before. Multiple-choice and true-false exams are types of recognition tests. For example, a recognition test on the list of words above might ask, "Which of the following words appeared on the list? (a) *plant* (b) *driver* (c) *string* (d) *radio*." People can often recognize items that they cannot recall. You have probably had the experience of not being able to answer a question but then recognizing an answer as correct when someone else supplies it. Likewise, adults shown yearbook pictures of their high-school classmates often have difficulty recalling the classmates' names, but they can easily pick the classmates' names out of a list.
In some cases, recall can be better than recognition. For example, if asked, "Do you know a famous person named Cooper?" you might answer "no." However, given the cue "James Fenimore," you might recall American writer James Fenimore Cooper, even though you did not recognize the surname by itself.

Implicit Memory
Implicit memory refers to using stored information without trying to retrieve it. People often retain and use prior experiences without realizing it. For example, suppose that the word *serendipity* is not part of your normal working vocabulary, and one day you hear the word used in a conversation. A day later you find yourself using the word in conversation and wonder why. The earlier exposure to the word primed you to retrieve it automatically in the right situation without intending to do so.
Another example of implicit memory in everyday life is unintentional plagiarism. That is, people can copy the ideas of others without being aware they are doing so. The most famous case involved British singer-songwriter George Harrison, formerly of the Beatles. Harrison was sued because his 1970 hit song "My Sweet Lord" sounded strikingly similar to "He's So Fine," a 1963 hit by The Chiffons. Harrison denied that he had intentionally copied the earlier song but admitted that he had heard it before writing "My Sweet Lord." In 1976 a judge ruled against Harrison, concluding that the singer had been unconsciously influenced by his memory.

Psychologists use the term *priming* to describe the relatively automatic change in performance resulting from prior exposure to information. Priming occurs even when people do not consciously remember being exposed to the information. One way to look for evidence of implicit memory, therefore, is to measure priming effects. In typical implicit memory experiments, subjects study a long list of words, such as *assassin* and *boyhood*. Later, subjects are presented with a series of word fragments (such as *a_ _a_ _in* and *b_ _ho_d*) or word "stems" (*as______* or *bo_____*) and are instructed to complete the fragment or stem with the first word that comes to mind. The subjects are not explicitly asked to recall the list words. Nevertheless, the previous presentation of *assassin* and *boyhood* primes subjects to complete the fragments with these words more often than would be expected by guessing. This priming effect occurs even if the subjects do not remember studying the words before—strong evidence of implicit memory. The hallmark of all implicit memory tests is that people are not required to remember; rather, they are given a task, and past experience is expressed on the test relatively automatically.

Remarkably, even amnesic individuals show implicit memory. In one experiment, amnesic patients and normal subjects studied lists of words and then were given both an explicit memory test (free recall) and an implicit memory test (word-stem completion). Relative to control subjects, the amnesic patients failed miserably at the free-recall test. Due to their memory disorder, they could consciously remember very few of the list words. On the implicit test, however, the amnesic patients performed as well or better than the normal subjects (see the accompanying chart entitled "Word Memory in Amnesia"). Even though the amnesic patients could not consciously access the desired information, they expressed prior learning in the form of priming on the implicit memory test. They retained the information without knowing it.
Studies have found that a person's performance on implicit memory tests can be relatively independent of his or her performance on explicit tests. Some factors that have large effects on explicit memory test performance have no effect—or even the opposite effect—on implicit memory test performance. For example, whether people pay attention to the appearance, the sound, or the meaning of words has a huge

effect on how well they can explicitly recall the words later. But this variable has practically no effect on their implicit memory test performance (see the accompanying chart entitled "Explicit and Implicit Memory"). Implicit tests seem to tap a different form of memory.

Retrieval Cues

One fascinating feature of remembering is how a cue from the external world can cause us to suddenly remember something from years ago. For example, returning to where you once lived or went to school may bring back memories of events experienced long ago. Sights, sounds, and smells can all trigger recall of long dormant events. These experiences point to the critical nature of retrieval in remembering.

A *retrieval cue* is any stimulus that helps us recall information in long-term memory. The fact that retrieval cues can provoke powerful recollections has led some researchers to speculate that perhaps all memories are permanent. That is, perhaps nearly all experiences are recorded in memory for a lifetime, and all forgetting is due not to the actual loss of memories but to our inability to retrieve them. This idea is an interesting one, but most memory researchers believe it is probably wrong.

Two general principles govern the effectiveness of retrieval cues. One is called the *encoding specificity principle*. According to this principle, stimuli may act as retrieval cues for an experience if they were encoded with the experience. Pictures, words, sounds, or smells will cause us to remember an experience to the extent that they are similar to the features of the experience that we encoded into memory. For example, the smell of cotton candy may trigger your memory of a specific amusement park because you smelled cotton candy there.

Distinctiveness is another principle that determines the effectiveness of retrieval cues. Suppose a group of people is instructed to study a list of 100 items. Ninety-nine are words, but one item in the middle of the list is a picture of an elephant. If people were given the retrieval cue "Which item was the picture?" almost everyone would remember the elephant. However, suppose another group of people was given a different 100-item list in which the elephant picture appeared in the same position, but all the other items were also pictures of other objects and animals. Now the retrieval cue would not enable people to recall the picture of the elephant because the cue is no longer distinctive. Distinctive cues specify one or a few items of information.

Overt cues such as sights and sounds can clearly induce remembering. But evidence indicates that more subtle cues, such as moods and physiological states, can also influence our ability to recall events. *State-dependent memory* refers to the phenomenon in which people can retrieve information better if they are in the same physiological state as when they learned the information. The initial observations that aroused interest in state-dependent memory came from therapists working with alcoholic patients. When sober, patients often could not remember some act they performed when intoxicated. For example, they might put away a paycheck while intoxicated and then forget where they put it. This memory failure is not surprising, because alcohol and other depressant drugs (such as marijuana, sedatives, and even antihistamines) are known to impair learning and memory. However, in the case of the alcoholics, if they got drunk again after a period of abstinence, they sometimes recovered the memory of where the paycheck was. This observation suggested that perhaps drug-induced states function as a retrieval cue.

A number of studies have confirmed this hypothesis. In one typical experiment, volunteers drank an alcoholic or nonalcoholic beverage before studying a list of words. A day later, the same subjects were asked to recall as many of the words as they could, either in the same state as they were in during the learning phase (intoxicated or sober) or in a different state. Not surprisingly, individuals intoxicated during learning but sober during the test did worse at recall than those sober during both phases. In addition, people who studied material sober and then were tested while intoxicated did worse than those sober for both phases. The most interesting finding, however, was that people intoxicated during both the learning and test phase did much better at recall than those who were intoxicated only during learning, showing the effect of state-dependent memory (see the chart entitled "State-Dependent Memory"). When people are in the same state during study and testing, their recall is better than those tested in a different state. However, one should not conclude that alcohol improves memory. As noted, alcohol and other depressant drugs usually impair memory and most other cognitive processes. Those who had alcohol during both phases remembered less than those who were sober during both phases.

Psychologists have also studied the topic of *mood-dependent memory*. If people are in a sad mood when exposed to information, will they remember it better later if they are in a sad mood when they try to retrieve it? Although experiments testing this idea have produced mixed results, most find evidence for mood-dependent memory. Recall tests are usually more sensitive to mood- and state-dependent effects than are recognition or implicit memory tests. Recognition tests may provide powerful retrieval cues that overshadow the effects of more subtle state and mood cues.
Mood- and state-dependent memory effects are further examples of the encoding specificity principle. If mood or drug state is encoded as part of the learning experience, then providing this cue during retrieval enhances performance.

Flashbulb Memories
A *flashbulb memory* is an unusually vivid memory of an especially emotional or dramatic past event. For example, the death of Princess Diana in 1997 created a flashbulb memory for many people. People remember where they were when they heard the news, whom they heard it from, and other seemingly fine details of the event and how they learned of it. Examples of other public events for which many people have flashbulb memories are the assassination of U.S. President John F. Kennedy in 1963, the explosion of the space shuttle Challenger in 1986, and the bombing of the Oklahoma City federal building in 1995. Flashbulb memories may also be associated with vivid emotional experiences in one's own life: the death of a family member or close friend, the birth of a baby, being in a car accident, and so on.
Are flashbulb memories as accurate as they seem? In one study, people were asked the day after the Challenger explosion to report how they learned about the news. Two years later the same people were asked the same question. One-third of the people gave answers different from the ones they originally reported. For example, some people initially reported hearing about the event from a friend, but then two years later claimed to have gotten the news from television. Therefore, flashbulb memories are not faultless, as is often supposed.

Flashbulb memories may seem particularly vivid for a variety of reasons. First, the events are usually quite distinctive and hence memorable. In addition, many studies show that events causing strong emotion (either positive or negative) are usually well remembered. Finally, people often think about and discuss striking events with others, and this periodic rehearsal may help to increase retention of the memory.

Tip-of-the-Tongue State
Another curious phenomenon is the *tip-of-the-tongue state*. This term refers to the situation in which a person tries to retrieve a relatively familiar word, name, or fact, but cannot quite do so. Although the missing item seems almost within grasp, its retrieval eludes the person for some time. The feeling has been described as like being on the brink of a sneeze. Most people regard the tip-of-the-tongue state as mildly unpleasant and its eventual resolution, if and when it comes, as a relief. Studies have shown that older adults are more prone to the tip-of-the-tongue phenomenon than are younger adults, although people of all ages report the experience.
Often when a person cannot retrieve the correct bit of information, some other wrong item intrudes into one's thoughts. For example, in trying to remember the name of a short, slobbering breed of dog with long ears and a sad face, a person might repeatedly retrieve *beagle* but know that it is not the right answer. Eventually the person might recover the sought-after name, *basset hound.*
One theory of the tip-of-the tongue state is that the intruding item essentially clogs the retrieval mechanism and prevents retrieval of the correct item. That is, the person cannot think of basset hound because beagle gets in the way and blocks retrieval of the correct name. Another idea is that the phenomenon occurs when a person has only partial information that is simply insufficient to retrieve the correct item, so the failure is one of activation of the target item (*basset hound* in this example). Both the partial activation theory and the blocking theory could be partly correct in explaining the tip-of-the-tongue phenomenon.

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LESSON 11

MEMORY III

The Biological Basis of Memory

Engrams are a hypothetical means by which memory traces are stored as biophysical or biochemical change in the brain (and other neural tissue) in response to external stimuli.
They are also sometimes thought of as a neural network or fragment of memory; sometimes using a hologram analogy to describe its action in light of results showing that memory appears to be non-localized in the brain. The existence of engrams is posited by some scientific theories to explain the persistence of memory and how memories are stored in the brain. The existence of neurologically defined engrams is not significantly disputed, though its exact mechanism and location has been a persistent focus of research for many decades.

Karl S. Lashley experimented for "search for the engram" and found that the engram did not exist in a specific part of the brain, but discovered that memory was widely distributed throughout the cortex. One possible explanation for Lashley's failure to locate the engram is that many types of memories (eg. visuo-spacial, smell, etc.) are used in the processing of complex tasks such as rats running mazes. Now the general view in neuroscience is that memory involved in complex tasks is distributed across multiple neural systems. At the same time, certain types of knowledge are processed and contained in specific brain regions. Gerrig and Zimbardo (2005) Psychology and Life (17th edition: International edition) Overall, the mechanisms of memory are not well understood. Brain areas such as the cerebellum, striatum, cerebral cortex, hippocampus, and the amygdala are thought to play an important role in the memory. For example, the hippocampus is believed to be involved in spatial learning and declarative learning.

In Lashley's experiments (1929, 1950), rats were trained to run mazes then the experimenter removed tissue from the rats' cortex and ran them through the same maze to see if their memory would be affected. It was found that increasing the amount of tissue removed further degraded the rats' memory. More importantly "where" the tissue was removed from made no difference to the rats' memory of the maze.
Later researcher, Richard F. Thompson, sought the engram of memory in the cerebellum instead of the cerebral cortex. Thompson and his colleagues used classical conditioning of the eyelid response in rabbits in their search for an engram. They puffed air upon the cornea of the eye and paired it with a tone. This air puff normally causes an automatic blinking response. After a number of trials they conditioned the rabbits to blink when they heard the tone even though the air puff was no longer administered. During the experiment, they monitored several brain cells to try to locate the engram.

One brain region that Thompson's group monitored that they thought was a possible part of the memory engram was the Lateral Interposed Nucleus (LIP). When chemically deactivated, it resulted in the rabbits, which were previously conditioned to blink when hearing the tone, to act as if the conditioning never took place; however, when researchers re-activated the LIP, they responded to the tone again with an eye blink. This gives evidence that the LIP is a key element of the engram for this behavioral response.
It is important to stress that this approach targeting the cerebellum, though relatively successful, only examines basic, automatic responses. Almost all animals have these (especially as defense mechanisms) and it is fairly difficult to resist them.

The problem here is that considerable studies have shown declarative memories tend to move about the brain between the limbic system (deep within the brain) and the outer cortical areas. This contrasts with the more "primitive" set-up of the cerebellum, which controls the blinking response and receives direct input of auditory information. Thus, it does not need to reach out to other brain structures for assistance in forming simpler memories of association.

