AN ABSTRACT OF THE THESIS OF

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A Study of the Laws of Learning Vernon Kruse

The word "learning" is defined in two ways. It is defined both as a product and as a process. Throughout the thesis "learning" was considered principally as a process.

All learning can be reduced to one relatively simple type; that is, stimulus, association, response. It can be either positive or negative. Many factors enter in the learning process on the physiological side. Among these are innate energy, native ability, excess ability, social approval, sensitivity, conductivity, and tendency to change.

Because the first contact of the nervous system with outside stimuli is through the sense organs, it is apparent that they play an important part in learning. If they are defective, learning is changed.

The importance of play and the development of imagery, especially during childhood, is that it is learning of a complex and valuable kind as it furnishes much of the factual material on which more formal and more extensive learning is based, especially perception and apperception.

There are several so-called levels of learning, namely, (1) physiological, (2) perceptual, (3) conditioned, (4) ideational, and (5) creative. Of these physiological learning is the first and basic one. Perceptual learning provides the material used in every other type of learning.

Conditioned learning is a process of attaching a response to a stimulus that previously did not bring about that response. Ideational learning establishes a new response through generalization of one's experiences through the formation and proper use of concepts that re-instate the concrete experiences one has had. Creative learning develops new adaptive responses much in the same way as does ideational learning.

The importance of the associative element in the learning lies in the two laws of association which are: (1) association by contiguity in space and time, and (2) association by similarity and contrast.

There are nearly a dozen laws, or statements of tendencies, of learning. These are: (1) primacy; (2) recency or repetition; (3) vividness or intensity; (4) frequency or repetition; (5) Jost's; (6) exercise; (7) disuse; (8) readiness; (9) effect.

Learning curves are characterized by five parts, namely, (1) initial spurt; (2) lag; (3) rapid rises; (4) plateau or plateaus; and (5) physiological and psychological limits.

Three theories advanced for any transfer that does take place in learning are: (1) the theory of identical elements (2) the flexibility of habits and the development of meanings; and (3), the theory of generalization. It is believed that at least six things do carry over, namely,

(1) identical elements; (2) similarities in methods; (3) helpful or detrimental attitudes; (4) ideals of performance; (5) self-confidence and attitude toward success; and (6) helpful methods of work.

The loss of learning, or forgetting, needs to be taken into account when any study of the learning process is undertaken. The usual curves of forgetting show a rapid rate of forgetting after the first several hours of learning with a gradual tapering off as time elapses.

One of the important factors which enters into and affects the learning process negatively is the factor of 'fatigue'. Whether or not there is such a thing as mental fatigue is not agreed upon.

The writer constructed a learning curve using a college class and himself as subjects. The different steps of the learning curve are shown together with several psychological and physiological implications.

A STUDY OF THE LAWS OF LEARNING

by

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THE NATURE OF LEARNING AND ITS ORIGINAL BASES

Chapter I

Definition of Learning

The word 'learning' is used in two ways. It is defined both as a product and as a process. As a product, learning is considered as knowledge obtained through the modification of an organism by experience. As a process, it is defined as the acquiring of an ability to do something that the learner has never before done as a whole, or, more probably, in exactly that same manner. In this thesis, learning and habit formation will be considered as synonymous. While learning is often used to refer to activities that are predominantly mental, one often hears of people 'learning to skate or to ride a bicycle' which are predominantly muscular activities. In the same way, habit is often used to refer to activities which are predominantly muscular, yet one has 'habits of thinking along certain lines and of using certain expressions habitually.' The writer believes that no useful purpose will be served by seeking any differentiation between the two terms.

Throughout this thesis learning will be considered, principally, as a process, or as the acquisition of the ability to do something new although no clear line of demarcation can be drawn in actuality between a process and its product. Learning, following Thorndike (46), is a connection of bonds of varying degrees of directness and strength between the situations furnished by material forces, such as plants, animals, and other objects, or the behavior of other human beings and the responses which the individual makes to them or because of them. The partially new responses may or may not be improvements over older responses but it is probable that they are mixtures of gain and loss of efficiency in their details. The wholly new responses may also be improvements over the tentative responses which have been followed briefly or thought of in preliminary reactions. Improvement may be thought of in terms of greater conservation of energy, conservation of time, more satisfactory products, or individual or social welfare.

The neural and mental steps in the different types of learning can all be reduced to one relatively simple type. This simple type consists of three steps in the process; that is, stimulus, association, response. To state this a little more explicitly, the process consists of the reception of impressions through the senses; the assimilation, analysis and combination of these impressions with others more or less similar or related from memory in the spinal cord or brain, and the direction of the resultant impulses to the muscles or glands or both to produce a usually overt response. In this manner, an individual learns to avoid an undesired situation by receiving the sensations from it, associating these with undesired consequences, and responding by avoiding the situation; in a similar way, an individual learns to attend to or welcome a desired stimulus by receiving the sensations from it, associating these with desired consequences, and responding by accepting the situation.

Positive and Negative Learning

Positive learning occurs when the bonds between a stimulus and a response are strengthened by exercise. The repetition and strengthening of the stimulus-response bonds result in a decrease in resistance in the neural pathways involved and a consequent decrease in the time required for the nerve impulse to reach its destination. The neural pathway becomes, in effect and probably in actuality, more direct. Unessential stimuli seeking to enter into the particular stimulus-response situation are less distracting, thus making the connection between the stimulus and response both stronger and easier to make. It must not be inferred, however, that all extraneous parts of an act are necessarily eliminated even when a skill is very great because many times they are not. An illustration of positive learning is the one given by Breed (11), who states that a high type of modification is acquired when an animal improves its native ability by learning to make a more precise and economical response, as when a newly hatched chick learns, after a few days' experience and practice, to pick up and swallow eighty-five per cent of all it attempts to pick up, whereas it succeeded in only twenty per cent of its attempts at first.

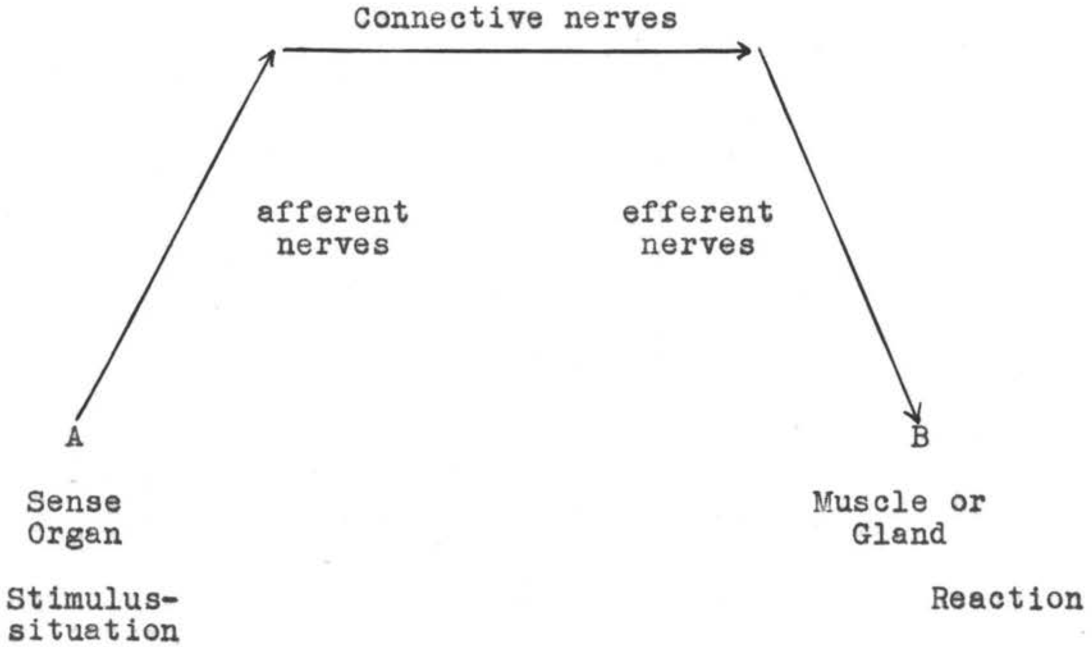
Negative learning, or negative adaptation, consists in blocking or dropping what has been acquired or is native in behavior responses but which no longer proves useful, either in general or in a particular situation. An illustration of negative learning is that of a cowboy getting his pony accustomed to the saddle. He first fastens the saddle to the pony's back. The pony vigorously objects at first, and then less and less vigorously until he eventually becomes negatively adapted to the stimulus of the saddle. After the pony remains still the cowboy mounts and the pony again objects, only this time he objects to the burden on his back. This episode occurs for several days, the pony objecting less and less each day until finally he does not object to either saddle or burden. By this process of inhibition or by a process of substitution any native or previously learned response may be detached from its original stimulus and may be dropped or re-attached to a new stimulus-situation. Before a negative adaptation is made to a stimulus, the learner makes the original response which was already attached to it. After negative adaptation is made the original stimulus no longer arouses the earlier response, but arouses the later desired response or no response. This detachment and re-attachment of stimulus-situation and responses in this manner is called conditioning, the basis of all learning or merely another name for learning. The process of conditioning is discussed and illustrated in a forthcoming chapter; therefore no further elaboration is needed here.

Physiological Basis of Learning

The fundamental basis of all learning is the stimulus-response situation that has its cause and its effect in the physiological structure of the human organism. When a stimulus-situation, either external or internal to the body but always external to the nervous system, is received by one or more of the sense organs, nerve impulses are set up and are carried by different afferent nerves to the spinal cord or to the brain. In either case, the connective nerves make possible the associative process or processes - which will be discussed in fuller detail later. The resulting impulses are then carried out by different efferent nerves to the muscles or the glands. This stimulus-response situation operates over a neural arc which can be shown diagrammatically as follows:

Fig. 1

Neural Arc Illustrated



General Factors of Physiological Learning

The first general factors of physiological learning to be considered are the capacities of innate energy and native ability. The physiological processes in a child are usually sufficiently well organized at birth to permit continuation of life. Many important changes occur at birth, such as the first functioning of the infant's digestive system and its adaptation to the chemicals contained in the mother's milk. There are numberless other inherent adjustments that are possible to the infant; for instance, its adaptation to heat if it is born in a warm climate; or, its adaptation to cold if it is born in a cold climate. The innate energy and native ability necessary to make these adjustments are present at birth and are developed and developable so as to make possible and more direct more complex adjustments later in life.

Another factor to be considered is that of excess ability. Excess ability is the ability that an individual has over the amount usually needed for a bare existence. It appears in every normal living organism from the time of birth until the time of death. Just how much excess ability or excess energy each individual does possess is not known but it is known that each one does have ability that is never entirely utilized. This excess ability or excess energy makes possible growth and development or the learning of new things.

Perhaps the reason that our excess abilities are never fully utilized are (a) the law of neural economy and (b) the law of social approval. The first law states that every individual, consciously or unconsciously, strives to conserve his energy as much as possible. He does this to establish and maintain abalance between his various mental and various physiological states. This is not to be considered unhealthful. It is highly desirable unless it is carried to an excess because it accounts, in a large measure, for the improvements that are made in the form of new adaptive responses. Energy is stored and available for use when needed to make new desired responses under this law. The second cause, the law of social approval, is that the majority of people are not only forced by limited ability to be average or normal, but they are most satisfied to be in the group because they have the general social approval of the majority on the one hand, and avoid the ridicule or the pity that is the portion of the markedly deficient group or the great expenditure of effort required for one to become a member of the most proficient group with its great rivalries and jealousies, on the other hand.