Mnemonic Techniques and Specific Memory Tricks to Improve Memory

Mnemonic devices are methods used to improve your memory. Most people when referring to a mnemonic device are referring to a trick that one uses to help memorize something. Mnemonic devices are not only helpful with memorizing facts, they can help remember peoples' names and faces, a grocery list.

Organization

Finding organization to what you need to memorize is often critical to understand the information. If you are able to group what you need to remember into categories, you process the information in more depth. You add meaning to what you are learning by making a judgment about the nature of the information. In some cases, you are incorporating the new knowledge with information you already know. This can be very helpful.

Subjective organization is categorizing seemingly unrelated items in a way that helps you recall the items later. (Benjamin, Hopkins, & Nation, 1994. p.266) This is useful because it breaks down the amount of information to learn. If you can divide a list of items into a fewer number of categories, then all you have to remember is the categories (fewer items), which will serve as memory cues so that you will also remember the items.

Reducing the amount of items to remember is valuable when trying to remember a lot of information. Once you have determined what information is necessary to memorize, you can reduce the number of items you must remember by grouping, or chunking, the information. The human memory spans approximately seven. Several phone numbers use seven digits. However, what about area or country codes, where the person dialing must remember more than 7 digits? He or she can chunk the numbers together, thus reducing the number of items to be remembered, but not the amount of information!

Acronyms

You form acronyms by using each first letter from a group of words to form a new word. This is particularly useful when remembering words in a specified order. Acronyms are very common in ordinary language and in many fields. Some examples of common acronyms include NBA (National Basketball Associations), SCUBA (Self Contained Underwater Breathing Apparatus), BTUs (British Thermal Units), and LASER (Light Amplification by Stimulated Emission of Radiation). What other common acronyms can you think of? The memory techniques in this section, for example, can be rearranged to form the acronym "SCRAM" (Sentences/acrostics, Chunking, Rhymes & songs, Acronyms, and Method of loci).

Let us suppose that you have to memorize the names of four kinds of fossils for your geology class: 1) actual remains, 2) Petrified, 3) Imprint, and 4) Molds or casts. Take the first letter of each item you are trying to remember: APIM. Then, arrange the letters so that the acronym resembles a word you are familiar with: PAIM or IMAP.

Although acronyms can be very useful memory aids, they do have some disadvantages. First, they are useful for rote memory, but do not aid comprehension. Be sure to differentiate between comprehension and memory, keeping in mind that understanding is often the best way to remember. Some people assume that if they can remember something that they must "know" it; but memorization does not necessarily imply understanding. A second problem with acronyms is that they can be difficult to form; not all lists of words will lend themselves equally well to this technique. Finally, acronyms, like everything else, can be forgotten if not committed to memory.

Rhymes

Rhythm, repetition, melody, and rhyme can all aid memory. Are you familiar with Homer's Odyssey? If you are familiar with the book, then you know that it is quite long. That is why it is so remarkable to realize that this, along with many ancient Greek stories, was told by storytellers who would rely solely on their memories. The use of rhyme, rhythm, and repetition helped the storytellers remember them.

You can use the same techniques to better remember information from courses. For example, even the simple addition of familiar rhythm and melody can help. Do you remember learning the alphabet? Many children learn the letters of the alphabet to the tune of "Twinkle, Twinkle, Little Star." In fact, a student demonstrated how she memorized the quadratic formula (notorious among algebra students for being long and difficult to remember) by singing it to a familiar tune!

Using these techniques can be fun, particularly for people who like to create. Rhymes and songs draw on your auditory memory and may be particularly useful for those who can learn tunes, songs, or poems easily. Like the other techniques in this section, however, they emphasize rote memory, not understanding also, when devising rhymes and songs, don't spend too much time creating them. Use these techniques judiciously and don't let them interfere with your studying.
Familiar rhymes from grade school such as nursery rhymes, spelling rhymes, etc.

EXAMPLE: Thirty days has September, April, June, and November; all the rest have thirty-one except February.

Chunking

This is a technique generally used when remembering numbers, although the idea can be used for remembering other things as well. It is based on the idea that short-term memory is limited in the number of things that can be contained. A common rule is that a person can remember 7 (plus or minus 2) "items" in short-term memory. In other words, people can remember between 5 and 9 things at one time. You may notice that local telephone numbers have 7 digits. This is convenient because it is the average amount of numbers that a person can keep in his or her mind at one time.

Look at the following chunks of letters:
T WAN BAC BSC PRC IA
At first glance, it seems like they would be difficult to memorize. However, with simple chunking, look at them now:
TWA NBA CBS CPR CIA
These common acronyms are already familiar to many people. For those who the letters are now in meaningful chunks, they are easier to remember.
S.F. was a college student who could remember 80 digits after practicing for 230 hours! How did he do it? This cross-country runner memorized the numbers was by grouping them into sets of 3-4 digits each. He memorized these values as running times for different track races, or as ages or significant dates. (Yount, p. 76)
Master chess players also use chunking as well. They will remember certain strategies for particular patterns on the board and fit them together with the other "chunks" on the board. This helps reduce their playing time greatly. (Ellis & Hunt, 1989)(Benjamin, Hopkins, & Nation, 1994. p.258)

Method of Loci

This technique was used by ancient orators to remember speeches, and it combines the use of organization, visual memory, and association. Before using the technique, you must identify a common path that you walk. This can be the walk from your dorm to class, a walk around your house, whatever is familiar. What is essential is that you have a vivid visual memory of the path and objects along it. Once you have determined your path, imagine yourself walking along it, and identify specific landmarks that you will pass. For example, the first landmark on your walk to campus could be your dorm room, next may be the front of the residence hall, next a familiar statue you pass, etc. The number of landmarks you choose will depend on the number of things you want to remember.
Once you have determined your path and visualized the landmarks, you are ready to use the path to remember your material. This is done by mentally associating each piece of information that you need to remember with one of these landmarks. For example, if you are trying to remember a list of mnemonics, you might remember the first--acronyms--by picturing SCUBA gear in your dorm room (SCUBA is an acronym).
You do not have to limit this to a path. You can use the same type of technique with just about any visual image that you can divide into specific sections. The most important thing is that you use something with which you are very familiar.

EXERCISE: METHOD OF LOCI

1. If someone reads a list of unrelated words to you, just once, how many do you think you could remember? Give it a try. Have someone read a list of 10 words to you at a slow but steady pace (about 1 word per second). Rather than using any of the memory techniques presented here, simply try to concentrate on the words and remember them. How many words did you remember?
2. Now take a few minutes to identify a path or object that you can use in the method of loci. Familiarize yourself with each of sections of your path or object. Mentally go through each of the loci (locations) and visualize them as best you can. Remember, it is important to be able to visualize and recall each location readily. Once you have done this, have your friend read you a different list of words. This time, try to create visual images of the words associated with one of the locations. This may not come easy at first, but with practice you should be able to create these visual images more readily. If you find that you are having difficulty coming up with the images quickly, practice on some more lists until you have improved. Chances are, when you become familiar with using this technique, you will be able to remember many more words (maybe all 10 items).
3. Practice the technique to sharpen your skills.

Imagery

Imagery is used to memorize pairs of words very often. An image is created for each word, and then the two images are connected through mental visualization. (Benjamin, Hopkins, & Natio, 1994.p.267)
Imagery is a great way to improve your memory. The more vivid or startling you can create the mental picture, the more likely you are to remember whatever it is you are trying to remember. Imagery is used as a part of several more complex mnemonic divices, such as the method of loci, or the peg system.
Try an activity to practice using imagery as a mnemonic device.

External Memory Devices

External memory devices are just that - objects outside of the body that you use to help you remember something. People should not be embarrassed to use an external memory device. They are actually quite a good idea. They are usually easier and require less training practice. (Remembering Well). Here, we give some examples of external memory devices. Each situation has certain strategies that work better than others. Likewise, each person has certain strategies that work better than others for them. Pick strategies that work for you and your situation.
Parking lots /garage with signs/code are helpful
Cars - can't lock doors with lights on, only lock from outside
Light/alarm when low on petrol or oil or when lights on & engine off

Organization & Ideas
Back-up records - could be for a computer, financial papers.
Financial record
Notebooks
Phonebooks
Filing cabinet
Programming phones with numbers to dial for you
Note-taking
Bookmarks
Post-it notes
Organizers
Electronic organizers
Files
Bookmarks
Date-stamping on camera
Object organizer
Cheque-book Manager (Gruneberg & Herrmann, 1997, p. 8)
Knowledge
Dictionary / encyclopedia
Recipe book

Notes - take them during a lecture!
Tapes - if your professor allows it, tape a lecture so you can listen to it again later.
Flashcards - repetition
Map
Alarm Devices
For alarms for things such as cooking, be sure you will be able to hear the alarm! Portable timers are very useful.
Credit card alarm - This is a special wallet that will sound an alarm if a credit card is taken out and it is shut without the credit card being placed back in the wallet. (Gruneberg & Herrmann, 1997, p. 82)
Medication Reminders - Pill boxes with an incorporated alarm are available. One can put the medication inside the pill box and set the alarm that will sound when it is time to take the medication.
Alarm clock - reminds your body to wake up
Timer - for cooking, turning off a sprinkler, practicing an instrument, etc.
Car finder - when you forgot where you parked, you can use this device to cause its lights to blink and or its horn to sound, so you can find your car.
Key finder - The whistle-activated key-ring has had mixed results. It is a device that addresses a problem all of us have - losing your keys. When you whistle, the key-ring will beep so that you can find your keys. Unfortunately, it often beeps when you aren't looking for your keys but a whistle-like sound is made. (Gruneberg & Herrmann, 1997, p. 82) We suggest you learn to always place your keys in the same place instead.
Appointments / Chores
Addressbooks
Calendars
List - for shopping, packing, things to do, etc.
Nametags / Labels - in case you lose something. ... in hopes that someone will return it ..
Smart Irons - It is not uncommon for someone to get distracted while ironing and have to leave the ironning board for a moment. Perhaps the phone rang or someone came to the door. Leaving the iron down on a piece of clothing can be dangerous - not only can it burn the piece of clothing being ironed, it could even start a fire! Fortunately, some irons are now available that will automatically turn off if left lying flat and is still for more than 30 seconds. (Gruneberg & Herrmann, 1997, p. 82)
People
Name tages
Photo board - This is especially good for remembering fellow staff-members.
Experiences
Diary
Camera - photographs
Video camera
tape recorder
Messages
White/black board (it won't get lost!)
Bulletin board
Memo pad
Post-it notes
Message machine - for the telephone
General reminders
If these work for you, great! But beware: sometimes it is difficult to remember what the reminder was for!
Watch on opposite wrist
String on finger
Rubber band around wrist
Lost Items
If you often find yourself losing something in particular, put it in a special place. Train yourself to ALWAYS return it to this place when you are done. It is helpful if you put it in a function-related spots. For example: put your keys by the door. Put your medicine either with your food or by your toothpaste (depending on when you take your medication.

Famous people with excellent memories

There is a myth about Napoleon Bonaparte's excellent memory. Perhaps it is partially true, who knows. Anyway the story goes that Napoleon memorized the rosters of his units. Every time he was to review the troops, he would greet the soldiers by name, causing them to feel a personal connection to their French emperor. (Kurland and Lupoff, 1999, p. 3-4)

Franklin Roosevelt, president from ____ to _____, is also said to have a good memory. In reception lines, Roosevelt would not only greet each person by name, he would ask a question of, or comment about, each person, showing his interest. Roosevelt used a terrific external memory device. His advisor, James Farley, kept a file of index cards on every such person Roosevelt might come across in such occasions. Before such occasions, he would brief Roosevelt beforehand, who would memorize a key question, brief story, or fact. (Kurland and Lupoff, 1999, p. 4)

Arturo Toscanini was the conductor of the ______ orchestra. This man had poor vision, but a terrific musical memory. Instead of following along with the score as he conducted, he memorized the entire score for each concert! He knew every note played by every instrument for 250 symphonies adn 100 operas! There is a legend that a man in Toscanini's orchestra who played second bassoon came to his conductor and said that he could not play the lowest F-sharp because of a broken key. But after a brief pause, Mistro Toscanini replied that it would not be a problem; that note would not be needed for the concert that night! (Yount, p. 70-71)

Mnemonics – Memory Techniques

The following are examples of techniques you can use to memorize important information.

When to Use It:	Technique:	Example:
For information involving key words	**Acronym** - an invented combination of letters with each letter acting as a cue to an idea you need to remember.	**BRASS** is an acronym for how to shoot a rifle-- Breath, Relax, Aim, Sight, Squeeze.
For information involving key words	**Acrostic** - an invented sentence where the first letter of each word is a cue to an idea you need to remember.	**EVERY GOOD BOY DESERVES FUN** is an acrostic to remember the order of the G-clef notes on sheet music-- E,G,B,D,F.
For ordered or unordered lists	**Rhyme-Keys** - a 2-step memory process: Memorize key words that can be associated with numbers (one-bun); Create an image of the items you need to remember with key words. (A bun with cheese on it will remind me of dairy products.)	**Food groups:** Dairy products: one-bun-cheese on a bun. Meat, fish, and poultry: two-shoe-livestock with shoes. Grains: three-tree-sack of grain hanging from tree. Fruit and vegetables: four-door- opening a door and walking into a room stocked with fruits and vegetables.
For approximately twenty items	**Loci Method**- Imagine placing the items you want to remember in specific locations in a room with which you are familiar.	To remember **presidents:** Place a dollar bill (George Washington) on the door. Walk into the room and see Jefferson reclining on a sofa and Nixon eating out of the refrigerator.
For foreign language	**Keyword Method**- Select the foreign words you need to remember, then	In Spanish, the word **"cabina"** means phone booth. Invent an image of a cab

vocabulary	identify an English word that sounds like the foreign one. Now imagine an image that involves the key word with the English meaning of the foreign word.	trying to fit in a phone booth. When you see the word "cabina," you should be able to recall this image and thereby retrieve the meaning "phone booth."
For remembering names	**Image-Name Technique**- invent a relationship between the name and the physical characteristics of the person.	**Shirley Temple** - her curly (rhymes with "Shirley") hair around her temples.
For ordered or unordered lists	**Chaining**- Create a story where each word or idea you have to remember will cue the next idea you need to recall.	**Napoleon, ear, door, Germany** Story: **Napoleon** had his **ear** to the **door** to listen to the **Germans** in his beer cellar.

Two Keys to Memory
Repetition and association are two essential components to any memory technique.
Repetition
Mnemonic devices demand active participation and a constant repetition of the material to be memorized. It is meaningful practice which involves familiarizing yourself with a list, trying to memorize it, duplicating it, and then checking it yourself.
Association:
New knowledge is more effectively stored in long term memory when it is associated with anything that is familiar. Mnemonics focus on a creative association that you can't help but remember.

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LESSON 12

FORGETTING

Although information can be stored in long-term memory for extended periods of time, "memory decay" does take place. In other words, we can forget what we learn. In fact, we forget things quickest shortly after we learn them. This has two implications in terms of improving our memory.

Why People Forget

Forgetting is defined as the loss of information over time. Under most conditions, people recall information better soon after learning it than after a long delay; as time passes, they forget some of the information. We have all failed to remember some bit of information when we need it, so we often see forgetting as a bother. However, forgetting can also be useful because we need to continually update our memories. When we move and receive a new telephone number, we need to forget the old one and learn the new one. If you park your car every day on a large lot, you need to remember where you parked it today and not yesterday or the day before. Thus, forgetting can have an adaptive function.

Memory is retention of information over a period of time. Ebbinghaus studied memories by teaching himself lists of nonsense words and then studying his retention of these lists over periods of hours to days. This was one of the earliest studies of memory in psychology.

The subject of forgetting is one of the oldest topics in experimental psychology. German philosopher Hermann Ebbinghaus initiated the scientific study of human memory in experiments that he began in 1879 and published in 1885 in his book, *On Memory*. Ebbinghaus developed an ingenious way to measure forgetting. In order to avoid the influence of familiar material, he created dozens of lists of nonsense syllables, which consisted of pronounceable but meaningless three-letter combinations such as XAK or CUV. He would learn a list by repeating the items in it over and over, until he could recite the list once without error. He would note how many trials or how long it took him to learn the list. He then tested his memory of the list after an interval ranging from 20 minutes to 31 days. He measured how much he had forgotten by the amount of time or the number of trials it took him to relearn the list. By conducting this experiment with many lists, Ebbinghaus found that the rate of forgetting was relatively consistent. Forgetting occurred relatively rapidly at first and then seemed to level off over time (see the accompanying chart entitled “Forgetting Curve”). Other psychologists have since confirmed that the general shape of the forgetting curve holds true for many different types of material. Some researchers have argued that with very well learned material, the curve eventually flattens out, showing no additional forgetting over time.

Ebbinghaus’s forgetting curve illustrated the loss of information from long-term memory. Researchers have also studied rate of forgetting for short-term or working memory. In one experiment, subjects heard an experimenter speak a three-letter combination (such as CYG or FTQ). The subjects’ task was to repeat back the three letters after a delay of 3, 6, 9, 12, 15, or 18 seconds. To prevent subjects from mentally rehearsing the letters during the delay, they were instructed to count backward by threes from a random three-digit number, such as 361, until signaled to recall the letters. As shown in the accompanying chart entitled “Duration of Working Memory,” forgetting occurs very rapidly in this situation. Nevertheless, it follows the same general pattern as in long-term memory, with sharp forgetting at first and then a declining rate of forgetting. Psychologists have debated for many years whether short-term and long-term forgetting have similar or different explanations.

Decay Theory of Forgetting

The oldest idea about forgetting is that it is simply caused by decay. That is, memory traces are formed in the brain when we learn information, and they gradually disintegrate over time. Although decay theory was accepted as a general explanation of forgetting for many years, most psychologists do not lend it credence today for several reasons. First, decay theory does not really provide an explanation of forgetting, but merely a description. That is, time by itself is not a causative agent; rather, processes operating over time cause effects. Consider a bicycle left out in the rain that has rusted. If someone asked why it rusted, he or she would not be satisfied with the answer of “time out in the rain.” A more accurate explanation would

refer to oxidation processes operating over time as the cause of the rusty bicycle. Likewise, memory decay merely describes the fact of forgetting, not the processes that cause it.
The second problem for decay theory is the phenomenon of *reminiscence,* the fact that sometimes memories actually recover over time. Experiments confirm an observation experienced by most people: One can forget some information at one point in time and yet be able to retrieve it perfectly well at a later point. This feat would be impossible if memories inevitably decayed further over time. A final reason that decay theory is no longer accepted is that researchers accumulated support for a different theory—that interference processes cause forgetting.

Interference Theory of Forgetting
According to many psychologists, forgetting occurs because of interference from other information or activities over time. A now-classic experiment conducted in 1924 by two American psychologists, John Jenkins and Karl Dallenbach, provided the first evidence for the role of interference in forgetting. The experimenters enlisted two students to learn lists of nonsense syllables either late at night (just before going to bed) or the first thing in the morning (just after getting up). The researchers then tested the students' memories of the syllables after one, two, four, or eight hours. If the students learned the material just before bed, they slept during the time between the study session and the test. If they learned the material just after waking, they were awake during the interval before testing. The researchers' results are shown in the accompanying chart entitled, "Forgetting in Sleep and Waking." The students forgot significantly more while they were awake than while they were asleep. Even when wakened from a sound sleep, they remembered the syllables better than when they returned to the lab for testing during the day. If decay of memories occurred automatically with the passage of time, the rate of forgetting should have been the same during sleep and waking. What seemed to cause forgetting was not time itself, but interference from activities and events occurring over time.
There are two types of interference. *Proactive interference* occurs when prior learning or experience interferes with our ability to recall newer information. For example, suppose you studied Spanish in tenth grade and French in eleventh grade. If you then took a French vocabulary test much later, your earlier study of Spanish vocabulary might interfere with your ability to remember the correct French translations. *Retroactive interference* occurs when new information interferes with our ability to recall earlier information or experiences. For example, try to remember what you had for lunch five days ago. The lunches you have had for the intervening four days probably interfere with your ability to remember this event. Both proactive and retroactive interference can have devastating effects on remembering.

Repression
Another possible cause of forgetting resides in the concept of *repression,* which refers to forgetting an unpleasant event or piece of information due to its threatening quality. The idea of repression was introduced in the late 19th century by Austrian physician Sigmund Freud, the founder of psychoanalysis. According to Freudian theory, people banish unpleasant events into their unconscious mind. However, repressed memories may continue to unconsciously influence people's attitudes and behaviors and may result in unpleasant side effects, such as unusual physical symptoms and slips of speech. A simple example of repression might be forgetting a dentist appointment or some other unpleasant daily activity. Some theorists believe that it is possible to forget entire episodes of the past—such as being sexually abused as a child—due to repression. The concept of repression is complicated and difficult to study scientifically. Most evidence exists in the form of case studies that are usually open to multiple interpretations. For this reason, many memory researchers are skeptical of repression as an explanation of forgetting, although this verdict is by no means unanimous. For further information on repressed memories, see the sidebar "Recovered Memories and False Memories" that accompanies this article.

Memory Reconstruction
Psychologists generally accept the idea that long-term memories are *reconstructive.* That is, rather than containing an exact and detailed record of our past, like a video recording, our memories are instead more generic. As a better analogy, consider paleontologists who must reconstruct a dinosaur from bits and pieces of actual bones. They begin with a general idea or scheme of what the dinosaur looked like and then fit the bits and pieces into the overall framework. Likewise, in remembering, we begin with general themes about

past events and later weave in bits and pieces of detail to develop a coherent story. Whether the narrative that we weave today can faithfully capture the distant past is a matter of dispute. In many cases psychologists have discovered that recollections can deviate greatly from the way the events actually occurred, just as in the anecdote about Piaget.

Sir Frederic Bartlett, a British psychologist, argued for the reconstructive nature of memory in the 1930s. He introduced the term *schema* and its plural form *schemata* to refer to the general themes that we retain of experience. For example, if you wanted to remember a new fairy tale, you would try to integrate information from the new tale into your general schema for what a fairy tale is. Many researchers have showed that schemata can distort the memories that people form of events. That is, people will sometimes remove or omit details of an experience from memory if they do not fit well with the schema. Similarly, people may confidently remember details that did not actually occur because they are consistent with the schema.
Another way our cognitive system introduces error is by means of inference. Whenever humans encode information, they tend to make inferences and assumptions that go beyond the literal information given. For example, one study showed that if people read a sentence such as "The karate champion hit the cinder block," they would often remember the sentence as "The karate champion broke the cinder block." The remembered version of the events is implied by the original sentence but is not literally stated there (the champion may have hit the block and not broken it). Many memory distortions arise from these errors of encoding, in which the information encoded into memory is not literally what was perceived but is some extension of it.

The question of memory distortion has particular importance in the courtroom. Each year thousands of people are charged with crimes solely on the basis of eyewitness testimony, and in many trials an eyewitness's testimony is the main evidence by which juries decide a suspect's guilt or innocence. Are eyewitnesses' memories accurate? Although eyewitness testimony is often correct, psychologists agree that witnesses are not always accurate in their recollections of events. We have already described how people often remember events in a way that fits with their expectations or schema for a situation. In addition, evidence shows that memories may be distorted after an event has occurred. After experiencing or seeing a crime, an eyewitness is exposed to a great deal of further information related to the crime. The witness may be interrogated by police, by attorneys, and by friends. He or she may also read information related to the case. Such information, coming weeks or months after the crime, can cause witnesses to reconstruct their memory of the crime and change what they say on the witness stand.

American psychologist Elizabeth Loftus has conducted many experiments that demonstrate how eyewitnesses can reconstruct their memories based on misleading information. In one study, subjects watched a videotape of an automobile accident involving two cars. Later they were given a questionnaire about the incident, one item of which asked, "About how fast were the cars going when they hit each other?" For some groups of subjects, however, the verb *hit* was replaced by *smashed, collided, bumped*, or *contacted.* Although all subjects viewed the same videotape, their speed estimates differed considerably as a function of how the question was asked. The average speed estimate was 32 mph when the verb was *contacted*, 34 mph when it was *hit*, 38 mph when it was *bumped*, 39 mph when it was *collided,* and 41 mph when it was *smashed.* In a follow-up study, subjects were asked a week later whether there was any broken glass at the accident scene. In reality, the film showed no broken glass. Those questioned with the word *smashed* were more than twice as likely to "remember" broken glass than those asked the question with *hit.* The information coming in after the original event was integrated with that event, causing it to be remembered in a different way.

This study, and dozens of others like it, shows the power of leading questions: The form in which the question is asked helps determine its answer. Our memories are not encapsulated little packets lying in the brain undisturbed until they are needed for retrieval. Rather, people are prone to the *misinformation effect*—the tendency to distort one's memory of an event when later exposed to misleading information about it. Eyewitnesses' testimony can be tainted and altered by information they hear or see after the critical event in question. Therefore, in court cases one must carefully consider whether the testimony of an eyewitness could possibly have been altered through misleading suggestions provided between the time of the crime and the court case.

The problem of determining whether memories are accurate is even more difficult when children are the witnesses. Research shows that in some situations children are more prone to memory distortions than are young adults. In addition, older adults (over 70 years of age) often show a greater tendency to memory distortion than do younger adults.
Even though psychologists have shown that memories can be distorted and that people can remember things that never occurred, our memories are certainly not totally faulty. Usually memory does capture the gist of events that have occurred to us, even if details may be readily distorted.

Cue dependent forgetting theory
Cue-dependent forgetting means that 'information is stored in the long-term memory but there is no suitable retrieval cue from the environment to prompt memory.' This means that information is available but is not accessible. An example of this is if you forget something about your childhood and you visit your old school/house it may help you remember by acting as a cue. Tulving split cue-dependent forgetting into two different types. One type is State dependent forgetting, which is the physical/physiological state of the person when the information is encoded and retrieved, examples of these are, happy or sad, alert or tired etc. These are internal cues. The other is Context dependent forgetting, this is the environment setting or situation in which the information is encoded or retrieved, an example of this is a particular room etc. These are external cues. A study that supports Tulving's theory is Aggleton and Waskett (1999) 'Can Viking smells aid the recall of Viking experiences?' The aim of this study was to test whether smells could act as cues to real life setting because most other studies of this nature had been done in a laboratory setting. The sample was 45 participants who had been to the Jorvik Viking Centre and used authentic smells from the actual museum in the study. The participants were given the same questionnaire of 20 questions and were split into three groups. There were three conditions; the first condition was of Jorvik smells, e.g. burnt wood, fish and rope. The second condition was of irrelevant smells e.g. peppermint and the third condition was no smells. Group one had Viking smells followed by irrelevant smells, group two had irrelevant smells followed by Viking smell and the third group had the no smell condition followed by the no smell condition. The results show that all the groups remembered more items on the second test than on the first. Group two had the greatest improvement. The mean number of the 20 questions correct for this group improved from 0.9 to 10.7. This supports the idea that smells act as a cue to aid memory.