There are several other very important factors that must be considered of which little or nothing is known at the present time. That these factors exist and operate is highly probable but the exact way in which each works and the ways in which each is related to every other factor is a problem yet to be solved. One of these mysterious factors is that of chemical changes in a nerve. It is highly probable that chemical changes occur in nerves over which impulses have passed. This is, however, not definitely shown as yet. It is highly probable that new points of chemical stability may be the bases of memory. It is also believed that the nervous system has a tendency, within itself, to change. Just what is at the bottom of this tendency is still to be solved. Two more factors are (a) the tendency to avoid monotony and (b) the tendency to maturation with its upper and lower limits. It is known that there are four qualities of the protoplasm of the nervous matter, namely (c) sensitivity, (d) contractility, (e) conductivity, and (f) reproductivity. The way in which each is related and the extent to which each shares in the learning process is not, however, exactly known. There are several possible forms of action that make learning possible at the synapses. These are (a) movement, (b) continuation of neurofibrillae, (c) chemical, and (d) electrical. It is not known just which ones operate as yet.

All the above, and perhaps more, constitute the physiological capacity to learn. Just how some of these factors enter into the learning process is, as has been stated, unknown at present but that they do assist in the process is very probable.

DEVELOPMENTAL BASES OF LEARNING

Chapter II

Influence of Sensory and Physical Defects

Because the first point of contact of the nervous system with outside stimuli is through the sense organs, it is obvious that these points of contact should be as perfect as possible. Perhaps the two most important sense organs that are connected with the learning process are the eye and ear.

There are several types of visual defects, namely:

1. Myopia or near-sightedness occurring when the eyeball is too long. Light coming in is focused in front of the retina causing an indistinct image when it is spread out at the retina.

2. Astigmatism is the result of the cornea and lens not in the same meridian. This causes some parts of the field of vision to be distinct and others indistinct.

3. Hypermetropia, or far-sightedness, results when the eyeball is too short. This results in an indistinct image because the rays of light entering the eye are not refracted enough to form a clear image when they fall upon the retina.

4. Cross-eyedness, or strabismus, results when the muscles of the eye are unbalanced in strength.

5. Color blindness is caused by improper functioning of the cones in the retina.

Visual defects arise largely from one of two causes: (a) heredity and (b) strain of the eye. It has been found that color-blindness and strabimus are, in general, inherited while other types are due in part to heredity but more to strain.

Defective vision makes school work and much other work fatiguing and irritating. It decreases the willingness if not the actual ability to do many kinds of work. Because of the pressure brought to bear on children, they often do the work asked of them even though they have defective vision. Others are clearly unable to. There are no data known to the writer that really show the effects of poor vision upon the work of the children or upon their personalities.

Besides defective visual conditions, there are also auditory defects that interfere. Starch (44) presents a report by Taussig showing the following percentages of defective hearing in various cities:

Table I

Percentages of Defective Hearings in Various Cities

Edinburgh, Scotland (1904)	12.2%
Dunfermline, Scotland (1907)	4.0
Cleveland, well-to-do district (1907)	5.2
Cleveland, congested district (1907)	1.8
Massachusetts, except Boston (1907)	5.8
Boston and environment (1907)	7.7
Boston (1908)	7.6
New York City (1906)	2.0
New York City, Borough of Manhattan	1.0
Chicago (1909)	2.7
St. Louis County, Mo., either ear defective (1909)	7.3
St. Louis County, Mo., both ears seriously defective (1909)	2.2

There are several other factors which affect the learning process. One of these is the influence of malnutrition. That malnutrition is often a cause of poor school work and learning can hardly be denied. One needs only to visit the schools in the slum districts of any of our large cities to witness the real problem of malnutrition and its effects on the learning process. Other physical defects, of less importance, that decrease learning efficiency arise from defective teeth, and from throat, nose and glandular troubles. These are not, however, as numerically important as either the ear or eye troubles.

The effects of markedly defective sense organs are (a) strain on the weakest parts, (b) worry, (c) pain, and (d) emotionality. Often children with defective sense organs do not know that their sense organs are defective and therefore accept the criticisms that they are "dumb" or clumsy as correct when they are not.

Perception of Sensory Material

Perception will be discussed later in this chapter; therefore, only a word needs to be said concerning it here in connection with sensory material. The material one learns and the way he learns it depend upon what and how he perceives it. It thus follows that the quality of his perception depends upon a normal functioning of the sense organs. One cannot think clearly about what his sense organs have not brought to him clearly. Conclusions are rarely better than the data on which they are based. It becomes obvious that much of the error in learning come from faulty observation. Anything may be learned incorrectly, at least in part, because of faulty observation and faulty perception.

The reasons for inaccuracies of perception and of report are many, the chief ones being: (a) not enough attention to the observed material, (b) insufficient experiences with which to link the observed material, (c) low retentiveness of the impressions, (d) faint imagery, (e) effect of suggestion, and (f) failure to keep apart observed and inferred items.

Three Types of Imagery

When a child is born, it has its nervous system, its sense organs, its capacities for growth and change, and its excess abilities or excess energy. It has, in fact, the actual or potential machinery for learning, but it knows nothing of the world external to it. It has to meet and develop the ability to predict the events of the world before it can protect itself against them or control them to its own advantage. The first step in this field, apart from the reflex activities connected with breathing, taking nourishment, and excretion, lies in the field of the development of imagery. The three ordinarily accepted types of imagery are: sensory after-images, images of memory, and images of imagination.

Brumbaugh's Theory of Imagery

The term 'imagery' as used by Brumbaugh (13) is not confined to the narrow limitations of the memory images and images of imagination of the adult but is expanded to cover the immediate effects of stimuli upon the sense organs. In his own words, his theory is as follows:

> For purposes of clarity in our later discussions, we wish to diverge from the customary limitation of the word image. We purpose to expand the term to cover not merely the revived experience essential to memory, but, also, the immediate effect of stimuli upon the sense organs insofar as these are interpretations of the outside world rather than of subjective experiences. The discrimination here, between the image and sensation, is in the view-point of the experience. When it is introspected as an inner state, it is sensation only; when taken to be the nature of some object external, it is an image. The image is short of being a percept, and becomes the latter when the image in turn is individualized and given a logical value and place in a wider setting or marginal contiguous imagery. These distinctions are important, if any clear understanding is to be gained of the intellectual development of the child. Out of the sensation milieu must arise the image, and out of the recurrence of imagery must evolve the logical norms, which bring experience into a rational system for the identification, placing, and regulation of objects in a world of space and time.

Brumbaugh's Theory of Play

Random physiological activity and, later, purposeful physical activity, lead to the development of imagery and of images in all or many of the related fields of mental activity. The greater the amount and variety of activity and the more satisfactory to the infant it is, the greater the variety, detail, and satisfactoriness of the derived or resultant imagery. This imagery plus its muscular and sensory precursors and accompaniments is the basis of the later play activity out of which come further images, mental and physiological learning methods and factualities, personality trait developments, and emotional maturization.

The play period is from approximately two until six years, that is, the period of almost exclusively play activity. It is the time when memory or revival imagery comes back in great profusion but with little identification as to source. In this period, motor co-ordination reaches a point of wide variety of expression and of dexterity of the hands and fingers especially. There is an immense amount of both motor and imaginative activity. There is little distinction between imagination and reality.

The following statements from Brumbaugh (13) indicate the nuclear idea of the importance of play in later mental and motor development:

I. Motor activity is the agency that puts the development of mind on the way.

II. It does this by bringing about objective contacts.

III. Objective contacts, in turn, register their particular characters in the form of brain patterns.

IV. Later excitation of these brain patterns occasion conscious symbolical equivalents called images.

V. These representative imagery-photos are the medium through which an outside, spatial-object-filled world is brought to the experience of the child.

VI. The repetition contacts with any series of similar stimuli results in a brain pattern and its correlated image becoming a standard symbol or concept, with a habit tendency to apply its content to any one of the group of like objects involved.

VII. Whenever, thereafter, any particular individual, of a class of objects that have produced a concept, is being experienced by sight, sound, touch, taste, or odor, and brings back by association the brain pattern and its concept belonging to the class, the object thus experienced is given the meaning belonging to the concept, and the experienced total is identified to be a percept pattern of a particular object, and a percept image is correlated to it.

VIII. Any present sense pattern has by a law of association the tendency to re-excite any brain concept, or percept pattern, and the correlated content, previously joined thereto.

IX. Imagery, which has not become identified with a definite source tends to be revived as free and floating imagination.

Brumbaugh (13) states his theory of play as follows:

The play period, in general, makes a survey of environment for the purposes of the organism. The organism must live, not independently of the world, but because of a circuit of energy which flows continuously into the organism and out again into the surrounding medium. Only by adjusting at every moment the inner to the outer can life be maintained. Mind, alone, can make this adjustment something more than a fatalistic small area solution. To compel the larger, if not complete world, to contribute to the fullness of individual life requires some sort of a medium that works with time and space limitations, yet in a sense independently of them. The individual must live within a very restricted body. It cannot as a small material body within its own restricted sphere utilize the world of the remote through a medium which can reach beyond a particular spot and moment. The mind can do this feat and its first preparatory work towards this end is to make a blueprint of the world without, in terms of its own symbolization medium. Environment must be charted, its values estimated, and its possibilities for individual development made available for the activities of the child's motor conquest. The play process does this.

We do not imply that the work begun in this period which lasts from perhaps the second year to the seventh, is completed. The play activity, as such, automatically ceases when the blueprint becomes definite enough to force behavior into set channels, and robs the child's activity of its vitalizing spontaneity, freedom and sensationalism. The charting process continues indefinitely, but under a very different form of motivation.

Brumbaugh (13) then outlines the mental processes involved during the play state, as

1. Generic movement of mind by synthesis and analysis in wholeing and parting.
2. Precipitated by an enormous back flow of free revived imagery.
3. For two or three years much expansion of totals into parts of larger totals with much conceptual formation of significant norms - an aggregation of object concepts.
4. For two or three more years much analysis and subdivision of totals into details with much identification of objects - an aggregate of object percepts.

5. Final more or less articulate pattern of the geography of things and places.
6. The time concept begins to function as a factor and chart of activity.
7. A consistent and orderly fixated world puts an end to play.
8. Concepts become articulated into a conversational medium.

Thus, according to this theory, play itself is learning of a complex and most valuable kind. Not only is it learning, but it furnishes much of the factual material on which later, more formal, and more extensive learning is based. Because it is first-hand and voluntary learning, it carries a tremendous influence on both present and future comprehension and assimilation of the material of the schools, so much of which is dependent upon rote memory as it is at present handled, and so much of which is not comprehended because the pupils have so little first-hand comprehension or voluntary interest in the material at the time or from their earlier experiences.

Formation of Perception

The fundamental meaning of the term perception is to "grasp" or "know", that is, to identify and to know something about the things that are brought to the brain through the senses. Perception acts both as a selective and as a combining agency. It always takes an object from the total background, but the object appears as a part of a pattern or group. To perceive, then, requires special motivation to define the object as of a definite pattern or group, usually leading to a predominantly motor or a predominantly mental response. Perception is necessary to and preliminary to motor reaction because, without first perceiving, the responses would be without understanding and, therefore, often futile and always unpredictable if not dangerous to ourselves and others. The first fragmentary percepts are ordinarily of movement and then of use.

Perceived figures are generally taken as objective facts or as signs of objective facts, but the connection of the sign and the meaning is due to learning. Perception is the middle ground between sensation and motor response, using association to select and combine; thereby making it possible for motor activity to vary instead of remaining on the automatic tropistic or reflex levels. A good illustration showing the way in which we perceive is that of taking a watch and noting the cues by which we identify it as a watch; that is, its shape, size, ring and stem, tick, material made of, scroll work on back, presence and position of numbers, presence of hands, movement of second hand, place carried, and apparent weight.

More will be said concerning perception in the next chapter where the levels of learning are discussed.

Formation of Apperception

Starch (44) has restated briefly the theory of apperception given by William James:

> The gist of the matter is this: Every impression that comes in from without, be it a sentence which we hear, an object of vision, or an effluvium which assails our noses, no sooner enters our consciousness than it is drafted off in some determinate direction or other, making connections with the other materials already there, and finally producing what we call reaction. The particular connections it strikes into are determined by our past experiences and the 'associations' of the present sort of impression with them. If, for instance, you hear me call out A, B, C, it is ten to one that you will react on the impression by inwardly or outwardly articulating D, E, F. The impression arouses its old associates. They go out to meet it; it is received by them, recognized by the mind as 'the beginning of the alphabet.' It is the fate of every impression thus to fall into a mind preoccupied with memories, ideas and interests, and by these it is taken in. Educated as we already are, we never get an experience that remains for us nondescript. It always reminds us of something in quality, or of some context that now in some ways suggests. This mental escort which mind supplies is drawn, of course, from the mind's ready-made stock. We dispose of it according to our acquired possibilities, be they few or many, in the ways of 'ideas'. This way of taking in the objects is the process of apperception. The concepts which meet and assimilate it are called by Herbart the 'apperceiving mass'. The apperceived impression is engulfed in this, and the result is a new field of consciousness, of which one part (and often a small part) comes from the outer world, and another part (sometimes by far the largest) comes from the previous contents of the mind.

Thus, we see that apperception as here stated is not much more than is involved in perception. The only difference is that an apperception or a concept is a perception of a class of objects or an abstract quality. It is the determining of the new in terms of the old. This principle has important bearing on learning in that it stresses the point of linking old experiences with the new so as to form a higher or more complex basis for creative learning or thinking and leaves one freer to deal with the newer and larger units of thought. Moreover, if the old information is unusually incomplete, partisan, or incorrect, the new material must become a part of this unsatisfactory conceptual material or cause a partial or complete revision of it. This may involve a very considerable expenditure of energy and a great deal of self-doubt and fluctuation of opinion and decision.

Influence of Analysis and Synthesis

When one realizes that all forms of learning involve the use of analysis and synthesis, he can readily see the importance and influence that these two factors play in the learning process. A living organism probably never duplicates exactly that which it is duplicating. Likewise it never repeats an act in exactly the same way because the central nervous system shuts out or includes certain marginal factors, either desired or undesired, as the case may be. All learning includes the stimulus-response situation, the analyzing and synthesizing being done in the brain or spinal cord before the effectors receive their stimulation to action, the reaction, and often the response which the reaction receives from others or our own judgment of its reception had others been present. It thus becomes evident that to learn any desired response an individual must first analyze the situation and second, by synthesis decide, formally or informally, upon his action before he can complete the act. This analysis and synthesis is a combination of the present percept, the related part of the apperceptive mass, memory of the past, and related imagination projected into the future.

Influence of Maturation

Maturation is growth of structure. It is a development of the human organism in response to its inherent capacities and to varied stimulation of outside influences. The difference between maturation and learning is that maturation is growth of a structure while learning is a growth in response to the functioning of that structure. Keeping in mind that learning is not entirely dependent upon environment but is the product of both heredity and environment, we can say that maturation has a substantial influence on the learning process. One does not need to go very far into the realm of thinking to realize that, if the nervous system did not mature in proportion to the complexity of problems to be solved, the learner would be very much at a loss. His learning ability would be greatly lessened and his ability to adjust himself to his material and social society would be diminished.

One's organism, then, needs to be mature in proportion to the amount and the kind of stimuli that are to be received.

LEVELS OF LEARNING

Chapter III

Physiological Learning

The first and basic modification of any living organism consists of physiological adjustments that are made to the stimuli that affect the organism itself. These physiological processes are present at birth and are capable of maintaining life. For instance a child's lungs begin to function from birth and the stomach slowly becomes adapted to the assimilation of food. Such physiological adaptations are not restricted to the perfecting of single organs but include the relation which one organ bears to another, for instance, when any organ of the body is active there is an increased amount of blood sent to this organ to help it carry out its activity.

The exact nature of these adaptations is not known but it is known, however, that they are very important for efficient learning and are subject to the influence of training or are capable of learning. Most of these physiological adjustments are formed by the unconscious action of conditioning stimuli coming from either within or without the organism. This takes place through conditioning which usually means that it is done without the intervention of conscious learning. The process of conditioning will be discussed in more detail in a later chapter.

Perceptual Learning

Because perceptual learning provides the material used in every other type of learning it is the basis of all other learning. An individual notes and makes an attentive adjustment to the stimulus-situation and also interprets this so that a more or less appropriate response may be made.

In a child the first responses to objects are instinctive or merely reflex reactions. By conditioning and development through association, the child attaches meaning to the objects and responses, meaning being defined as that which is, or is intended to be, signified. The correct meaning can only be obtained by getting experiences with the objects and events being interpreted; that is, telling a child an apple is to eat means nothing to the child until it has eaten one. Book (8) explains, in the following manner, the way in which any experience with an object may be recalled:

> Having any object or event arouse the experiences that an individual has had with that object constitutes for him the correct perception of this object or event. In this way, any experience a child has had

with an object may be recalled when the object is not present.

How such an object will be perceived and reacted to depends upon many things: (a) upon the particular combination of stimuli that are presented when the object is observed; (b) upon the kind of experiences the observer has already had with this and with similar objects; (c) upon how these experiences were obtained (which determines very largely how well they can be recalled and used in the present situation); (d) upon the intensity of the sensory stimuli the object presents; (e) upon the kind of motivation that is present.

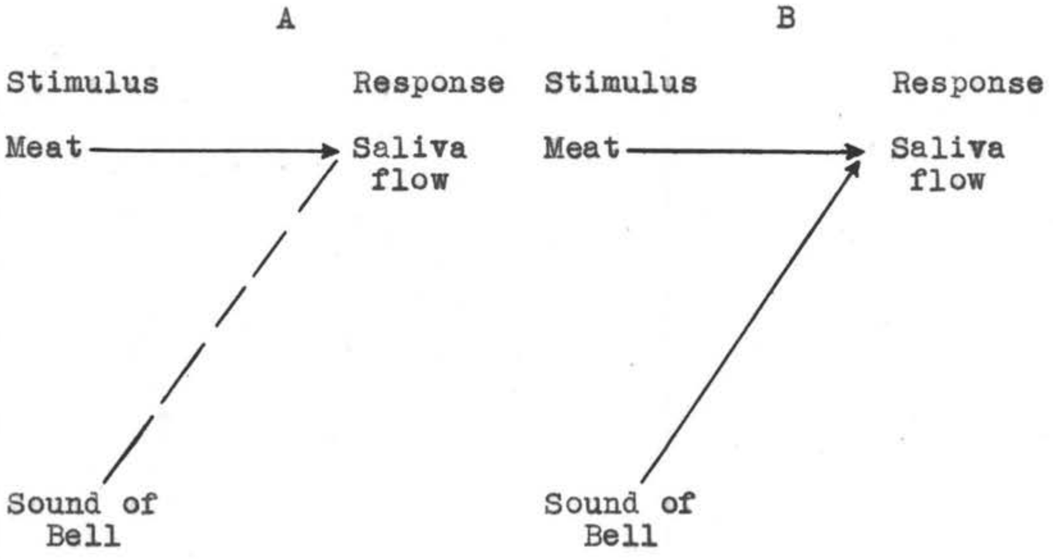
Thus perceptual learning is related to every type of acquisition that takes place, beginning with an attentive adjustment to outside stimuli and ending in acquiring the ability to make appropriate responses to them.

Conditioned Learning

All learning is a matter of conditioning. By conditioning is meant the attachment of a response to a stimulus that previously did not bring about that response. The capacity to connect any response that a learner can make to any stimulus that can impress him is very important when progress is considered. The experiment conducted by the Russian physiologist, Pavlov, illustrates this principle very well. Pavlov found that if a dog is given a piece of meat there is a natural physiological tendency to increase the flow of saliva from the dog's salivary glands. In one of Pavlov's experiments a dog was presented with a piece of meat on several occasions and a bell was rung each time a piece of meat was offered to the hungry dog. It was discovered by the Russian physiologist that after several repetitions of this procedure, the bell could be rung without any meat being presented and still saliva would flow from the dog's salivary glands. In other words the dog had been conditioned to respond to the situation so that every time a bell was rung saliva would begin to flow. Book (8) illustrates this diagrammatically as follows:

Fig. 2

Pavlov's Experiment Diagrammatically Illustrated



At first the actual presence or sight of the meat was the thing that would bring a flow of saliva. This is shown by the solid black line in A of Fig. 2. After a time the bell-stimulus will arouse the same reflex response that was formerly produced only by the meat. After repeated association with the meat, the bell will elicit the salivary response as readily as the biologically adequate stimulus, the meat. This is shown by the solid black line in B of Fig. 2.

The thing that happens in conditioned learning is a response already learned becoming linked with any stimulus-situation attended to by the learner. Neurologically it means that new connections are made in the organism between a previously formed neural pattern and a different stimulus from the one formerly used.

Early learning consists very largely of attaching responses that already can be made to stimuli to which they were formerly unresponsive. It accounts for nearly all the simple sensory-motor habits that the individual makes whether acquired unintentionally or purposely. Most of our physiological habits are formed by conditioning.

If proper stimulating conditions, either physiological or environmental or both, are present, good or desirable habits may be established unconsciously. More caution should be taken in regard to the control and proper use of the conditioning stimuli because (a) through unintentional learning an individual may form the right or wrong habits; (b) conditioning stimuli may be used to weaken or break undesirable habits; (c) conditioning stimuli may facilitate the forming of new habits; (d) conditioning stimuli must be used in linking every new adaptive response to the appropriate stimulus after this new desirable response has been made for the first time.

It is thus obvious that in the study of the learning processes one must take into consideration the improvement that can be made by the utilization of conditioning stimuli.

Ideational Learning

Learning on the ideational plane presupposes two things: (a) the development and the use of the various memory functions, and (b) the ability to generalize one's experiences through the formation and proper use of concepts that reinstate the concrete experiences one has had. This is done by what we commonly call thinking.

Thinking is a process that comes from within. The objects thought about may be absent but thinking uses the materials that have been observed previously. Thought is capable of creating because it is freed from the time and the space restrictions found on the perceptual level. The development of thought is closely related to the development of language because one cannot, in all probability, exist without the other. Words become the means of self-stimulation since they can be used to represent any recalled experience.

The first step in learning to think is making responses or using certain perceived symbols to represent objects and events not present to the senses. The second step is the acquisition of the meaning and the use of words as well as learning to make appropriate responses to them in other ways.

There are two steps that must be taken to establish new adaptive responses. The first is that some stimulus must be located that will produce the desired response. This is found by the learner's manipulation of the problem and is usually trial and error. Second, a problem may be solved and the response developed by direct and intelligent use of the appropriate past experiences. If a third step is to be added it would, perhaps, be that of experimentation or of mental trial and error.

Just what courses are followed in the development of thought responses is not known, but it is known that it is clearly an integrative process, a putting of old ideas or habits in new forms, a creating of new patterns of thought. The way in which we learn to think is unknown, but it is known that the process takes place involuntarily as far as direct guidance by the learner is concerned.