LESSON 13

REASONING AND PROBLEM SOLVING

Reasoning: Making Up Your Mind

Professors deciding when students' assignments are due

An employer determining whom to hire out of a pool of job applicants

The president concluding it is necessary to send troops to a foreign nation

The common thread among these three circumstances: Each requires reasoning, the process by which information is used to draw conclusions and make decisions. Although philosophers and logicians have considered the foundations of reasoning for centuries, it is only relatively recently that cognitive psychologists have begun to investigate how people reason and make decisions. Together, their efforts have contributed to our understanding of formal reasoning processes as well as the mental shortcuts we routinely use shortcuts which may sometimes lead our reasoning capabilities astray (Evans, Newstead, & Byrne, 1994; Johnson-Laird & Shafir, 1994; Corrigan, 19%).

Deductive and Inductive Reasoning

One approach taken by cognitive psychologists in their efforts to understand decision making is to examine how people use formal reasoning procedures. Two major forms exist: deductive reasoning and inductive reasoning (Rips, 1990, 1994a, 1995).
In deductive reasoning, we draw inferences and implications from a set of assumptions and apply them to specific cases. Deductive reasoning begins with a series of assumptions or premises that arc thought to be true, and then derives the implications of these assumptions. If the assumptions are true, then the conclusions must also be true.

A major technique for studying deductive reasoning involves asking people to evaluate syllogisms. A syllogism presents a series of two assumptions, or premises, that arc used to derive a conclusion. By definition, the conclusion must be true if the assumptions or premises are true. For example, consider the following syllogism:

All men are mortal. [premise]
Socrates is a man. [premise]
Therefore, Socrates is mortal. [conclusion]

In this case both premises are true, and so, then, is the conclusion. More abstractly, we can state the syllogism as the following:

All As are B. C is an A.
Therefore, C is a B.

[premise] [premise] [conclusion]

On the other hand, if either or both of the premises in a syllogism are not accurate, then there is insufficient support for the accuracy of the conclusion. Suppose, for example, you saw the following syllogism:
All men are mortal. [premise] Socrates is a man. [premise] Therefore, all men are Socrates. [conclusion]
Obviously, such a conclusion makes no sense. We can more easily see why it's unreasonable by restating the syllogism in the abstract and coming up with an obviously false conclusion:

All As are B. C is an A.
Therefore, all As are C.

[premise] [premise] [conclusion]

The conceptual complement of deductive reasoning is inductive reasoning. In inductive reasoning, we infer a general rule from specific cases. Using our observations, knowledge, experiences, and beliefs about the world, we develop a summary conclusion. (You can recall the distinction between deductive and inductive reasoning in this way: In Deductive reasoning, the conclusion is derived through the use of general rules, whereas in inductive reasoning, a conclusion is inferred from specific examples.

Sherlock Holmes used inductive reasoning in his quest to solve mysteries. By amassing clues, he was ultimately able to determine the identity of the criminal. Similarly, we all use inductive reasoning, although typically in more ordinary situations. For instance, if the person in the apartment below you constantly plays Spice Girls music, you may begin to form an impression of what that individual is like, based on the sample of evidence available to you. Like Sherlock Holmes, you use pieces of evidence to draw a general conclusion.

The limitation of inductive reasoning is that conclusions may be biased if insufficient or invalid evidence is used. Psychologists know this well: The various scientific methods that they may employ in the collection of data to support their hypotheses are prone to several sorts of biases, such as using an inappropriate sample of subjects. Similarly, you may fail to draw appropriate conclusions about your neighbor if your impression is based only on the music he or she plays and not on a broader sample of behavior.

Inductive reasoning: A reasoning process whereby n general rule is inferred from specific cases, using observation, knowledge, experience and beliefs

Algorithms and Heuristics

When faced with a decision, we often turn to various kinds of mental shortcuts, known as algorithms and heuristics, to help us. An algorithm is a rule which, if followed, guarantees a solution to a problem. We can use an algorithm even if we cannot understand why it works. For example, you may know that the length of the third side of a right triangle can be found using the formula a2 + b2 - c2. You may not have the foggiest notion of the mathematical principles behind the formula, but this algorithm is always accurate and therefore provides a solution to a particular problem.

For many problems and decisions, however, no algorithm is available. In those instances, we may be able to use heuristics to help us. A heuristic is a rule of thumb or mental shortcut that may lead to a solution. Heuristics enhance the likelihood of success in coming to a solution but, unlike algorithms, they cannot ensure it. For example, some tic-tac-toe players follow the heuristic of placing an "X" in the center of the squares at the start of the game. This lactic doesn't guarantee that they will win, but it does increase their chances of success. Similarly, some students follow the heuristic of preparing for a test by ignoring the assigned textbook reading and only studying their lecture notes—a strategy that may or may not pay off (Nisbett et aL, 1993), to consider as many as 200 million possible chess positions a second in and of itself, such sheer calculating speed does not constitute thinking. On the other hand, Herbert Simon, a cognitive psychologist at Carnegie Mellon University and Nobel prize-winner, argues that the computer did show rudiments of human like thinking because of its selectivity, its knowledge of where to look—and where not to look—for an answer to a problem. Simon suggests that Deep Blue's capacity to evaluate potential moves and to ignore unimportant possibilities gives it thinking ability (Webber, 1996; Wright, 1996).

Some critics, however, suggest that Deep Blue's ability to consider billions of moves is qualitatively no different from what a simple calculator can do. Perhaps Deep Blue can do more calculations than a pocket calculator, but neither, machine is capable of worrying about what comes next, strategizing about how to take account of an opponent's emotions, or dreaming about what one might do with the prize money for winning the tournament. In the view of critics, because such feelings and expectations are not part of the abilities of the computer, it is not engaged in true thinking (Weber, 1996).

Obviously, many of the questions surrounding the ability of computers to think are more philosophical than psychological and are not readily answered. Still, it is clear that computers are becoming increasingly sophisticated, ever more closely approximating human thought processes. For example, psychologists Jack Gelfand and Susan Epstein are developing a computer that can demonstrate expertise in a variety of tasks, rather than being a master at only a single task, such as chess. To do so, they are seeking to design a

machine that can learn to play games using experience, memory, and heuristics. The computer also has a visual recognition component, permitting it to perceive patterns in board games. The ability to "see" patterns on the board permits the computer to draw conclusions about whether a specific pattern of game pieces is more or less likely to produce success (Epstein, 1995; Azar, 1997).
One of the computer's programs, called Hoyle, is designed to become an expert game-player. Starting off simply, it plays as a novice would, practicing with "expert" computers designed to play just one game. For instance, it might initially play tic-tac-toe. As it gains experience, it learns strategies, balancing and weighing the different strategies to you which will be most successful. If a strategy is particularly effective, the computer increases its weight, so this strategy counts more in the future; if strategy is not very useful, its weight decreases.
Hoyle has so far mastered almo twenty different board games. Because like humans, it learns some games more quickly than others, it appears to be employing strategies effectively to help learn. Furthermore, research on children how they learn games suggest that they and Hoyle use similar strategies (Rattermann, 1992).
Is Hoyle thinking like a human? The question remains unanswerable. Machines like Hoyle and Dee Blue are clearly making strides towards imitating the moves of expert game players. In fact, it is possible that one day this world chess champion will be a machine But even if this forecast becomes a reality, the real champions will remain the people who program the computers—the humans behind the machines.

Although heuristics often help people solve problems and make decisions, certain kinds of heuristics may backfire. For example, we sometimes use the representative heuristic, a rule we apply when we judge people by the degree to which they represent a certain category or group of people. Suppose, for instance, you are the owner of a fast-food store that has been robbed many times by teenagers. The representative heuristic would lead you to raise your guard each time someone of this age group enters your store (even though, statistically, it is unlikely that any given teenager will rob the store).
The availability heuristic involves judging the probability of an event by how easily the event can be recalled from memory (Tversky & Kahneman, 1974, 1990). According to this heuristic, we assume that events we remember easily are likely to have occurred more frequently in the past than those that are harder to remember. Furthermore, we assume that the same sort of event is more likely to occur in the future. For example, we are more apt to worry about being murdered than dying of diabetes, despite the fact that it is twice as likely that we will die of the disease. We err because of the ease with which we remember dramatic, highly publicized events like murder; this leads us to overestimate the likelihood of their occurrence.
Similarly, many people are more afraid of dying in a plane crash than in an auto accident—despite statistics clearly showing that airplane travel is much safer than auto travel. The reason is that plane crashes receive far more publicity than car crashes, and arc therefore more easily remembered. It is the availability heuristic that leads people to conclude that they are in greater jeopardy in an airplane than in a car (Slovic, Fischhoff, & Lichtcnstien. 1976: Schwarz et al., 1991).
Are algorithms and heuristics confined to human thinking, or can computers programmed to use them? As we discussed in the Applying Psychology in 21 Century box, new research suggests that a future in which machines think is not altogether far-fetched. At the same time, such work raises some fundamental questions about the nature of thought and the mind.

Problem Solving
According to an old legend, a group of monks in Vietnam devote much of their time to the effort of solving a problem called the Tower of Hanoi puzzle. The monks believe that, if they succeed, the world as we know it will come to an end (Raphael, 1976). (Should you prefer that the world remain in its present state, there's no need for immediate concern: According to one estimate, the puzzle is so complex that it will take about a trillion years to reach a solution.)

Why are cognitive psychologists interested in the Tower of Hanoi problem? The answer is that the way people go about solving this puzzle and simpler ones like it helps illuminate the processes by which people solve complex problems that they encounter in school and at work. For example, psychologists have found that problem solving typically involves three major steps: preparation for the creation of solutions, production of solutions, and evaluation of solutions that have been generated (Sternberg & Frensch, 1991).

Preparation: Understanding and Diagnosing Problems

When approaching a problem like the Tower of Hanoi, most people begin by trying to ensure that they thoroughly understand the problem. If the problem is a novel one, they ire likely to pay particular attention to any restrictions placed on coming up with a solution as well as the initial status of the components of the problem. If, on the other hand, the problem is a familiar one, they are apt to spend considerably less time in this stage.

Problems vary from well-defined to ill-defined (Reitman, 1965; Axlin, 1989). In a well-defined problem—such as a mathematical equation or the solution to a jigsaw puzzle—both the nature of the problem itself and the information needed to solve it are available and clear. Thus, straightforward judgments can be made about whether a potential solution is appropriate. With an ill-defined problem, such as how to increase morale on an assembly line or bring peace to the Middle East, not only may the specific nature of the problem be unclear, but the information required to solve the problem may be even less obvious.

For example, consider the following problem, first devised by Karl Duncker (1945):

Suppose you are a doctor faced with a patient who has a malignant tumor in his stomach. To operate on the patient is impossible, but unless the tumor is destroyed, the patient will die. A kind of ray, at a sufficiently high intensity, can destroy the tumor. Unfortunately, at this intensity the healthy tissue that the rays pass through on the way to the tumor will also be destroyed. At lower intensities the rays are harmless to healthy tissue but will not affect the tumor, either. How can the rays be used to destroy the tumor without injuring the healthy tissue?

Most people have a great deal of difficulty in thinking of even one solution to this problem. The major barrier is that the ill-defined nature of the problem, which involves some vague sort of "rays," doesn't suggest any immediate solutions. However, there is an ingenious solution to the problem: aiming weak rays at the tumor from several different entry points. In this way, no one portion of healthy tissue is damaged, while the tumor receives a full dosage.

Kinds of Problems

Problems typically fall into one of the three categories: arrangement, inducing structure, and transformation (Greeno, 1978; Spitz, 1987). Solving each type requires somewhat different kinds of psychological skills and knowledge.

A. Arrangement problems

1. Anagrams: Rearrange the letters in each set to make an English word:

a. Two strings hang from a ceiling but are too far apart to allow a person to hold one and walk to the other. On the floor are a book of matches, screwdriver, and a few pieces of cotton. How could the strings be tie together?

1 Inducing structure

1. What number comes next in the series?

1424344454 6 4

2. Complete these analogies:

Baseball is to bat as tennis is to

Merchant is to sell as customer is to

Arrangement Problems require that a group of elements be rearranged or recombined in a way that will satisfy a certain criterion. There are usually several different possible arrangements that can be made, but only one or a few of the arrangements will produce a solution. Anagram problems and jigsaw puzzles represent arrangement problems.

In problems of inducing structure, a person must identify the relationships that exist among the elements presented and construct a new relationship among them. In such a problem, it is necessary to determine not only the relationships among the elements, but the structure and size of the elements involved.

The Tower of Hanoi puzzle represents a third kind of problem. Transformation problems consist of an initial state, a goal state, and a series of methods for changing the initial state into the goal state. In the Tower of Hanoi problem, the initial state is the original configuration; the goal state consists of the three disks on the third peg; and the method consists of the rules for moving the disks.