Creative Learning

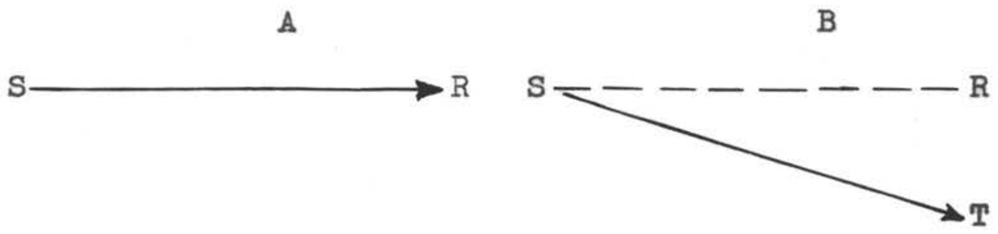
Creative learning is more important than is generally believed. A learner's habits condition the creative side of learning and care should be taken in the manner in which the desirable habits are developed so that creative work will result.

There are five steps in the creative process of learning that must be taken by every learner when a new adaptive response is developed: (a) first, the new reaction pattern must be formed or the desired response made a first time; (b) this new adaptive response must then be identified or checked as to its adequacy for attaining the goal; (c) it must then be strengthened by further repetitions; (d) all wrong responses made during the process must be eliminated; and (e) the new and correct response must usually be improved in form while it is being strongly linked to the appropriate stimulus-situation.

What happens when a new adaptive response must be created and linked to some familiar stimulus is shown by Book (8) as follows:

Fig. 3

Formation of a New Adaptive Response



A particular response, R, has been linked by previous experience or training to the stimulus, S, (part A) but in the new situation the learner finds the response, R, undesirable. Therefore a new response, T, must be found and linked to S to produce the desired new habit as illustrated by the S____T linkage in Fig. 3, B.

There are several conditions that favor creative learning: (a) there must be a problem, either internal or external; (b) the learner must be motivated to such an extent that he will try everything reasonably possible to acquire this desired response; (c) the problem must be adjusted to the experience, to the degree of motivation, and to his structural and functional ability, and to his intelligence and to his habit of success already attained by previous learning; (d) the learner must possess all the habits and information needed; (e) after the desired response has been found the situation must be repeated until the bond is firmly established; (f) in making these repetitions the trial responses made by the learner must be carefully checked by him; (g) he usually must be in a good physical condition; (h) he must have a favorable attitude toward his task; and (i) the learner's goal should be definite and easy to identify.

ASSOCIATIVE LEARNING

Chapter IV

Laws of Association

The importance of association in learning was recognized a long time ago. In his treatise on "Memory and Reminiscence", Aristotle cited four fundamental laws, or tendencies, of association. He distinguished among association by similarity, association by contrast, and association by contiguity in time and in space. These four principles were elaborated upon in the Middle Ages and later by Locke, Hume, Berkeley, and Hartley. These four tendencies as we now know them are known as principles of association by contiguity in space and time, and association by similarity and contrast. Illustrations of these principles are given by Colvin (15):

> For example, if in learning nonsense syllables, the syllables "mej" and "vot" come side by side or one after the other, on the presentation of the first, the second tends to come into mind rather than some subsequent or preceding syllable. Again, if on crossing the railroad track, I am accustomed each time to see the flagman, I associated the track and the flagman in such a way that when I see or think of the former I am likely to recall the latter, and vice versa. Two events happening at the same time are more likely to be recalled than two between which there is an interval. Attempts have been made to explain this general fact

> of association in terms of purely physiological laws. Those brain cells which are stimulated at approximately the same time are supposed to be more likely to form associative bonds than those which are stimulated with a time interval between them; those which lie more closely together are more apt to be connected than those that are separated by some distance. The principle of Association by Resemblance finds illustration in the recall of a friend not present, on seeing some one who resembles him. The full moon may bring to mind a balloon, because of the roundness of each. A red flag may, on the same principle, suggest bloodshed. The principle of contrast is the exact reverse of that of resemblance. Darkness brings to mind light; beauty suggests ugliness, and the wintry landscape the luxurious foliage of summer.

It should be remembered, however, that comparison and contrast are fundamentally the same thing with different emphasis. Comparison involves analysis into similarities and dissimilarities, but the emphasis and the retention involves the similarities. Another factor of difference is the attitude or the purpose of the person making the comparison. To one person the night might suggest peace and quietness and to another the opposite - noise and gaiety. The situation itself does not make the difference - it depends upon the person who thinks of it.

Importance of Partial Cues and Selection of Cues

One does not, as a rule, respond to a total situation after he has responded to it a few times. Very seldom does he respond to a situation as a whole but lets one or a few elements of the situation serve as a cue for the desired response. These elements obscure the rest of the situation and serve as clews or cues for the response.

In early infancy and among feebleminded people, however, the total situation must be present to bring about the response; thus, a young child occasionally must have the same person present, the same room, or the same play things before it will perform its little stunt.

As one matures and his environment becomes more complex, it becomes exceedingly difficult, if not impossible, to demand an exact situation each time a desired response is to be made. It is, therefore, important and favorable in learning that man is able to select and respond to only one or more of the elements of the total situation present. He very rarely copies a total situation but selects only those elements which will later serve as cues to give the desired response. It is well that nature provided these two factors; that is, learning by partial cues and by selection because they make possible conservation of energy and more extensive learning. Without these factors of analysis and selection very much learning could not occur.

<u>Association by Wrong Partial Identity - Illusions</u>

Learning by and reaction to partial cues involves a difficulty as well as an advantage. Illusions are the result of errors in perception, or are normal false perceptions. There are four principle reasons that illusions occur. These are: (a) illusions due to peculiarities of the sense organs, (b) illusions due to preparatory set, (c) illusions of the false type cue, and (d) illusions due to false presentation of the fact to be perceived.

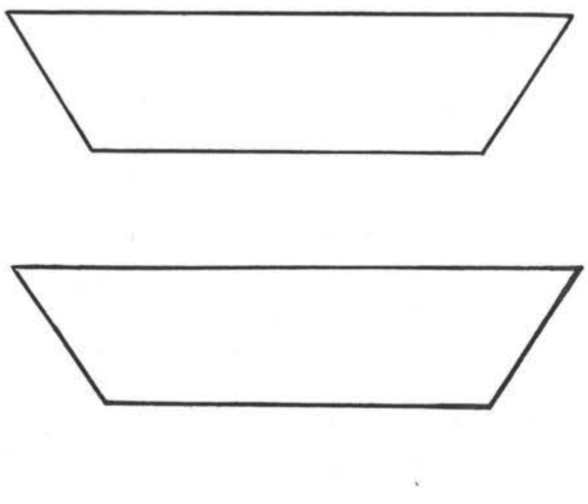
Illusions (a) due to the peculiarities of various sense organs are very common but are not very important and are ignored or compensated for since they are, as a rule, of a regular and predictable nature; for example, the fact that a vertical line appears longer than a horizontal line of the same length. This does not, usually, influence us to react in one way or another in any important matter without further measurement and checking.

Illusions (b) due to preparatory set are illusions due to the projection of one's own images and their acceptance for real sensations. This type of illusion is sometimes called "hallucination" since it is an extreme case of illusion. They most often appear in insane people but the same illusions, in a milder form, may appear in normal people. This is well illustrated by the person who sees a ghost, burglar, dragon, et cetera, when he is in the right environment. The situation suggests these various things and the person accepts the suggestions as realities.

The illusion (c) of the false cue type is the most common kind and appears very often in every day life. If the stimulus presented at the moment has some thing in common with stimuli which in the past have aroused certain perceptions and acceptable responses, the stimulus at the moment may be associated with the past response. Because of some peculiarity in the design of the illusion, however, its classification is incorrect and the usual or normal response which it involves is not satisfactory. A good illustration of this is the pan illusion:

Fig. 4

The Pan Illusion

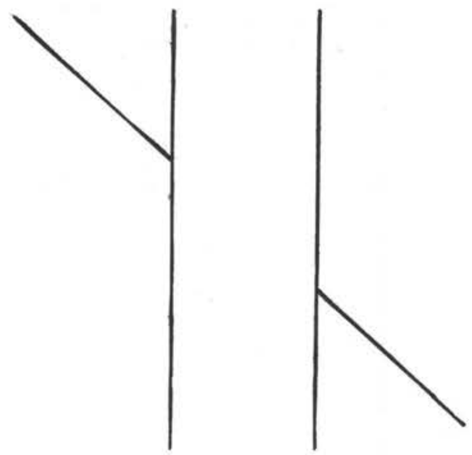


The two pan-shaped outlines are identical, but it is hard to compare the corresponding sides - hard to isolate from the total figure just the elements one needs for comparison with the result that the lower one appears larger than the upper.

The illusions (d) due to false presentation of the fact to be perceived are illustrated by those that are produced in the laboratory by various odd combinations of lines. For example one experiment is to draw a figure so as to make the observer fall in error when he tries to isolate the fact to be observed. These laboratory illusions are artificial and do not very often occur in every day life, but many illusions of appearance and of value occur wherever business is conducted.

Fig. 5

The Poggendorf Illusion: Are the two oblique lines parts of the same line?



Association through Identical Elements

In nearly all types of learning there are certain identical elements. Certain common elements of sensation and perception are involved in the reception of stimuli in any kind of learning. Associative bonds are formed in certain fundamental ways no matter what the mental processes are between the bonds that are being formed. Starch (44) points out that:

> Retention, assimilation, analysis, abstraction and generalization have certain uniform characteristics. Likewise the re-direction and reaction processes follow certain general principles. But on the other hand, each type of learning has its own special sensory material presented and perceived in its own particular manner; it has its own peculiar elements; and it has its own type of reaction occurring in its own individual way. Thus learning to read, the series is, first, visual-auditory impressions and the memory of the objects which they represent, and third, the response of speaking.

Common Defects of Association

The common defects of the association process are several in number. These are:

(a) Faulty association may arise from insufficient attention to the things being observed.

(b) The learner may not have a sufficient amount of experience and number of ideas to make an accurate and complete association possible.

(c) Low retentiveness in a learner may result in the impression being distorted easily.

(d) Lack of imagery results in poor association.

(e) Weakness of the ability to separate the observed and the inferred items, with the result that inaccurate items are supplied.

(f) The degree of suggestion affects the associative process either toward greater or less correctness.

(g) Among many people, especially the dull and uneducated, a striving for effect in narration brings about a loss of accuracy in retention which is projected into what the person believes to be his perception.

(h) Youth and old age, degree of intelligence and education, self-confidence, familiarity with report, types of training (special and general), and susceptibility to suggestion all influence the accuracy of perception through memory, imagination, and report and their mingling with the original perception.

LAWS OF LEARNING

Chapter V

There are nearly a dozen laws that have been formulated by different authors in the field of learning and elsewhere. These will be considered briefly in this chapter.

Law of Primacy

The law of primacy, or, more strictly, the statement of tendency toward the effects of primacy is: other things being equal, the first new experience or experiences are better remembered than those that follow. One can very easily find examples of this. Men easily remember when they purchased their first pair of long trousers or when they first learned to swim, but subsequent experiences in these fields often escape their memory. Many social institutions base their instruction on the principle by placing the most important thing to be learned at the first.

Law of Recency

This law or statement of tendency asserts that, other things being equal, the things which are learned last are remembered best. Thus, the last day at school, the last visit to the store, the last pair of shoes purchased, are more easily remembered than the preceeding events.

Law of Vividness or Intensity

This law states that, other things being equal, the things that make the sharpest or most colorful impression at the time they are presented are first learned and best retained. It thus happens that the child remembers the day at the ball park when his favorite ball player knocked four home runs.

Law of Frequency or Repetition

This law asserts that the things which are most often repeated are first learned and better remembered, other things being equal. This law extends its influence over all drill work which is being done in the schools today.

These four laws have been worked out experimentally and their general validity clearly established. Seashore (42) gives the following interesting introspections of a subject's associations in response to the word "fig":

> Fig suggested apple, because apple is the most common (freq.) specimen of the kind of a thing a fig is, a fruit. Apple suggested tree, because they had been experienced together most frequently (freq.). Tree suggested blossoms because I had been looking for blossoms on the cherry tree this morning (rec.).