Whether the problem is one of arrangement, inducing structure, or transformation, the initial stage of understanding and diagnosing is critical in problem solving because it allows us to develop our own cognitive representation of the problem and to place it within a personal framework. The problem may be divided into subparts or some information may be ignored as we try to simplify the task. Winnowing out nonessential information (such as the matches and cotton in the hanging strings problem) is often a critical step in problem solving.

Representing and Organizing the Problem
A crucial aspect of the initial encounter with a problem is the way in which we represent it to ourselves and organize the information presented to us (Brown & Walter, 1990, 1993; Davidson, Deuser, & Sternberg, 1994). Consider the following problem:
A man climbs a mountain on Saturday, leaving at daybreak and arriving at the top near sundown. He spends the night at the top. The next day, Sunday, he leaves at daybreak and heads down the mountain, following the same path that he climbed the day before. The question is this: Will there be any time during the second day when he will be at exactly the same point on the mountain as he was at exactly that time on the first day?

Production: Generating Solutions
If a problem is relatively simple, a direct solution may already be stored in long-term memory, and all that is necessary is to retrieve the appropriate information. If the solution cannot be retrieved or is not known, we must instigate a process by which possible solutions can be generated and compared with information in long- and short-term memory.

Trial and Error
At the most primitive level, solutions to problems can be obtained through trial and error. Thomas Edison was able to invent the light bulb only because he tried thousands of different kinds of materials for a filament before he found one that worked (carbon). The difficulty with trial and error, of course, is that some problems are so complicated it would lake a lifetime to try out every possibility.

Means-Ends Analysis
In place of trial and error, complex problem solving often involves the use of heuristics, which, as we discussed earlier, are rules of thumb that can lead the way to solutions. Probably the most frequently applied heuristic in problem solving is a means-ends analysis. In a means-ends analysis, people repeatedly test for differences between the desired outcome and what currently exists. For example, people using a means-ends analysis to search for the correct sequence of roads to get to a city that they can see in the distance would analyze their solutions in terms of how much closer each individual choice of roadway brings them to the ultimate goal of arriving at the city. Such a strategy is only effective, though, if there is a direct solution to the problem. If the problem is such that indirect steps have to be taken that appear to increase the discrepancy between the current state and the solution, means-ends analyses can be counterproductive.
For some problems, the converse of a means-ends analysis is the most effective approach: working backward by beginning with the goal and moving toward the starting state. Instead of starting with the current situation and moving closer and closer to the solution, people can work in the opposite direction, starting with the goal and aiming to reach the beginning point (Malin, 1979; Bourne et al., 1986; Hunt, 1994).

Subgoals

Another commonly used heuristic is to divide a problem into intermediate steps, or subgoals, and to solve each of those steps. For instance, in our modified Tower of Hanoi problem, there are several obvious subgoals that could be chosen, such as moving the largest disk to the third post.
If solving a subgoal is a step toward the ultimate solution to a problem, then identifying subgoals is an appropriate strategy. There are cases, however, in which the formation of subgoals is not all that helpful and may actually increase the time needed to find a solution (Hayes, 1966; Reed, 1996). For example, some problems cannot be subdivided. Others are so difficult to subdivide that it takes longer to identify the appropriate subdivisions than to solve the problem by other means. Finally, even when a problem is divided into subgoals, it may be unclear what to do after a given subgoal has been reached.

Insight

Some approaches to problem solving focus less on step-by-step processes than on the sudden bursts of comprehension that one may experience during efforts to solve a problem. Just after World War I, German psychologist Wolfgang Kohler examined learning and problem-solving processes in chimps (Kohler, 1927). In his studies, Kohler exposed chimps to challenging situations in which the elements of the solution were all present; all that was needed was for the chimps to put them together.
For example, in one series of studies, chimps were kept in a cage in which boxes and sticks were strewn about, with a bunch of tantalizing bananas hanging out of reach. Initially, the chimps engaged in a variety of trial-and-error attempts at getting to the bananas: They would throw the stick at the bananas, jump from one of the boxes, or leap wildly from the ground. Frequently, they would seem to give up in frustration, leaving the bananas dangling temptingly overhead. But then, in what seemed like a sudden revelation, they would abandon whatever activity they were involved in and standing on a box in order to be able to reach the bananas with a stick. Kohler called the cognitive processes underlying the chimps' behavior insight, a sudden awareness of the relationships among various elements that had previously appeared to be independent of one another.

Although Kohler emphasized the apparent suddenness with which solutions were revealed, subsequent research has shown that prior experience and initial trial-and-error practice in problem solving are prerequisites for "insight" (Metcalfe, 1986). One study demonstrated that only chimps who had experience in playing with sticks could successfully solve the problem; inexperienced chimps never made the connection between standing on the box and reaching the bananas (Birch, 1945). Some researchers have suggested that the behavior of the chimps represented little more than the chaining together of previously learned responses, no different from the way a pigeon learns, by trial and error, to peck a key (Epstein el al., 1984; Epstein, 1987, 1996). It is clear that insight depends on previous experience with the elements involved in a problem.

Judgment: Evaluating the Solutions

The final step in problem solving is judging the adequacy of a solution. Often, this is a simple matter: If there is a clear solution—as in the Tower of Hanoi problem—we will know immediately whether we have been successful.
On the other hand, if the solution is less concrete, or if there is no single correct solution, evaluating solutions becomes more difficult. In such instances, we must decide which solution alternative is best. Unfortunately, we are often quite inaccurate in estimating the quality of our own ideas (Johnson, Parrott, & Stratton, 1968). For instance, a team of drug researchers working for a particular company may feel that their remedy for an illness is superior to all others, overestimating the likelihood of success and belittling the approaches of competing drug companies.
Theoretically, if the heuristics and information we rely on to make decisions are appropriate and valid, we can make accurate choices among problem solutions. However, as we see next, there are several kinds of obstacles to and biases in problem solving that affect the quality of the decisions and judgments we make.

Impediments to Problem Solving

Consider the following problem-solving test (Duncker, 1945):
You are presented with a set of tacks, candles, and matches in small boxes, and told your goal is to place three candles at eye level on a nearby door, so that wax will not drip on the floor as the candles burn. How would you approach this challenge?
If you have difficulty solving the problem, you are not alone. Most people are unable to solve it when it is presented in the manner illustrated in the figure, in which the objects are located inside the boxes. On the other hand, if the objects were presented beside the boxes, just resting on the table, chances are you would solve the problem much more readily—which, in case you are wondering, requires 'tacking the boxes to the door and then placing the candles inside them.
The difficulty you probably encountered in solving the problem stems from its presentation and relates to the fact that you were misled at the initial preparation stage. Actually, significant obstacles to problem solving exist at each of the three major stages. Although cognitive approaches to problem solving suggest that thinking proceeds along fairly rational, logical lines as a person confronts a problem and considers various solutions, a number of factors hinder the development of creative, appropriate, and accurate solutions.
The problem here is to place three candles at eye level on a nearby door so that the wax will not drip on the floor as the candles burn—using only the tacks, candles, and matches in the small boxes.

Functional Fixedness and Mental Set

The reason that most people experience difficulty with the candle problem is a phenomenon known as functional fixedness, (he tendency to think of an object only in terms of its typical use. For instance, functional fixedness probably leads you to think of the book you are holding in your hands as something to read, as opposed to its value as a doorstop or as kindling for a fire. In the candle problem, functional fixedness occurs because the objects are first presented inside the boxes, which are then seen simply as containers for the objects they hold rather than as a potential part of the solution.
Functional fixedness is an example of a broader phenomenon known as mental set, the tendency for old patterns of problem solving to persist. This phenomenon was demonstrated in a classic experiment carried out by Abraham Luchins (1946). As you can see in Figure 8-8, the object of the task is to use the jars in each row to measure out the designated amount of liquid. (Try it yourself to get a sense of the power of mental set before moving on.)
If you have tried to solve the problem, you know that the first five parts are all solved in the same way: Fill the largest jar (B) and from it fill the middle-size jar (A) once and the smallest jar (C) two times. What is left in B is the designated amount. (Stated as a formula, it is B - A - 2C.) The demonstration of menial set comes with the sixth part of the problem, a point at which you probably encountered some difficulty. If you are like most people, you tried the formula and were perplexed when it failed. Chances are, in fact, that you missed the simple (but different) solution to the problem, which merely involves subtracting C from A. Interestingly, those people who were given problem 6 first had no difficulty with it at all.
Mental set can also affect perceptions. It can prevent you from seeing your way beyond the apparent constraints of a problem. For example, try to draw four straight lines so that they pass through all nine dots in the grid below—without lifting your pencil from the page.

If you had difficulty with the problem, it was probably because you felt compelled to keep your lines within the grid. If you had gone outside the boundaries, however, you would have succeeded with the solution

Inaccurate Evaluation of Solutions

When the nuclear power plant at Three Mile Island in Pennsylvania suffered its initial malfunction in 1979, a disaster that ALMOST led to a nuclear meltdown, the plant opera-
tors were faced immediately with solving a problem of the most serious kind. Several monitors indicated contradictory information about the source of the problem; One suggested that the pressure was too high, leading to the danger of an explosion; others indicated that the pressure was too low, which could lead to a meltdown. Although the pressure was in fact too low, the supervisors on duty relied on the one monitor—which was faulty—that suggested the pressure was too high. Once they had made their decision and acted upon it, they ignored the contradictory evidence from the other monitors (Wickens, 1984).

One reason for the operators' mistake is the confirmation bias, in which initial hypotheses are favored and contradictory information supporting alternative hypotheses or solutions is ignored. Even when we find evidence that contradicts a solution we have chosen, we are apt to stick with our original hypothesis.

There are several reasons for the confirmation bias. One is that it takes cognitive effort to rethink a problem that appears to be solved already, so we are apt to stick with our first solution. Another is that evidence contradicting an initial solution may present something of a threat to our self-esteem, leading us to hold to the solutions that we have come up with first (Fischoff, 1977; Rasmussen, 1981).

Creativity and Problem Solving

Despite obstacles to problem solving, many people are adept at coming up with creative solutions to problems. One of the enduring questions that cognitive psychologists have sought to answer is what factors underlie creativity, the combining of responses or ideas in novel ways (Isaksen & Murdock, 1993; Boden, 1994, 1996; Smith, Ward, & Finke, 1995).

Although identifying the stages of problem solving helps us to understand how people approach and solve problems, it does little to explain why some people—such as Jacob Rabinow, whose inventions were described in the Prologue—come up with better solutions than others. For instance, the possible solutions to even the simplest of problems often show wide discrepancies. Consider, for example, how you might respond to the question, "How many uses can you think of for a newspaper?"

Now compare your own solution with this one proposed by a 10-year-old boy:

You can read it, write on it, lay it down and paint a picture on it. . . . You could put it in your door for decoration, put it in the garbage can, put it on a chair if the chair is messy. If you have a puppy, you put newspaper in its box or put it in your backyard for the dog to play with. When you build something and you don't want anyone to see it, put newspaper around it. Put newspaper on the floor if you have no mattress, use it to pick up something hot, use it to stop bleeding, or to catch the drips from drying clothes. You can use a newspaper for curtains, put it in your shoe to cover what is hurting your foot, make a kite out of it, and shade a light that is too bright. You can wrap fish in it, wipe windows, or wrap money in it. . . . You put washed shoes in newspaper, wipe eyeglasses with it, put it under a dripping sink, put a plant on it, make a paper bowl out of it, use it for a hat if it is raining, tie it on your feet for slippers. You can put it on the sand if you had no towel, use it for bases in baseball, make paper airplanes with it, use it as a dustpan when you sweep, ball it up for the cat to play with, wrap your hands in it if it is cold (Ward, Kogan, & Pankove, 1972).

It is obvious that this list shows extraordinary creativity. Unfortunately, it has proved to be considerably easier to identify examples of creativity than to determine its causes. Several factors, however, seem to be associated with creativity (Swede, 1993; Csikszentmihalyi, 1997; Ward, Smith, & Vaid, 1997).

One of these factors is divergent thinking. **Divergent thinking** refers to the ability to generate unusual, yet nonetheless appropriate, responses to problems or questions this type of thinking contrasts with convergent thinking, which produces responses that are based primarily on knowledge and logic. For instance, someone response lying or convergent thinking answers "You read it"'

Psychologists Robert Sternberg and Todd Lubart suggest that one important ingredient of creativity is the willingness to take risks that may result in potentially high payoffs (Sternberg & Lubart. 1992, 1995, 1996; Lubart & Sternbreg. 1995). In their view, creative people are similar to successful stock market investors, who follow the rule of "buying low and selling high." In an analogous fashion, creative individuals formulate and promote ideas that arc, at least for the moment, out-of-synch with prevailing wisdom ("buying low"). Ultimately, though, highly creative people expect that their ideas will rise in value and that others will ultimately find them of value and adopt them ("selling high").

Another ingredient of creativity is cognitive complexity; the use of and preference for elaborate, intricate, and complex stimuli and thinking patterns. Similarly, creative people often have a wider range of interests and are more independent and more interested in philosophical or abstract problems than arc less creative individuals (Barron, 1990).

One factor that is not closely related to creativity is intelligence. Most items on intelligence tests, which are well defined and have only one acceptable answer, focus on convergent thinking skills. Creative people who are divergent thinkers may therefore find themselves at a disadvantage when taking such tests. This may explain why researchers consistently find that creativity is only slightly related to intelligence or school grades, particularly when intelligence is measured using typical intelligence tests (Barron & Harrington, 1981; Sternberg, 1988; Albert, 1992; Simonton, 1994; Hong, Milgram, & Gorsky, 1995).

LESSON 14

THINKING

What is thinking?

The mere ability to pose such a question illustrates the distinctive nature of the human ability to think. No other species can contemplate, analyze, recollect, or plan in the way that humans can. Yet knowing that we think and understanding what thinking is are two different things. Philosophers, for example, have argued for generations about the meaning of thinking, with some placing it at the core of human beings' understanding of their own existence.

To psychologists, thinking is the manipulation of mental representations of information. The representation may be a word, a visual image, a sound, or data in any other modality. What thinking does is to transform the representation of information into a new and different form for the purpose of answering a question, solving a problem, or reaching a goal.

Although a clear sense of what specifically occurs when we think remains elusive, the nature of the fundamental elements involved in thinking is becoming increasingly well understood. We begin by considering our use of mental images and concepts, the building blocks of thought.

Mental Images: Examining the Mind's Eye

Think of your best friend. Chances are that you "see" some kind of visual image when asked to think of her or him, or any other person or object, for that matter. To some cognitive psychologists, such mental images represent a major part of thinking.

Mental images are representations in the mind that resemble the object or event being represented. They are not just visual representations; our ability to "hear" a tune in our head also relies on a mental image. In fact, it may be that every sensory modal¬ity produces corresponding mental images (Paivio, 1971, 1975; Kosslyn, 1981; Koss-lyn et al., 1990; Kosslyn & Shin, 1994).

Research has found that our representations of mental images have many of the properties of the actual perception of objects being represented. For example, it takes more time to scan the mental visual representations of large objects than small ones, just as it takes more time to scan an actual large object than an actual small one. Similarly, we are able to manipulate and rotate mental visual images of objects, just as we are able to manipulate and rotate them in the real world (Kosslyn. 1981; Cooper & Shepard, 1984; Denis & Greenbaum, 1991; Brandimonte. Hitch, & Bishop, 1992; Sharps, Price. & Williams 1994)

The production of mental images has been heralded by some as a way to improve performance of various skills. For instance, many athletes use mental imagery in training. Basketball players may try to produce vivid and detailed images of the basket, the ball, and the noisy crowd. They may visualize themselves' taking a foul shot, watching the ball, and hearing the swishing sound as it goes through the net (May, 1989; Issac A: Marks, 1994). Systematic evaluations of the use of mental imagery by athletes suggest that it is useful in providing a means for improving performance in the sports arena (Druckman & Bjork. 1991).

Mental imagery may produce improvements in other types of skills as well. For example, from the realm of music, researcher Alvaro Pascual-Lconc taught a group of people to play a five-finger exercise on the piano. One group practiced every day for five days, while a control group played without any training, just hitting the keys at random. Finally, the members of a third group were taught the exercise but were not allowed to actually try it out on the piano. Instead, they rehearsed it mentally, sitting at the piano and looking at the keys, but not actually touching them.

When brain scans of people in the groups were compared, researchers found a distinct difference between those who manually practiced the exercise and those who just randomly hit keys. However, the most surprising finding came from the group that mentally rehearsed: Their brain scans were virtually identical to those of the people who had actually practiced the exercise manually. Apparently, the same network of brain cells involved in carrying out the task was involved in mentally rehearsing it (Chase. 1993; Pascual-Leone et al.. 1995).

Such researches suggest that children whose parents nag them about practicing an instrument, a dance routine, or some other skill that requires practice can now employ a new excuse: They are practicing mentally.

Concepts: Categorizing the World

If someone asked you what was in your kitchen cabinet, you might answer with a detailed list of every item ("a jar of Skippy peanut butter, three boxes of macaroni and cheese, six unmatched dinner plates," and so forth). More likely, though, you would respond by using some broader categories, such as "food" and "dishes."

The use of such categories reflects the operation of concepts. Concepts are categorizations of objects, events, or people that share common properties. By employing concepts, we are able to organize complex phenomena into simpler, and therefore more easily usable, cognitive categories.

Concepts allow us to classify newly encountered objects on the basis of our past experience. For example, we can surmise that a small rectangular box with buttons that is on a chair near a television is probably a remote control—even if we have never encountered that specific brand before. Ultimately, concepts influence behavior; we would assume, for instance, that it might be appropriate to pet an animal after determining that it is a dog, while we would behave differently after classifying the animal as a wolf.

When cognitive psychologists first studied concepts, they focused on those that were clearly defined by a unique set of properties or features. For example, an equilateral triangle is a shape that has three sides of equal length. If an object has these characteristics, it is an equilateral triangle; if it does not, then it is not an equilateral triangle.

Other concepts—often those with the most relevance to our everyday live—are more ambiguous and difficult to define. For instance, concepts such as "table" or "bird" share a set of general, relatively loose characteristic features, rather than unique, clearly defined properties that distinguish an example of the concept from a nonexample. When we consider these more ambiguous concepts, we usually think in terms of examples called prototypes. Prototypes are typical, highly representative examples of a concept. For instance, a prototype of the concept "bird" is a robin; a prototype of "table" is a coffee table. Relatively high agreement exists among people as to which examples of a concept are prototypes, as well as which examples are not. For instance, most people consider cars and trucks good examples of vehicles, whereas elevators and wheelbarrows are not viewed as very good examples. Consequently, cars and trucks are prototypes of the concept of vehicle.

Concepts enable us to think about and understand more readily the complex world in which we live. For example, the judgments we make about the reasons for other people's behavior are based on the ways in which we classify their behavior. Hence, our evaluations of a person who washes her hands twenty times a day could vary, depending on whether we place her behavior within the conceptual framework of health care worker or mental patient. Similarly, physicians make diagnoses by drawing upon concepts and prototypes of symptoms that they learned about in medical school. Finally, concepts and prototypes facilitate our efforts to draw suitable conclusions through the cognitive process we turn to next: reasoning.

Thinking Critically and Creatively

Cognitive researchers have found that all of us can learn to perform better on decision making and problem-solving tasks. Abstract rules of logic and reasoning can be taught, and such training can improve the way in which we are able to reason about the underlying causes of everyday life events.

In short, research by cognitive psychologists has suggested that critical and creative thinkers are made, not born. Consider, for instance, some of these suggestions for increasing critical thinking and creativity (Anderson, 1993; Feldman, Coats, & Schwartzberg, 1994; Conti, Amabile, & Pollak, 1995; Halpern, 1995; Schaller et al., 1996; Levy, 1997; Baer, 1997):

Redefine problems. The boundaries and assumptions we hold can be modified. For example, a problem can be rephrased at either a more abstract or more concrete level.

Use fractionation. In fractionation, an idea or concept is broken down into the parts that make it up. Through fractionation, each part can be examined for new possibilities and approaches, leading to a novel solution for the problem as a whole.

Adopt a critical perspective. Rather than passively accepting assumptions or arguments, we can critically evaluate material by considering its implications and thinking about possible exceptions and contradictions.

Consider the opposite. By considering the opposite of a concept we're seeking to understand, we can sometimes make progress. For example, in order to define "good mental health," it might be useful to consider what is meant by "bad mental health."

Use analogies. Analogies not only help us uncover new understanding, they provide alternative frameworks for interpreting facts. One particularly effective means of coming up with analogies is to look for them in the animal kingdom when the problem concerns people, and in physics or chemistry when the problem concerns inanimate objects. For instance, the idea for the unique packaging of Pringles potato chips reputedly arose when a manufacturer noticed that dry tree leaves, which normally crumble easily, could be packed together tightly if they were moistened slightly (Rice, 1984; Holyoak & Thagard, 1994; Reisbcrg, 1997; Getner & Holyoak, 1997).

Cognitive psychologists haw found that creativity and critical thinking skills, such as those involved in the

Think divergently. Instead of thinking in terms of the mt>st logical or most common use for an object, we can consider how it might be of help if we were forbidden to use it in its usual way.
Take the perspective of another person. By temporarily adopting the point-of-view of another person, it may be possible to gain a fresh view of the situation.
Use heuristics. Heuristics are rules of thumb that can help bring about a solution to a problem. If the nature of the problem is such that it has a single correct answer, and a heuristic is available or can be constructed, using the heuristic frequently helps to develop a solution more rapidly and effectively.
Experiment with various solutions. We shouldn't be afraid to use different routes to find solutions for problems (verbal, mathematical, graphic, and even acting out a situation). For instance, we might try to come up with every conceivable idea we can, no matter how wild or bizarre it may seem at first. After we've come up with a list of solutions, we can review each one and try to think of ways of making what at first appeared impractical seem more feasible.

Language

Our ability to make sense out of nonsense, if the nonsense follows typical rules of language, illustrates both the sophistication of human language capabilities and the complexity of the cognitive processes that underlie the development and use of language. The use of language—the systematic, meaningful arrangement of symbols—clearly represents an important cognitive ability, one that is indispensable for communicating with others. But language is not only central to communication, it is also closely tied to the very way in which we think about and understand the world, for there is a crucial link between thought and language. It is not surprising, then, that psychologists have devoted considerable attention to studying the topic of language (Harley, 1995; Forrester, 1996; Velichkovsky & Rumbaugh, 1996).

Grammar: Language's Language

In order to understand how language develops, and what its relationship to thought is, we firs! need to review some of the formal elements that constitute language. The basic structure of language rests on grammar. Grammar is the system of rules that determine how our thoughts can be expressed.
Grammar deals with three major components of language: phonology, syntax, and semantics. Phonology is the study of the smallest sound units, called phonemes, affect the meaning of speech, and of the way we use those sounds to produce meaning by forming them into words. For instance, the "a" in "fat" and the "a" in "fate" represent two different phonemes in English (Halle, 1990; Feldman, 1995; Hirsh-Pasek & Golinkoff, 1996; Vihman, 19%).

Although English speakers use just 42 basic phonemes to produce words, the basic phonemes of other languages range from as few as 15 to as many as 85 (Akmajian, De-mers, & Hamish, 1984). Differences in phonemes are one reason people have difficulty in learning other languages: For example, to the Japanese speaker, whose native language does not have an "r" phoneme, English words such as "roar" present some difficulty.

Syntax refers to the rules that indicate how words and phrases can be combined to form sentences. Every language has intricate rules that guide the order in which words may be strung together to communicate meaning. English speakers have no difficulty recognizing that "Radio down the turn" is not an appropriate sequence, while "Turn down the radio" is. The importance of appropriate syntax is demonstrated in English by the changes in meaning that are caused by the different word orders in the following three utterances: "John kidnapped the boy," "John, the kidnapped boy," and "The boy kidnapped John" (Lasnik, 1990).

The third major component of language is semantics. Semantics refers to the rules governing the meaning of words and sentences (Larson, 1990; Hipkiss, 1995; O'Grady & Dobrovolsky, 1996). Semantic rules allow us to use words to convey the subtlest of nuances. For instance, we are able to make the distinction between "The truck hit Laura" (which we would be likely to say if we had just seen the vehicle hitting Laura) and "Laura was hit by a truck" (which we would probably say if asked why Laura was missing class while she recuperated).

Despite the complexities of language, most of us acquire the basics of grammar without even being aware that we have learned its rules (Pinker, 1994). Moreover, even though we might have difficulty explicitly stating the rules of grammar that we employ, our linguistic abilities are so sophisticated that they enable us to utter an infinite number of different statements. We turn now to a consideration of how such abilities are acquired.

Language Development: Developing a Way with Words

To parents, the sounds of their infant babbling and cooing are music to their ears. These sounds also serve an important function: They mark the first step on the road to the development of language.

Children babble—make speech like but meaningless sounds—from around the ages of 3 months through 1 year. While they babble they may produce, at one time or another, any of the sounds found in all languages, not just the one to which they are exposed. Even deaf children display their own form of babbling: Infants who are unable to hear and who are exposed to sign language from birth "babble," but they do it with their hands (Petitto & Marentette, 1991; Pettito. 1993; Meier & Willerman, 1995).

Babbling increasingly reflects the specific language that is being spoken in the environment, initially in terms of pitch and tone, and eventually in terms of specific sounds (Reich, 1986; Kuhl et ah, 1992; de Boysson-Bardies & Halle, 1994). By the time the child is approximately 1 year old, sounds that are not in the language disappear. It is then a short step to the production of actual words. In English, these are typically short words that start with a consonant such as "b," "d," "m," "p," or "t"— which helps to explain why "mama" and "dada" are so often among babies' first words. Of course, even before they produce their first words, children are capable of understanding a fair amount of the language they hear. Language comprehension precedes language production.

After the age of 1 year, children begin to learn more complicated forms of language. They produce two-word combinations, which become the building blocks of sentences, and the number of different words they are capable of using increases sharply. By the age of 2 years, the average child has a vocabulary of more than fifty words. Just six months later, that vocabulary has grown to several hundred words. At that time, children can produce short sentences, although they use telegraphic speech—sentences that sound as if they were part of a telegram, in which words not critical to the message are left out. Rather than saying, "I showed you the book," a child using telegraphic speech might say, "I show book"; and "I am drawing a dog" might become "Drawing dog." As the child gets older, of course, the use of telegraphic speech declines and sentences become increasingly complex.