> Blossoms suggested bee, because bees are frequently seen with blossoms, and their presence has an exciting interest (freq. and int.). Bee suggested honey, because bee and honey are thought of as cause and effect (freq.). Honey suggested juice of a flower, because the image of honey has followed the image of flowers (rec.). Flower-juice suggested sweetness, because sweetness is the principal characteristic of flower-juice or honey (int. and freq.).

Jost's Law - Distribution of Practice

Jost (25), working with syllables, found that two repetitions a day for six days were better than four repetitions a day for three days. His law, as stated, is that when two associations or ideas of equal initial strength but of different ages since recall are reintroduced into consciousness, the older is the more strengthened, both in the present and for the future.

Kirby (28), in another study, found that practice intervals gave more improvement and that more frequent shorter time practices resulted in more improvement than fewer longer practice periods. He took four groups of fourth grade children at random and used addition as his practice material. All groups practiced fifteen minutes at the beginning and fifteen minutes at the end, but the forty-five minutes of practice between the initial and last practices were distributed as follows:

Group 1 2 practice periods of 22½ minutes.

Group 2 3 practice periods of 15 minutes.

Group 3 7 practice periods of 6 minutes and 1 practice period of 3 minutes.

Group 4 21 practice periods of 2 minutes and 1 three-minute period

Table II

Results found by Kirby

	Median Initial Ability	Median Gain	Median Gain in Rate Per cent	Median Gain in Accuracy Per cent
Group 1	22.9	9.5	45	3.5
Group 2	25.4	11.0	43	-1.6
Group 3	21.1	9.6	42	-1.5
Group 4	25.1	12.6	56	-2.7

Kirby found also that the pupils lost none of this increased proficiency as long as they continued to exercise these same functions.

Just what is the ideal distribution of practice time is hard to say but it is known that it varies with age, intelligence, and the skill of the learner. It is also affected by the factors of monotony in the longer practice periods and, without much doubt, by incidental practice (conscious or unconscious), and by some perservation. Lastly, it also varies with the type and the difficulty of the material.

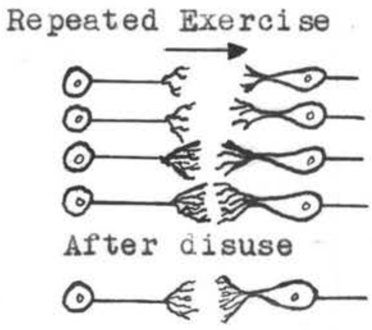
Laws of Exercise and Disuse

In exact psychological terms this law reads, "When a particular stimulus arouses a certain response, the bondage between this particular stimulus and the response is strengthened." This takes place because of the fact that every stimulus makes an impression on an individual's nervous system which facilitates the repetition of the act. This law is considered one of the most important laws of learning because it affects the four laws previously described.

The law of disuse operates in an opposite manner from the law of exercise or use. It asserts that when a stimulus-response situation is not operative or has not been operative, the bondage between the stimulus and response tends to be weakened although not totally destroyed for a long time.

These two laws are shown in a speculative diagram:

Fig. 6



Although it is not known in what way the synapses actually operate, there are several similar explanations for the law of exercise in terms of synapse. Of these, Woodworth's is typical. He supposes that a nerve current passes along a pair of neurones as in the direction of the arrow above. Every time it passes, it exercises the end-brush and dendrites at the synapse and the after-effect of this exercise is growth of the exercised parts, resulting in a closer linkage between one neurone and the other. Repeated exercise, he states, probably brings a synapse from a very loose condition to a state of close interweaving and excellent power of transmitting the nerve current.

Law of Readiness

All the laws of learning would amount to very little if the reactor himself was not taken into consideration. The reaction that occurs will depend very much upon the individual who receives the stimulus. The response that a learner makes will depend, not on the stimulus alone, but also upon his original nature, structure, past experience, present physiological state and mental attitude or readiness to perceive and react to the stimulus. The law of readiness asserts that, when the latter conditions are satisfactory, the learning will be more effective and will be remembered for a longer period of time than if these same conditions are found to be unsatisfactory and annoying. Stated in the words of Thorndike (46) the law of readiness is:

> When any conduction unit is in readiness to conduct, for it to do so is satisfying. When any conduction unit is not in readiness to conduct, for it to conduct is annoying. When any conduction unit is in readiness to conduct, for it not to do so is annoying. By a satisfying state of affairs is meant one which a person does nothing to avoid. By an annoying state of affairs is meant one which a person does nothing to preserve.

It is important that the learner should be in a state of readiness if he expects to solve any problem rapidly and with satisfaction. By the state of readiness is meant the psychological and physiological adequacy of a person for response to a given stimulus. The person must be in a condition to use the situation after it is presented. One's interests, attention, perceptual centers and sense organs must harmonize with the situation if the desired response is to be attained.

Law of Effect

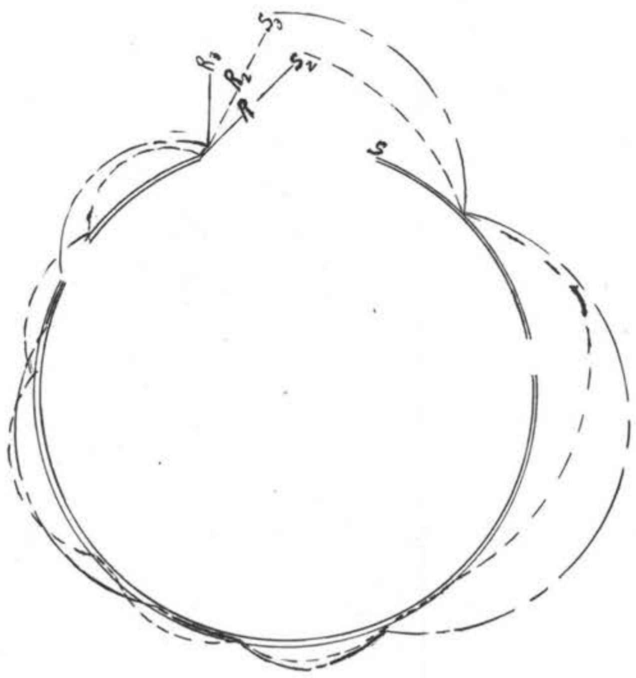
This law states that when a particular stimulus arouses a certain response and a modifiable connection is made and when this is accompanied by a satisfying state, the strength of the connection is increased. Conversely, if the connection is followed by an annoying state of affairs, the strength of the connection is decreased.

All learning is dependent upon the psychological and physiological effects that an individual's reactions are producing. If his efforts are successful the sensory effects of his responses will act as responses to further activity. If his efforts are unsuccessful the sensory effects will act as an inhibiting force to further activity. If the sensory effects are painful any further activity will be inhibited and if the sensory effects are pleasant the sensory effects will again serve as stimuli to further activity.

The conventional picture of the neural arc, which consists of one of three lines, either straight in a series or curved in a series, has been illustrated in a previous chapter. This begins with a stimulus (S) and ends with a response (R). This, usually, is believed to include the entire picture except when R-2, R-3, R-4, et cetera, are substituted for R or R-1, et cetera. Laslett (30) has undertaken to show this process in a different light. He states that if the feeling or emotion involved in the process is more than the minimum the action will tend to be repeated several times in memory and imagination, when some part of the situation is re-aroused through association. The entire series will not be repeated mechanically; only the most important parts or those in which a different trend of action would have changed the whole sequence for success where there was embarrassment or failure before or vice versa. Through these S-R reviews it is possible that the successful parts of the S-R series are strengthened and the unsuccessful ones weakened. It is also probable that the law of effect processes do not operate from R backward toward S, as Peterson (38) states, as much as it follows the course of the original series. It is also probable that the feeling or emotion is most noticeable near the end of the original S-R series and that its influence is greatest at similar points near the ends of the several repetitions where it is felt most keenly at first and the end-results of the original series become apparent without much possibility of their being changed either way. Laslett (30) has chosen to call this phase of the law of effect "the reverberations around the law of effect." It is reproduced diagrammatically below:

Fig. 7

Reverberations around the Law of Effect



In the diagram "R" or "R-1" blends with or is a part of "S-2" (the reception of the act and judgment of it by oneself and by others) and this leads to a review of a considerable part of the original series. "R-2", in turn, blends with added acts of others or added thoughts of one's own and leads to a repetition of parts of the original series and parts of the first repetitive series and to a further partial conclusion "R-3". The number of such series of reviews is perhaps in proportion to the strength of the feeling or emotion involved.

By the action of all the laws mentioned in this chapter tendencies are either strengthened and preserved, or weakened and discarded. No one law or statement of tendency is uniformly dominant. One may exercise great influence in a particular instance and another in the succeeding instance. Often the "laws" co-operate with each other, as vividness and primacy, and, at other times, they seem to be in conflict with each other. New responses attach themselves to new stimuli or to old responses. Old responses attach themselves to other old responses and these multiple connections result in many habits, interests and attitudes.

THE CURVE OF LEARNING - THE HIERARCHY OF HABITS

Chapter VI

Types of Learning Curves

There are two main ways of presenting the material of a learning curve. The first type pictures the amount of work that can be done in a given unit of time in successive practices. A graphical illustration of this is given by Bryan and Harter (14) and is shown in Fig. 8 on page 54.

The second type shows the decreasing amount of time required to solve a problem at successive periods of practice, or the reduced number of trials required to solve it as an indication of the progress of the learner as the practice proceeds. This is presented graphically by Woodworth (50) and is reproduced in Fig. 9 on page 55.

It is possible to use either one of the two graphical methods to show all the fluctuations in improvement.

Parts of the Learning Curve

All learning curves are characterized by certain variations from day to day and from minute to minute. These curves show the following six important characteristics which will be discussed in their order of appearance:

Fig. 8

Improvement in Telegraphy

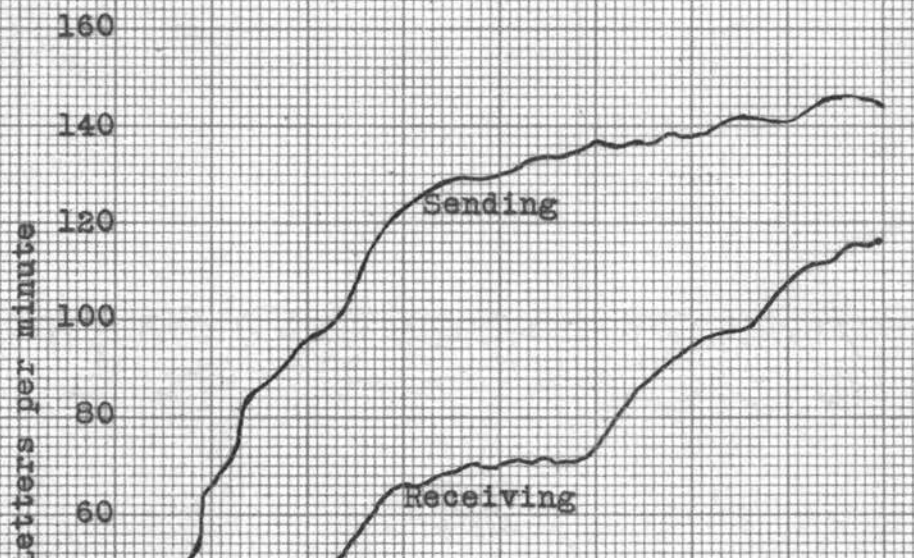
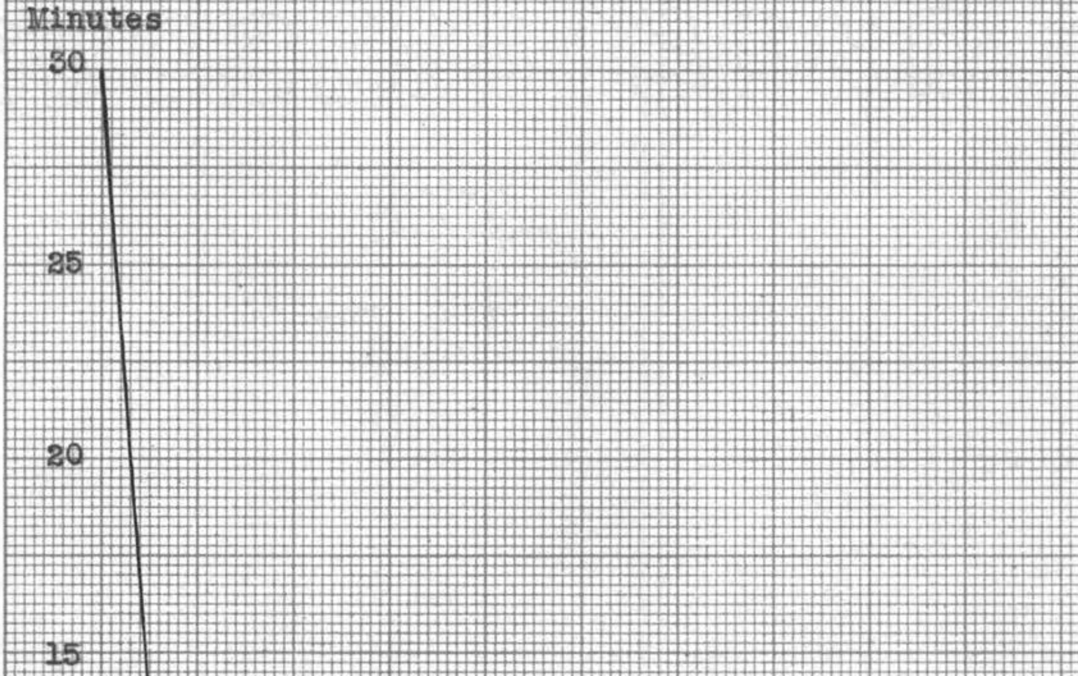


Fig. 9

Learning Curve for Rat in a Maze



(a) the initial spurt

(b) the lag after the initial spurt

(c) the rapid rise after the initial period

(d) the plateaus

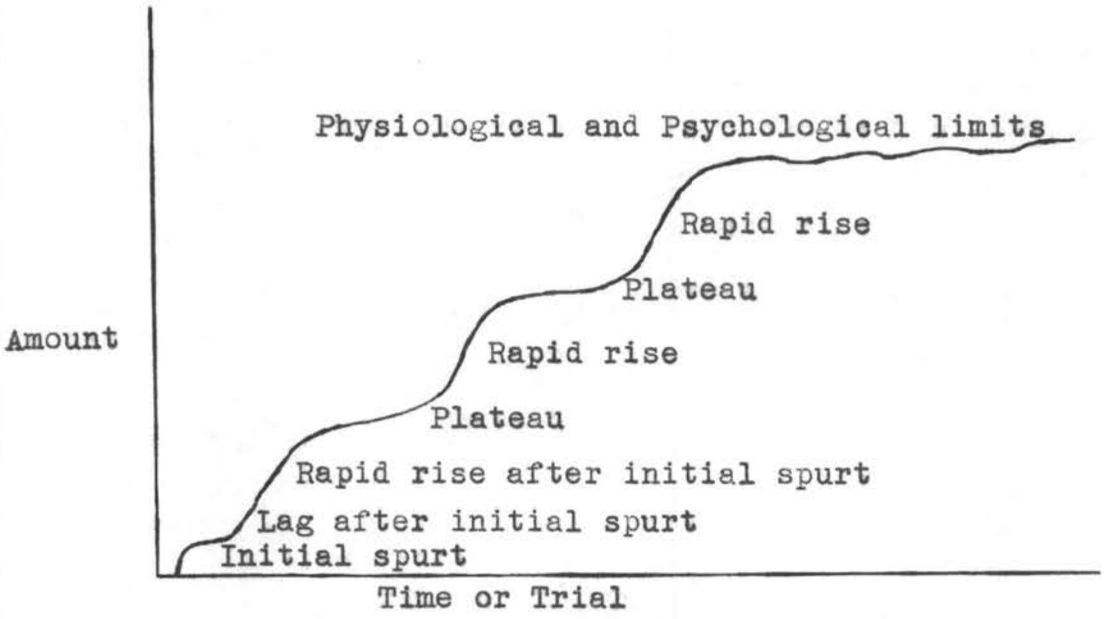
(e) the rapid rise after the plateaus

(f) the physiological and the psychological limits

These six characteristics are shown in the following conventional learning curve:

Fig. 10

A Conventional Learning Curve showing Characteristic Parts



There (a) are several causes which contribute to the initial spurt. It is, in part, due to the newness of the task and the extra zest and enthusiasm of novelty, the numerous ready-to-hand minor skills transferred intact from previous learning, and the fear of abject failure in a largely new task. Most individuals dread the thought of social disapproval or individual disapproval and therefore strive to do their best work so as to meet the approval of all. The beginning learner is also making various different easy, minor improvements from the first, according to Book (9) in his study of typewriting skill:

> The learners are improving their method of locating the keys, of directing and controlling their fingers, of initiating and controlling the sequence of the letter-making movements, of getting the copy, of learning to deal with many special difficulties which the task of learning this feat presents. They are also making progress in developing and fixing letter, word and phrase habits almost from the start. Moreover, the improvement in each of these lines is easy at first and becomes increasingly difficult as skill is increased.

As long as these previous skills exist and are used the learning curve will rise, but as soon as increased skill is required the curve will tend to become horizontal. Fear of failure decreases, as well, or results in dissatisfaction and a refusal to try further. The effect of the novelty diminishes, also, while the psychophysical coordination has not been set up to the point at which it can run smoothly and with a minimum of attention.

There (b) is a noticeable lag after the initial spurt in most learning curves. This is due to the increase of skill that is needed to continue, or to the decrease of interest and effort and the absence of a new and firm co-ordination of the mental, neural, and muscular units involved in the activity. The novelty has worn off somewhat and the learner begins to see his task becoming increasingly more difficult.

The next part (c) of the learning curve is characterized by a second rise. This is the time when co-ordination begins to take place and the skills possessed merge with the new skills acquired for improvement. Renewed interest occurs, usually, and the learner becomes aware that he can make improvements.

The next part (d) is the plateau or plateaus. These plateaus that occur in learning curves are due to: (1) automatization of the previously learned skills or ideas. It is the time when the lower-order-habits and higher-order habits merge so as to allow greater improvement; (2) overcoming the effects of a bad learning habit which must be corrected before further commensurate improvement is possible. It is the time when checking is taking place so that the learner can eliminate any obstacles in his pathway; (3) assumption of a freedom in higher-order-habits before it has been earned by practice. The learner believes he has mastered the situation thus far only to find out that he has not; (4) persistence in seeking to improve a lower-order-habit beyond its worth or merit instead of proceding to higher-order-habits. This is the converse of the previous assumption; (5) finding oneself in a slump and making a rash or confused effort to overcome it; and (6) decreased interest, diversion of attention, distractions from environment, changes in the worker's attitude, poor physiological or psychological hygiene and many other factors of an individual nature. It is a period when no progress is evident, as shown in the graphical illustration by Book (8) and reproduced in Fig. 11 on page 60.

Most learning curves contain one or more of these critical stages or plateaus. There are, however, some learning curves that do not show a critical stage or plateau, but whether the plateaus were absent or whether they were concealed by other related factors is a question which can not be answered with certainty at the present time. Byran and Harter (14) found such a condition to exist in their experiment in sending messages by telegraphy (Fig. 12, page 61).

That plateaus occur at fairly definite stages in the learning curve is generally agreed upon by investigators.

Fig. 11

Improvement made in Typewriting by the Sight Method

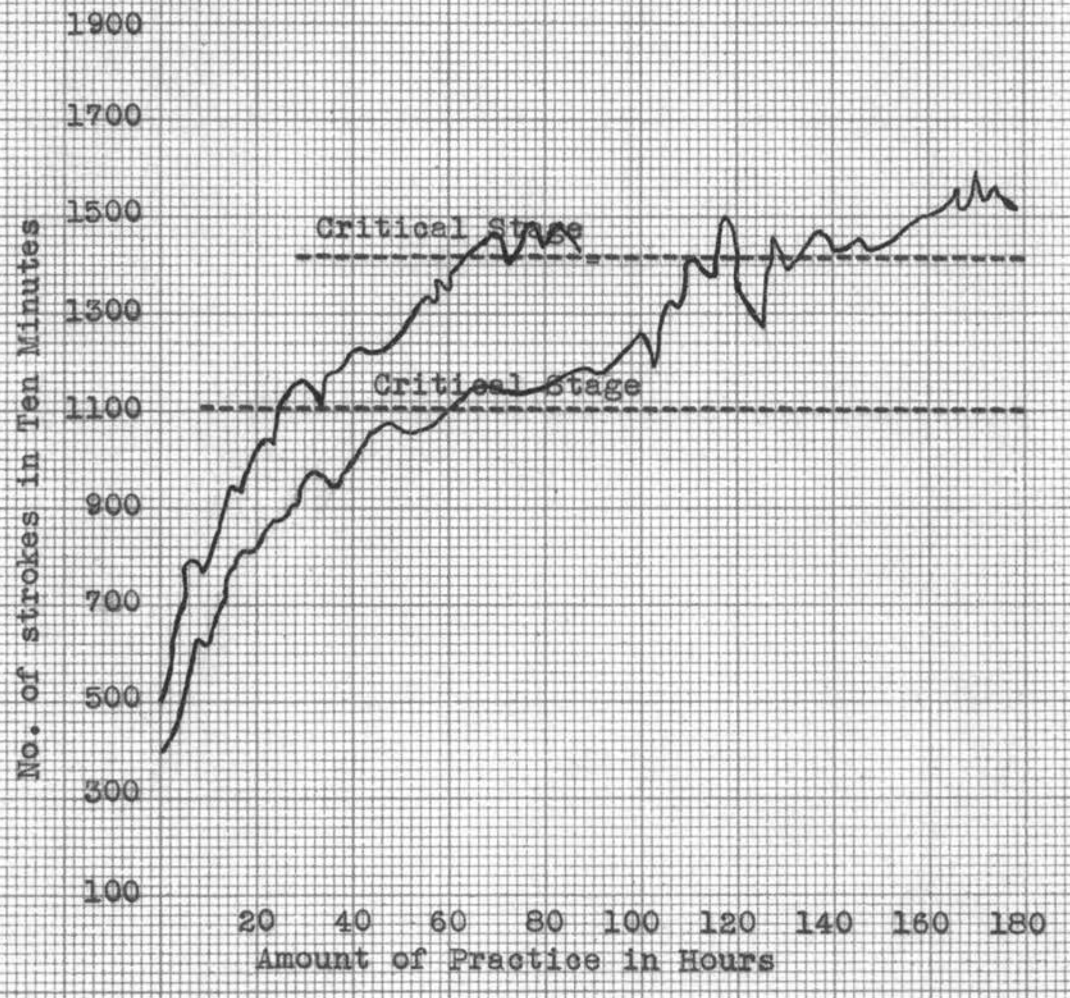
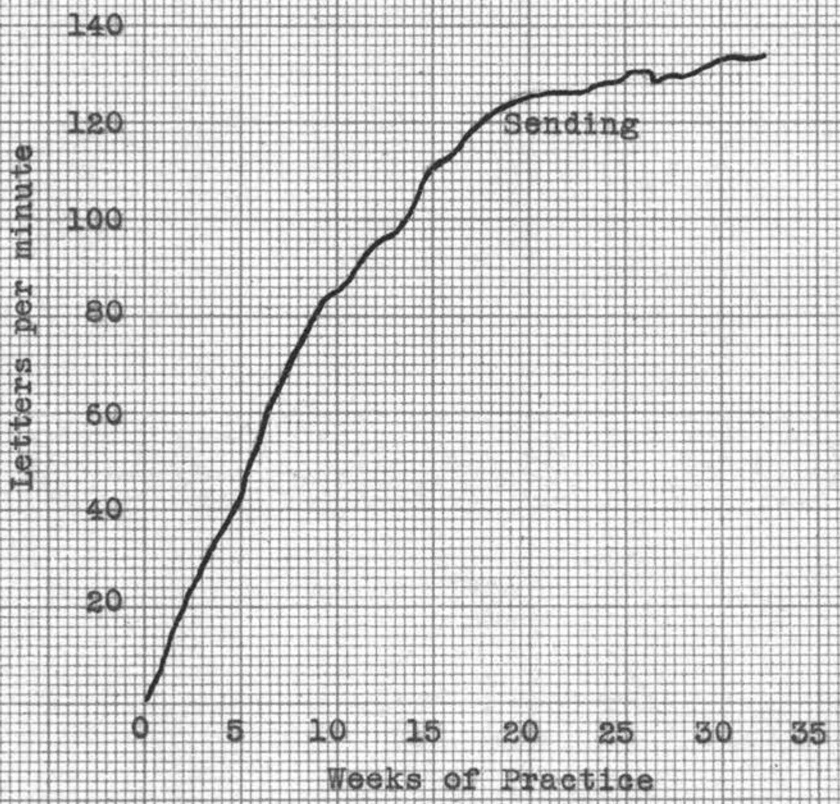