By age 3, children learn to make plurals by adding "s" to nouns and to form the past tense by adding "ed" to verbs. This ability also leads to errors, since children tend to apply rules too inflexibly. This phenomenon is

known as overgeneralization, whereby children apply rules even when the application results in an error. Thus, although it is correct to say "he walked" for the past tense of "walk," the "ed" rule doesn't work quite so well when children say "he runned" for the past tense of "run" (Marcus, 1996).
Much of children's acquisition of the basic rules of language is complete by the time they are five. However, a full vocabulary and the ability to comprehend and use subtle grammatical rules are not attained until later. For example, a 5-year-old boy who is shown a blindfolded doll and asked, "Is the doll easy or hard to see?" would have great difficulty responding to the question. In fact, if he were asked to make the doll easier to see, he would probably try to remove the doll's blindfold. On the other hand, 8-year-olds have little difficulty understanding the question, realizing that the doll's blindfold has nothing to do with an observer's ability to see the doll (Chomsky, 1969).

Understanding Language Acquisition: Identifying the Roots of Language
Anyone who spends even a little time with children will notice the enormous strides that they make in language development throughout childhood. However, the reasons for this rapid growth arc far from obvious. Two major explanations have been offered: one based on learning theory and the other on innate processes.

The learning-theory approach suggests that language acquisition follows the principles of reinforcement and conditioning For example, a child who utters the word "mama" is hugged and praised by her mother, which reinforces the behavior and makes its repetition more likely. This view suggests that children first learn to speak by being rewarded for making sounds that approximate speech. Ultimately, through a process of shaping, language becomes more and more like adult speech (Skinner, 1957).
The learning theory approach is supported by research that shows that the more parents speak to their young children, the more proficient the children become in language usage. In addition, higher levels of linguistic sophistication in parents' speech to their young children arc related to a greater rate of vocabulary growth, vocabulary usage, and even general intellectual achievement by the time the children are 3 years of age (Hart & Risley, 1997).

On the other hand, the learning theory approach is less successful when it comes to explaining the acquisition of language rules. Children arc reinforced not only when they use proper language, but also when they respond incorrectly. For example, parents answer the child's "Why the dog won't eat?" as readily as they do the correctly phrased question "Why won't the dog eat?" Both sentences arc understood equally well. Learning theory, then, has difficulty in providing the full explanation for language acquisition.
Pointing to such problems with learning theory approaches to language acquisition. Noam Chomsky (1968. 1978. 1991), a linguist, provided a ground-breaking alternative. Chomsky argued that humans are born with an innate linguistic capability that emerges primarily as a function of maturation. According to his analysis, all the world's languages share a similar underlying structure called a universal grammar. Chomsky suggests that the human brain has a neural system, the language-acquisition device that both permits the understanding of the structure of language and provides strategies and techniques for learning the unique characteristics of a given native language.

In a sense, then, the brain's hard-wired language-acquisition device provides the hardware for our acquisition of language; exposure to language in our environment allows us to develop the appropriate software. Chomsky argues that language is a uniquely human phenomenon made possible by the presence of the language-acquisition device.

Chomsky's view, as you might suspect, is not without its critics. For instance, learning theorists contend that the apparent ability of animals such as chimpanzees to learn the fundamentals of human language contradicts the innate view. Thus, the issue of how humans acquire language remains hotly' contested (Rice, 1989; Pinker, 1990, 1994; McDonald, 1997).

The Influence of Language on Thinking
Do Eskimos living in the frigid Arctic have a more expansive vocabulary for discussing snow than people living in more temperate climates?' Contrary to conventional wisdom, probably not arguments that the

Eskimo language has many more words than English for "snow" have been made since the early 1900s. At that time, linguist Benjamin Lee Whorf contended that because snow is so relevant to Eskimos' lives, they had developed a rich vocabulary to describe it —far richer than what we find in other languages, such as English. As time went on, the supposed number of Eskimo words for snow took on mythic proportions, with one account suggesting that there were four hundred distinct Eskimo terms for snow (Martin & Pullum, 1991; Pinker, 1994).

However, most psychologists now agree that such claims were based more on myth than on reality. Eskimos have no more words for snow than English speakers. In fact, if you examine the English language closely, it is hardly impoverished when it comes to describing snow. (Consider sleet, slush, blizzard, dusting, and avalanche, for starters.)

The contention that the Eskimo language is particularly rich in snow-related terms was used as evidence for a controversial notion known as the linguistic-relativity hypothesis. According to the **linguistic-relativity hypothesis**, language shapes and, in fact, may determine the way people of a particular culture perceive and understand the world "(Whorf, 1956; Lucy, 1992,1996; Smith, 1996). According lo this view, language provides us with categories that we use to construct our view of people and events in the world around us. Consequently, language shapes and produces thought.

Let's consider another possibility, however. Suppose that, instead of language being the cause of certain ways of thinking about the world, language is a result of thinking about and experiencing relevant stimuli in the environment. In this view, thought produces language. The only reason to expect that Eskimo language might have more words for "snow" than English is that snow is considerably more relevant to Eskimos than it is to people in other cultures.

In an effort to determine which of the two descriptions (language produces thought versus thought produces language) provides the more accurate account, investigators have carried out a significant amount of research. In one important study, Eleanor Rosch (1974) compared the perception of colors by Americans and by members of the Dani tribe of New Guinea. The Dani have only two names for color: one for cold, dark colors and one for warm, lighter colors. In English, of course, there arc hundreds of color names, but eleven of them represent major color categories (red, yellow, green, blue, black, gray, white, purple, orange, pink, and brown). Rosch argued that if the linguistic-relativity hypothesis were accurate. English speakers should be more efficient at recognizing and distinguishing colors that represent the major categories than colors that are not members of major categories. In contrast, she reasoned that the Dani tribe members should show no difference in recognition between colors that are members of major or non-major categories, since there arc no words in their vocabulary to describe any of them.

However, the results did not support this hypothesis. There was no difference in the way that English speakers and Dani perceived the colors; both perceived colors in the major categories more efficiently than colors outside the major categories. According to these results, then, language differences do not influence perception.
Subsequent research supports Rosch's findings and, by and large, has not supported the linguistic-relativity hypothesis (Brown, 1986; Pinker, 1990; Laws. Davics. & Andrews, 1995). It seems most appropriate to conclude that, in general, cognition influences language and not the other way around.

For years Sondra's future was considered bleak. Born deaf, mute, and mentally retarded Sondra appeared to have no hope of ever speaking. Today, though, she is able to make simple requests using a computer-based language developed by a group of researchers who were initially interested in the language capabilities of chimpanzees.
Sondra"s transformation came about as a result of a line of research being pursued by psychologist Rose Sevcik as a member of a team of researchers seeking to refine our understanding of language development by studying both children and chimpanzees. Scvcik's goal is to develop a language system for children who due to various disabilities, do not develop speech.

Sevcik began her pursuit of this goal at John Carroll University, a small liberal arts institution in Ohio, which provided the right blend of courses and faculty. "The school offered a lot of undergraduate requirements in all types of disciplines," says Sevcik. "I found a course on research methods quite stimulating because I had the opportunity to learn about the neural sciences, and how the brain influences and affects behavior.'"

Graduating with an A.B. in psychology, Sevcik went on to the University of Connecticut and obtained a master's degree in experimental physiological psychology, followed by a doctorate in developmental comparative psychology at Georgia State University.

It was at the University of Connecticut, however, that she began to study how children and chimpanzees use and develop language. "I had the experience of taking courses that focused on the relationship between biology and behavior," she notes. "I developed my thesis on the abilities of monkeys to perceive synthesized speech. What really got me into all of this was asking the question, 'Do these animals have any capacity to teach us something about how humans use and develop language?'

"When I came to Atlanta to continue my graduate studies, we used an artificial language developed in a study of how the great apes handle a systematic language system," Sevcik continues. "My doctoral thesis was on how a rare species of infant pygmy chimps would develop a communication system when their only exposure was being shown the language."

Currently Sevcik works in the mornings with children and in the afternoons with chimps. '"We are at work on a long-term project involving the use of microcomputer technology to develop an augmented system for kids who do not develop speech." she says. "We want to know if such children can be taught to speak, despite severe cognitive and linguistic disabilities. To answer this question, we need to determine how they proceed toward normal' development and how they learn. We don't just want to look at the kids: we also want them to benefit." For developmentally disabled children such as Sondra, who may learn to communicate effectively for the first time such work offers real promise.

On the other hand, language does affect thinking and cognition in certain respects. The manner in which information is stored in memory—and how well such information can subsequently be retrieved —is related to language. Similarly, our impressions and memories of others' personality and behavior are affected by the linguistic categories provided us by the language we speak (Hoffman Lau. & Johnson, 1986: McFadyen. 1996)

Do Animals Use Language?

One of the enduring questions that has long puzzled psychologists is whether language-is uniquely human or if other animals are able to acquire it as well. It is clear that many animals communicate with one another in some rudimentary forms, such as fiddler crabs that wave their claws to signal, bees whose dance indicates the direction in which food will be found, or certain birds that say "zick. zick" during courtship and "kia" when they are about to fly away. But researchers have vet to demonstrate conclusively that these animals use true language, which is characterized in part by the ability to produce and communicate new and unique meanings following a formal grammar.

Psychologists have, however, been able to teach chimps to communicate at surprisingly high levels. For instance, Kanzi, a 9-year-old pygmy chimpanzee, has linguistic skills that some psychologists claim are close to those of a 2-year-old human being. Psychologist Sue Savage-Rumbaugh and colleagues, who have worked extensively with Kanzi, suggest that he can create sentences that are grammatically sophisticated and can even concoct new rules of syntax (Savage-Rumbaugh et al., 1993).

Despite the skills displayed by primates such as Kanzi critics contend that the language they use still lacks the grammar and sufficiently complex and novel constructions that characterize the realm of human capabilities (Seidenberg & Petitto, 1987). Instead, they maintain that the chimps are displaying a skill no different from that of a dog that learns to lie down on command in order to get a reward. Furthermore, firm evidence is lacking that animals are able to recognize and respond to the mental states of others of their species, an important aspect of human communication (Cheney & Seyfarth. 1990; Seyfarth & Cheney, 1992, 1996).

Most evidence supports the contention that humans are better equipped than animals to produce and organize language in the form of meaningful sentences. But the issue of whether animals are capable of being taught to communicate in a way that resembles human language remains controversial (Savage-Rumbaugh, 1987; Gibbons, 1991; Cenami Spada, 1994; Gilbert, 1996; Savage-Rumbaugh & Brakke, 1996).

LESSON 15

EXPERIMENTAL RESEARCH

Psychological Experiment

We use the term psychological experiment to refer to investigations in which at least one variable is manipulated in order to study cause-and-effect relationships. We will emphasize experimental research in which the researcher manipulates some factors (variables), controls others, and ascertains the effects of the manipulated variable on another variable. In some experiments the researcher may not manipulate a variable physically, but can manipulate it through selection, as was the case in the toy selection example. The researchers did not inject androgen into the bloodstream of the girls (although such a procedure might be an even more direct test of the hypothesis), but they did select children whom the researchers had good reason to suspect had a high level of androgen in their blood. In this case, the manipulation of one variable was done through selection rather than with the imposition of a factor. It is this search for relationships between specific events and their consequences (cause and effect) that is so characteristic of scientific research.

The tendency for boys to play with dump trucks, tractors, race cars, and Erector sets, and for girls to play with dolls, doll furnishings, and kitchen equipment, has been known for a very long time. What causes this difference in play between the sexes? How might it be studied and analyzed? What would the results of such a study tell us about gender behavior?

These questions and others were posed by Sheri Berenbaum and Melissa Hines, who work as research psychologists in medical settings.* In an article that appeared in Psychological Science (Berenbaum & Hines, 1992), entitled "Early Androgens Are Related to Childhood Sex-Typed Toy Preferences,"** the basis of gender-specific preferences for certain types of toys was examined.

It is well known, not only from the psychological literature but also from common knowledge,* that young boys and young girls are encouraged to play with certain toys and are discouraged from playing with others. Boys who play with dolls, for example, soon learn that such behavior may be seen as unacceptable and they may be labeled as "sissies," while girls who eschew kitchen toys for dump trucks may be labeled "tomboys." Although social learning and social pressure surely influence what toys children play with, might other forces be operating, such as hormones and/or genetics?

To test this idea, Berenbaum and Hines selected girls who experienced a genetic disorder known as congenital adrenal hyperplasia (CAH), a condition that produces a high volume of the hormone androgen, normally found in large concentrations in boys. (Boys with similar conditions were also reviewed in this study.) The researchers then evaluated the amount of time girls with CAH spent playing with "boys' toys" versus the amount of time with "girls' toys" and "neutral toys." They discovered that girls who had CAH spent more time playing with cars, fire engines, and Lincoln Logs than did girls with similar environmental backgrounds but without CAH. The authors concluded that "early hormone exposure in females has a masculinizing effect on sex-tied toy preferences." Thus, one more part of the determinants of sex-linked behavior was solved.

Scientific Methodology

Our approach to the use of scientific methodology in the study of psychology is established on two principles. The first is that scientific observations are based

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Experimental psychologists do not trust common knowledge but seek scientific validation for beliefs.
On sensory experiences, we see, hear, touch, taste, and smell the world we live in. These observations, which are made under certain defined circumstances, or controlled conditions as they are called in experimental psychology, should correspond to the observations made by another scientist under

comparable conditions. This feature of replicating the results of an experiment is called reliability of results and is a major requisite of scientific credibility.