Fig. 12

Improvement of W.J.R. in Telegraphy



In cases where a new problem is to be solved, the plateaus occur early in the curve. It is quite possible for one person to develop a plateau and another person not to develop one at the same place, both studying the same problem, because of individual differences, but with groups of about equal ability and interest, the plateaus will occur at about the same places and at about the same time. The number of plateaus will vary with the complexity of the task. In a very complicated task, there may be a dozen or more of these critical stages.

The (e) rise from a plateau is the result of the procedure to higher-order-habits, and is, in many ways, similar to a new initial spurt. It may be due to the use of a more economical method of work, though continued improvement of the lower-order of habits continues and accounts for some of the rise. The learner's attitude, increased effort, and interest may influence the rise, as well.

Next (f) is the point or zone called the physiological or the psychological limit. The physiological limit is defined as the limit of the organism to react. The psychological limit is divided into two parts. The first is the willingness of the worker to continue further effortful practice. This occurs when the learner thinks that he has reached his limit and can use his time more profitably in doing something else. The second part is the belief that the physiological limit has been reached and that there is no possibility of further improvement when, as a matter of fact, there is.

Fluctuations During the Course of a Single Practice Period or Period of Work

That there are fluctuations during the course of a single practice period or period of work is shown by a number of experiments. These experiments show the following characteristics in the curves of performance:

(a) an initial spurt
(b) a warming-up process
(c) irregular fluctuations
(d) end spurt succeeding a decrease in efficiency

The initial spurt is due to the extra fervor and the physiological fitness at the beginning of the day. The worker begins his daily task with extra enthusiasm and zest that gradually wear off during the course of the day or half-day.

The warming-up process is due to relearnings and physiological limbering up. Because of the law of disuse, mentioned in a previous chapter, it is evident that all neural connections become considerably weakened if the learner's time and attention are taken up by outside stimuli which may be antagonistic to those neural connections which the learner has already formed. Book (8), for example, found that much of the ease of performance on a certain day was very much reduced on the following day. He also noticed that associations made at the beginning of practice were fewer than those formed later on during the practice period.

The importance of this physiological principle lies in the fact that before a learner can do his most efficient work this warming-up and adaptive process must take place. The learner must proceed slowly at first, giving his individual attention to his work. If the learner fails to observe this principle failure to progress may come, with the result that his attitude toward his work will become unfavorable and thereby decrease his working efficiency. Only as these associations are slowly revived can the learner expect to progress at a faster rate.

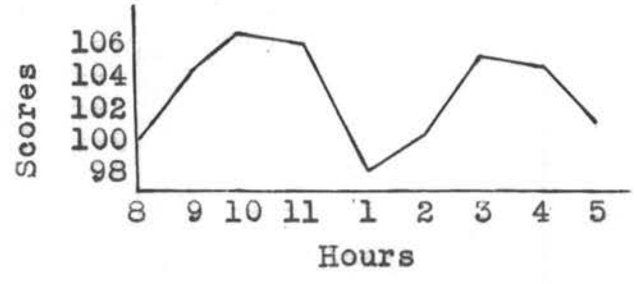
Irregular fluctuations occur just as in the case of long-time learning curves. The reasons for the fluctuations are the same; namely, loss of interest, distractions from environment, or changes to the worker's attitude and physiological or psychological state.

The end spurt is due to increased efforts and adaptability. It is also due to knowledge of the close of the period of effort. There is no end spurt if the periods of work are of irregular length and there is no knowledge of the approach of the close of the work period. If, on the other hand, the work period is prolonged beyond the usual closing time and after the end spurt has occurred, the drop in performance is sharp unless great effort has been made to prepare against this by showing causes for the prolongation of the work period. The end spurt is usually much more a sign of boredom and the effects of monotony than of actual fatigue.

Below are the results of a study made by Gates (18) when he tested 165 college students in auditory memory, visual memory, substitution, recognition and logical memory.

Fig. 13

Showing the courses of working efficiency of college students during the day



Difference Between Daily Work Curves and the Continuous Learning Curves

That there is a difference between these two types of learning curves is not hard to see. The most obvious difference is the fact that one is a single unit of work while the other is not. The daily work curve covers a protracted working period while the continuous curve takes into account, usually, only a small part of a total working day. The main differences are those of the plateaus, the effects of monotony, and the end spurt. In the daily curve we find no plateaus but do find a decrease in proficiency until the end spurt while in the continuous curve we find, usually, noticeable plateaus and a leveling off at the end. Many people confuse these two curves and arrive at incorrect conclusions as a result of the confusion. The curves portray measurements of two very dissimilar processes and should be kept clearly separate.

Developing a Hierarchy of Habits

A hierarchy of habits presents the curve of learning material in a different form. In a hierarchy of habits there is a certain number of habits which are primary parts of all other habits in the hierarchy. The higher-order habits embrace the lower-order habits as elements.

A lower-order habit or higher-order habit when acquired has physiological and, if conscious, psychological unity. The habits of the lower-order tend to fuse into those of the higher-order. This is very well illustrated in the letter-making, syllable and word-habits in Book's (9) learning to typewrite:

> The habits which give direct control over the manipulation of the keyboard are of various kinds and grades, ranging from the simplest responses made by a beginner to the most complex hierarchy of psycho-physical habits used by the world's champion typist. In beginning to write by the touch method, for example, a linkage is established between the sight of each letter in the copy, or its mental equivalent (some form of actual or incipient mental spelling) and the thought or image of the exact position of the key to be struck. But this is only a preliminary step in the process of moving the proper finger to the corresponding key. The process of mentally locating the key is only a means employed to locate it with the appropriate finger and must give rise to certain other psycho-physical processes that are used to initiate and direct the appropriate finger movements in a later stage of practice. This process of locating each key with the correct finger and hand represents, in the beginning, a very difficult and roundabout procedure for all learners and must take place for each letter before or while the final movement for striking the key is made.
>
> In the earliest writing of undirected beginners five distinct steps are required to make a letter on the machine: (1) fixing the letter in mind; (2) pronouncing it or initiating the letter-making movement; (3) mentally locating the corresponding key on the keyboard, which starts (4) the process of locating it with the proper finger and hand; (5) again pronouncing the letter either actually or incipiently before or while the correctly located key is being struck.

By the principle of negative adaptation and the action of conditioning stimuli, this five-fold process of making each letter is "short-circuited" and the five steps combined into one unitary response as the practice proceeds. When this ability has been acquired, the mere sight of a letter in the copy, or its mental representation, the spelling, calls up at once the one correct letter-making movement required to write it, which can not be guided while it is made, merely by attending closely to its motor-tactual "feel." When this has been accomplished, a letter-making habit has been originated. It needs only to be improved and fixed by much correct practice to give the learner perfect control over the process of making the letters one at a time.

In the course of the practice, steps one, two and three of this earliest method of locating each key, are combined by learning the keyboard. Steps four and five are also fused as soon as the learner acquires some skill in the use of right methods of fingering the keyboard. Finally, the mere thought or sight of the letter in the copy gives rise to the one correct letter-making movement, which can now be controlled both as to direction and distance while made.

As letter habits are improved and finally mechanized by use, a habit of reacting directly and in a unitary way to certain groups of letters composing familiar syllables and oft recurring words is acquired, improved, and finally fixed for all familiar syllables and words. In the course of the practice, the separate letter-making movements required to write these syllables and words come to be controlled as a group, the separate responses becoming fused into one unitary response in the same general manner as were the five steps required to make each letter in the earliest stage of writing. The individual letter-making movements do not represent single and isolated movements, but always a series of closly related movements because the letters follow each other in a fixed order in the writing of sentences and words. This makes it possible, as the individual letter-making movements begin to need less and less attentive direction, to "short-circuit" the process of controlling them and to begin to react to several of them at once. By the same principle of negative adaptation and conditioning stimuli, which operated in producing the letter by letter method of control, the learners develop a method of control which enables them to handle an entire syllable or word by making one unitary response to the group of letters taken as a whole.

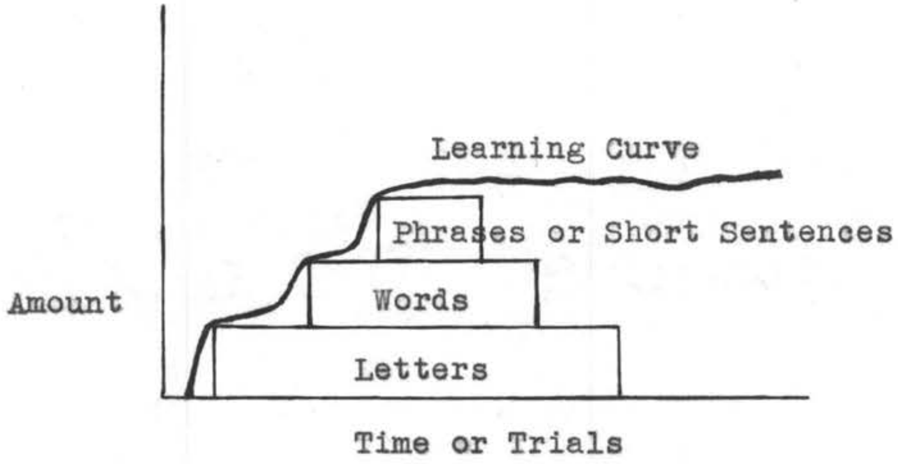
When the mere sight of such a syllable or word in the copy or its actual or incipient pronunciation gives rise to the series of letter-making movements required to write it on the machine, the movements being guided, both as to sequence and correctness of stroke, by the sensations aroused by the previous movements in the series, a syllable or word habit has been formed. It needs only to be improved and mechanized by the principle of positive adaptation and the law of effect to make the acquisition of this order of habit complete.