However, because our sensory systems are limited in capability as well as scope, many signals outside the range of normal sensitivity remain unnoticed, meaning that those things that are detected take on a disproportionately greater significance. We call this the tyranny of the senses, recognizing that it is difficult to consider the importance of some of the real phenomena in the universe that lie outside the range of unassisted human perception.

Consider electromagnetic forces, which are all around us. At one end of the electromagnetic spectrum are cosmic rays, gamma rays, and X rays, and on the other end are radio waves and television waves. In the middle, between about 380 and 760 nanometers, are waves that are detectable by the human eye. For most of human history, the energy that fell within the visual spectrum was considered to be "reality." The same constricted view of reality applies to all the other senses. Even though we have become aware of the presence of forms of energy that we cannot experience, we continue to emphasize the sensations that we can detect through the ordinary senses.

Some augmentation of the senses has been achieved through the development of technology. Many instruments and techniques in science are designed primarily to make "visible" those things that are "invisible" to the unaided sensory system. These instruments—the microscope, radio telescope, and spectroscope, for example—translate energy outside the normal range of human detection into signals that can be understood by humans. In psychology, many sophisticated instruments have been developed that allow us to see deep within the psyche of a species and reveal secrets of human and animal life that were invisible and left to conjecture and speculation only a few years ago. We will encounter many of these techniques in this book, and we remind reader that if a technique does not yet exist for a topic of interest, there is no prohibition against the invention of one.
The second principle upon which scientific methodology relies is that observations from our senses are organized logically into a structure of knowledge. Frequently in experimental psychology these structures of knowledge are called models. Cognitive psychologists may, for example, develop a model of memory based on their observations of two types of memory and the laws that govern their relationship and the storage of information. The structural web that creates models from observations and turns these models into theories is based on the principles of logic, which in the current context has developed out of the rich history of Western empirical thought. It is not our purpose here to deal in detail with this structural web, but rather to discuss some topics in the philosophy of science that relate to experimental psychology. The interested student can find extensive writings on this topic.

Development of Thoughts and Hypotheses in Experimental Psychology
One of the most difficult tasks confronting beginning students in experimental psychology is to organize their thoughts and develop a testable hypothesis for a given topic. For many reasons, this is difficult not only for the novice but also for the seasoned researcher. A major reason for the difficulty is a lack of knowledge. New research ideas rarely, if ever, erupt spontaneously from an intellectual void. Rather, new ideas and hypotheses usually are built on existing knowledge and past research. Therefore, the best advice on how to develop new thoughts and hypotheses is to immerse yourself in the literature of a branch of psychology that holds some real interest for you.* Read, discuss, investigate, and become well versed in the subject matter. But passive knowledge is not enough. As you acquire knowledge about a topic, question the premise, the conclusions, and the technique and relate it to your knowledge of other matters. The development of new ideas in psychology, as well as in other disciplines, rests on the acquisition of the fundamental elements of a subject and flexibility in thinking about them, which allows one to combine and recombine the elements of thought in increasingly novel and meaningful patterns.
New ideas are based on old ideas, new inventions on old inventions, and new hypotheses on old hypotheses. Contrary to popular lore and media fiction, scientific advancements often come from small increments of progress, rather than from a single brilliant discovery. Of course, we all aspire to that major scientific breakthrough and your budding enthusiasm for achieving scientific eminence should not be

discouraged. But such profound achievements are rare, and while most research projects fall short of seminal programs, they can nonetheless contribute mightily to the overall growth of scientific knowledge.
To illustrate the point of the accumulation of knowledge, consider an innocent question asked a few years ago Dy a son of one of the authors: "Who invented the automobile?" Trying to be instructive, the author told the boy that in about 1886 Karl Benz invented the automobile. "Wow, he must have been a real genius to figure out the-engine, the brakes, the spark plugs, the wheels, and how everything worked together!" "Well, there were others, such as Henry Ford, R. E. Olds, and Daimler, and someone else invented the tires; I think it was Firestone. And then there was even the person who invented the wheel. . . But then the author experienced a moment of realization. "I think I may have

Recently, the growth of knowledge in nearly every branch of scientific inquiry, including psychology, has been so rapid that it is difficult for students and professional scientists to keep up with current facts and theories in their field. More and more we are seeing scientists use data banks, which store vast amounts of information in computer memories. As a consequence of the explosion of scientific information, a first step in the experimental process is frequently a computer-assisted search of the literature
No one person invented all of the components of the automobile any more than a single person invented the television, the theories of memory, or the symphony. Many people made significant discoveries that led to the invention of the automobile as well as scientific discoveries."
The development of knowledge in psychology progresses along similar lines. Given an inquiring and creative mind, knowledge, resources, flexibility, dedication, and a determined heart, many important scientific truths lie waiting to be uncovered by future scientists. Past discoveries beget future discoveries, past knowledge begets future knowledge, and, indeed, past wisdom may beget future wisdom.

Nonexperimental (but Empirical) Research
Rigid thinking and dogmatism have been the two enemies of creativity and flexibility in research. For years experimental psychology in America eschewed research that did not conform to the paradigm in which a variable is introduced (or inferred) and its consequence observed. The traditional experimental design followed the pattern of finding cause-and-effect relationships between antecedent events and their consequences.
But there are many interesting psychological issues that do not lend themselves to this neat experimental paradigm, and we need to investigate these issues with reliable measures. Some of these issues include the buying habits of steel workers in Pittsburgh, the difference between the number of bipolar personalities in Miami and Seattle, and the trends in fashion over the past century. These topics, and hundreds of other like topics, are interesting, worthwhile, and important to psychologists and they may be investigated scientifically, studied empirically, and can yield reliable data. The task of the researcher is to make decisions and justify them. The first of which is often the type of experiment or study to conduct, given the particular researcher question. Therefore, it is important that the student of experimental psychology be familiar with a variety of research methods in order to know when it is (and when it is not) appropriate to use an experimental design.

Operational Definitions
Before a researcher proceeds with an experiment he or she usually has conceptual definitions of variables to be studied—anxiety, intelligence, ego involvement, drives, distributed practice, and reinforcement, for example. But to do creditable research, which not only communicates effectively with one's audience but also allows others to replicate one's work, psychologists must operationally define these concepts (words) by specifying precisely how each is manipulated or measured. An operational definition is a statement of the operations necessary to produce and measure a concept. In other words, it defines a concept in terms of how it is measured. There is considerable variability as to the extent to which variables can be operationally defined in a precise manner that retains the full meaning of the concept. On one hand, variables such as the spacing of practice, as used in the Lorge experiment, or the delay of feedback, as used in More's (1969) experiment later in this chapter, or the presence of congenital adrenal hyperplasia (CAH) in young girls, as indicated in the Berenbaum and Hines experiment, are fairly easy to operationally define. On the other hand, psychologists use abstract concepts such as intelligence, hostility, antisocial behavior, or anxiety, which may be somewhat more difficult to operationally define in a manner that includes the full complexity

of the concept and has some empirical basis. What exactly do those terms really mean? Good experimental psychologists insist on the "operational definition" of terms. Words that describe concepts in psychology need to be tied to objective circumstances. Anxiety is a good example of such a variable. Almost everyone has some idea of what anxiety is. There are several dictionary definitions of anxiety, most of which agree that it is a complex emotional state with apprehension as its most prominent component. In attempting to operationally define this variable, researchers have used pencil-and-paper tests, a Palmar sweat technique, the galvanic skin response, heart rate tests, and eye movement tests. Each of these operational definitions probably measures some part of anxiety, although none of them measures its total complexity. A researcher must choose and develop an operational definition that is suited for the specific research question. It is absolutely necessary that the variables used in research be operationally defined.

Experimental and Control Groups

Whereas in many experiments treatment groups are exposed to different levels of the independent variable, on other occasions an experimental group and a control group are used. Although these experiments can be described using our definition of an independent variable, the concepts are discussed here because they present some unique problems in experimental design.

The experimental group is the group that receives the experimental treatment—that is, some manipulation by the experimenter. The control group is treated exactly like the experimental group except that the control group does not receive the experimental treatment. The Spallanzani experiment is a good example of this. The group of female dogs receiving the sperm-free filtrate was the experimental group, and the group receiving the normal semen was the control group. In the next example we look at control and experimental groups where the participants are treated differently based on group assignment.

Case Study

Blind people are very adept at avoiding obstacles; however, little was known about how they do this. One hypothesis was that blind people developed "facial vision"; that is, they react to air pressure on exposed parts of the skin. A second theory was that avoidance of obstacles comes through the use of auditory cues. Supa, Cotzin, and Dallenbach (1944) set out to test these theories. They had blind people walk around in a large room in which obstacles (screens) had been set up. Two experimental treatments were used. In the first treatment, blind participants wore a felt veil over their face and gloves on their hands (thus eliminating "skin perception"). In the second treatment, blind participants wore earplugs (thus eliminating auditory cues). A third treatment was the control treatment, in which blind participants walked around the room as they would normally. The results indicated that participants in the control group and in the felt-veil group avoided the obstacles every time, but the participants in the earplug group bumped into the obstacles every time. Based on these results, the authors concluded that the adeptness of the blind in avoiding obstacles is due primarily to their use of auditory cues and not to any facial vision.

The previous experiment is an abbreviated version of a series of experiments on the perception of sighted and blind subjects. In this example, it is somewhat difficult to specify an independent variable. The experiment is most easily described as having two treatment groups—one in which facial vision is eliminated and one in which auditory cues are eliminated. The control group is treated the same as the other treatment groups except they do not receive the veil or earplug treatment. The control group provides a baseline to help determine whether the treatments improve or hamper the avoidance of obstacles. The dependent variables in this study "the ability to respond to sensory-deprived cues" was measured by the number of times the subjects walked into the obstacles.

Sometimes more than one control group is needed. For example, in pharmacology a placebo control group is frequently used. A placebo group is best described as a group who is made to believe that it is getting a treatment that will improve its performance or cure some symptom, when in fact no treatment is provided. This type of control group is also used in testing the effectiveness of therapy. Consider the following example drawn from the psychological literature.

Case Study

Paul (1966) conducted an experiment to test the effectiveness of two types of therapy in treating speech phobia. His subjects were students enrolled in public speaking classes at a large university. Paul took 67 students who had serious performance problems in the course and assigned them to one of four conditions. One group of 15 participants received a form of behavior therapy. A second group of 15 participants received an insight therapy. A third group of 15 participants received placebos in the form of harmless and ineffective pills, and were told that this would cure them of their problems. A fourth group of 22 participants was informed that they would not be given any treatment and simply answered questionnaires that were also given to the other three groups. All participants had to give one speech before the treatment began and one after the treatment had been completed. The dependent variable was the amount of improvement shown by the participants from the first to the second speech, based on racings made by four clinical psychologists. The four psychologists were not involved in the treatment the participants received nor did they know which participants were in which treatment group. The results indicated that 100 percent of the behavior therapy participants improved, 60 percent of the insight therapy participants improved, 73 percent of the placebo participants improved, and 32 percent of the no-treatment control participants improved.

The Paul experiment illustrates the need, in some experiments, for different types of control groups. The interpretation of the results of the experiment would have been quite different if Paul had not used a placebo control group. Without it, insight therapy would have appeared effective as a therapy in improving speech-giving difficulties. On the contrary, with the placebo group included in the design it appears that the insight therapy was ineffective as a therapy and may have only acted as a placebo. In fact, the placebo group's performance improved more than the insight therapy group's performance. The experiment also points out the need for a no-treatment control group, as over 30 percent of the subjects in this group improved in spite of the fact that they received no treatment. This can form a baseline to measure the effectiveness of a treatment compared to no treatment at all.

Different types of control groups are used in different areas of research. Researchers who remove a part of the brain of animals and use the animals as an experimental group sometimes use a control group that undergoes all of the surgical procedures except that the brain is left alone. This would control for a factor such as postoperative shock causing the effect found in the experimental group. The point to remember is that the control group must be treated exactly like the experimental group except for the specific experimental treatment.

The Paul experiment also illustrates an important control procedure used to avoid experimenter bias. The psychologists who rated the subjects' speaking performances were not the same people who treated the subjects in therapy, nor did they know which subjects were in which experimental group. It is reasonable to assume that therapists might be biased when it comes to evaluating the improvement of their own patients. Furthermore, the four judges might prefer a particular therapy, and if they knew which subjects had received this therapy, they might be prone to see more improvement in these subjects than in subjects in the other experimental conditions. Or perhaps the judges would have assumed that the subjects in the no-treatment control group could not have improved and would therefore rate those people's performances accordingly. Paul controlled for these potential biasing effects by using independent judges and keeping the judges blind as to what experimental group a particular subject belonged.

The term blind is used in a special sense in experimental research. Single blind usually means that the participants in an experiment are not informed as to which treatment group they are in and might not he informed as to the nature of the experiment. Double blind is frequently used in drug research or any research that involves observers who are judging the performance or progress of the participants of an experiment. Both the judges and the participants are kept blind as to the type of experimental treatment that is being used as well as the type of effect that might be expected. The case study we have selected illustrates the influence of experimental bias in experimental psychology and the serious implications it can have for psychology and other scientific studies.