As soon as these word habits have been acquired, the syllable or word becomes the unit for attention and can be reacted to as a whole, in the same general manner as were the letters at the letter-association level, or as were the individual steps in the process of making each letter in the earliest stage of the practice. But in developing this higher-order habit the learner must first watch every step in the unified word-response. Later, the response can be directed more generally, the entire group of letter-making movements being controlled both as to sequence and correctness by attending to the group of movements taken as a whole.

That a hierarchy of habits presents the learning curve material in a different manner is shown in Fig. 14, page 70.

Fig. 14

Showing the Development of a Hierarchy of Habits



The series of rectangles illustrates the way one learns to write. First letters are learned, then words, and lastly phrases or short sentences. The continuous line is the conventional learning curve and, when drawn, follows the contour made by the hierarchy. In other words, the learning curve and the hierarchy curve are essentially the same thing.

TRANSFER OF TRAINING AND LEARNING

Chapter VII

One of the important problems in learning is to discover the ways that an individual's ideas, knowledge, experiences, habits, attitudes, and skills can be used in further learning and in adjustments to life situations. What an individual learns in solving one situation may well be used in solving a like situation. It becomes apparent that transfer and learning go hand in hand. What one learns in one situation may or may not help to solve any further problems.

Recognition of the Problem

Until thirty-five years ago the problem of transfer of training was one of opinion only but since that time many research studies have been made, the experimental method being practically the same in every case, namely: (a) testing the strength of a variety of mental capacities, (b) training one or more capacities for a specified period of time, and (c) finally testing again the same capacities tested before the training in order to determine what changes may have been produced in them as a result of the intervening training.

The problem of transfer is not as simple as some educators would have us believe. Four problems are involved when one attempts to explain the nature of transfer, namely, (a) does transfer of training occur, (b) if it does occur, to what extent does it take place, (c) to how closely or how distantly related functions does transfer take place, and (d) how does transfer take place? These four aspects of the problem will be taken up in the order of their appearance.

Does Transfer of Training Occur?

Whether or not transfer of training takes place is largely a matter of definition. The experimental work done to ascertain the effect of one type of learning upon another has not as yet been attempted to find out just the ways in which a person's skills and knowledge operate in making future acquisitions. As a rule, these experiments have been conducted to determine the value of traditional school subjects or to test the validity of mental discipline. Some valuable information has been attained, however, and the trend of belief is, at present, toward adherence to the effectiveness of transfer of training.

To what Extent does Transfer take place?

When due allowances are made for gains produced by practice in a new subject to be learned, and for faulty methods, the studies in transfer seem to show positive effects. This is true for the experiments made of (a) the perceptual processes, (b) the memory processes, (c) the reasoning processes, and (d) most of the studies that are made to determine transfer effects from one school subject to another. It is, however, true that the transfer effect is not large unless the content and method of performance are similar.

How Closely or how Distantly Related Functions Transfer

It may be said that, in general, practically every investigation shows that improvement in one mental or neural function of a pair is accompanied by some modification in the other function. This modification in most cases is a positive transfer although negative transfer does occur especially among sensori-motor habits. The amount of improvement in the one function, however, is very seldom accompanied by an equal amount of improvement in the other function; for example, Thorndike and Woodworth found that the gain in various types of perception or discrimination closely related to the type in which the training took place was from 0% to about 40% as great as that made in the particular kind of perception trained.

Starch (44) makes the following statement:

> As a general estimate, on the basis of experimental work done thus far, the amount of transference between the extremes of 100% and 0% transfer lies nearer to the zero end and is probably in the neighborhood of 20% to 30% of transfer to allied functions and from that point on down to 0% of transference to more unlike functions.

The experiments that have been undertaken give no evidence from one type of learning to every other type. They show that there may be actual interference as well as facilitation, depending on the nature of the problem, upon the methods used, and upon the experience and knowledge needed to solve the problem.

To show that all previously acquired knowledge is not always helpful in solving a new problem, Book (8) has cited several studies:

> Bergstrom showed that if a person practiced arranging into four piles, the fifty-two cards of a deck of ordinary playing cards, using a certain order, and repeated the performance until the time could not be further decreased, more time would be required in learning to place these cards according to a new arrangement than was consumed in learning the first arrangement. More mistakes were also made in the new arrangement.
>
> Munsterberg noted how many times he felt in his right vest pocket for his watch, where it was usually placed, after he had purposely placed it in the left pocket. He soon learned to seek the watch in his left pocket, but in acquiring this new, conflicting habit there was an actual interference on the part of a habit that had previously been established. Bair made a similar experiment with a typewriter and found that, after he had learned to

strike a certain arrangement of colored keys, there was a direct interference by this habit when he tried to learn a new arrangement of keys.

When an animal is confronted by two diverging paths in a maze, and is taught to choose the left path when a bell is sounded and the right path when no sound is given, this training will produce a very detrimental effect upon his ability to establish the habit of turning to the right when the bell is sounded and to the left when no signal is given.

W. H. Pyle had four groups of subjects sort 150 cards into 30 boxes numbered from 11 to 40. One group of subjects sorted an hour a day for fifteen days with one arrangement of the boxes and then practiced for fifteen days with another arrangement, the boxes always having the same number. A second group of subjects were asked to place the same cards into these boxes, but for them the arrangement of the boxes was changed from day to day. The first method of forming these conflicting habits was decidedly the better, and indicates that the best method of forming some mutually interfering sets of motor habits is to form first one set and then the other. Other experiments have shown that the interference present during the learning vanishes after both sets of antagonistic habits have been firmly established.

In general then, it can safely be asserted that transfer of training does take place to quite an extent providing the materials, methods, experiences and knowledge needed, are the same or are related and especially if direct emphasis is placed upon training for transfer.

How Transfer Takes Place

Three theories have been advanced to account for any transfer that does take place. The first is the theory of identical elements given by Thorndike (46). This theory asserts that transfer takes place because there are identical elements in the two activities. These elements might be identical either in content or method; for instance, reading would help an individual in most activities because one needs to be able to read before he can understand many problems. Thorndike accounts for all improvement upon the establishment in the nervous system of definite bonds between each specific response learned and some stimulus-situation to bring about this response. Out of the very many responses which are learned some would be bound to several situations. The greater the number of these related response-situations, the greater would be the transfer effect.

A second theory is that offered by a disciple of Gestalt, Henry Bode. Bode (7) makes transfer of learning take place because of the flexibility of habits and the development of meanings:

> What makes habits flexible is the integration of different activities with one another so as to form larger units, which are modified or adjusted when dealing with specific situations. The readjustment is made necessary by the fact that some new element or factor gets into the situation. This complex of reactions expresses itself in

> meanings; hence it is possible to say that we meet the new situation with an old meaning, and that transfer takes place through meanings. ....The recognition of the old meaning in a new situation is a form of analysis. But in order to make this analysis possible, it is necessary, at the same time, to relate this meaning to the new factors or circumstances, which is synthesis. Sometimes this synthesis can be achieved only by making an important change in the original meaning, as for example, in the discovery that the moon is a falling body.

Thus, according to Bode, transfer depends upon the flexibility of perception and association and of the habits that have already been established and upon the type of mearning responses the learner is able to make in solving a new problem - not, in effect, very different from Thorndike's much earlier position.

A third theory is the one formulated by Thorndike but later enlarged and elaborated upon by Judd (26). This theory is generally called the 'theory of generalization' and tries to explain the spread of improvement in terms of the recognition of application of an experience obtained in one connection to other connections. To show this an investigation was made by Scholckow and Judd (27) in which they attempted to show the effect of knowledge of the principle of refraction upon learning to hit, with a dart, a target under water. A group of boys was given a clear explanation of the theory of refraction. Another group of boys was left to learn the theory as best they could. The two groups then began to practice with the target under twelve inches of water. It was found that the two groups gave about the same results, neither group surpassing the other. Explaining the theory of refraction did not help the first group in the least as each group had to learn to use the dart. At this point the target was placed under four inches of water. The results were striking in that the first group made many fewer errors than did the second group (the group that was not given any explanation). The boys who had the theory adjusted themselves to the new conditions very rapidly.

Thorndike and his assistants (46) by means of a complicated technique and statistical procedure, have evaluated the high school subjects for disciplinary and transfer effects and later revalued them in terms of improvement in learning performance resulting from their study, as shown in Table III:

Table III

Evaluation of Various High School Subjects for Disciplinary and Transfer Effects

	1924 mental discipline : value	--- rank	1927 m.d.v.	rank
arithmetic and bookkeeping	2.92	1	2.60	4
chemistry, physics, general science	2.64	2	2.71	3
geometry, algebra, trigonometry	2.33	3	2.99	1
Latin, French	1.64	4	.79	6
physical training	.66	5	.83	5
civics, economics, sociology, psychol.	.27	6	2.89	2
history, music, shop, Spanish, English business	.00	7	---	-
dramatic art	-.29	8	-.48	10
stenography, cooking, sewing	-.47	9	-.14	8
agriculture, biology	-.90	10	-.15	8

(Notes:

(1) .00 does not mean no value, but the least positive value. The other scores are multiples of the number for which .00 stands.

(2) the space between biology and psychology and between chemistry, physics, and general science seems pretty wide, especially in the case of biology.

(3) the low places given to the rule-of-thumb subjects accords with general opinion.

(4) the trend of selection of subjects by good or poor pupils would affect these scores extensively.

(5) if the experiments are corroborated by other experiments, it will change current opinions definitely on the parts of both the classicists and the vocationalists as to the disciplinary values of subjects but will probably not affect the estimate of interest values. It will change the emphasis within the subjects. The experiment appears to me to be weak because of variations in the training of the teachers, standardization and formalization of courses, varying effects of the teachers' personalities on pupils, the purposes of the pupils in attending school and in selecting the courses within the school, the competition among courses, the selection of subjects by types of pupils according to intelligence and ambition.)

Before the question of the ways in which transfer of learning takes place is answered, much more experimental work, with improved technique, will have to be done. These experiments must show the ways that identical elements and methods from experience come to be used when a new problem is to be solved and they must also show the ways in which flexible habits and meanings facilitate transfer, even though some of this is explained in associative studies.

What Probably Carries Over

Summarizing the experimental results on the transfer of training the following have been said to carry over:

1. Identical elements
2. Similarities in methods
3. Helpful or detrimental attitudes
4. Ideals
5. The feeling of self-confidence or attitude toward success
6. Helpful methods of work

CONDITIONS FAVORING LEARNING

Chapter VIII

Common and Special Elements

Every type of learning has certain common bases or certain processes in common. Certain aspects of sensation and perception are common in the reception of any stimuli in each learning process. Retention, analysis, synthesis, assimilation, recall, abstraction and generalization have common like characteristics. Associative bonds are formed in certain fundamental ways regardless of the structural mental processes involved.

On the other hand, each type of learning has its own special sensory material arranged, presented, and perceived in its own characteristic way. It likewise has its own special bonds and its own types of reaction which take place in their own peculiar way; for example, in learning to read, the continuity is first the visual-auditory-vocal motor impressions with the objects they represent; and, lastly, the response to verbal expression.

Activity of the Learner

There are many things that favor the learning process.

The activities of the organism furnish very important inner drives which serve as motivating forces to overt behavior; for example, energetic responses result from a high degree of bodily energy and activity while a decrease in a learner's potentiality as a learner will result from a low bodily vigor. Such organic conditions as headache, fatigue, indigestion, toothache, earache, backache, cold, hay fever, eye trouble, et cetera, will direct the learner's attention toward other things than the problem to be solved.

It becomes necessary, therefore, if the learning process is to be most favorable for the learner, he must be in good physical condition so that he will possess vigor enough to meet and solve the problem in hand.

Since adjustment to the situation is necessary to produce real learning, it follows that this learning will result when favorable conditions are set up.

Observation

Learning on the observational or perceptual level has been previously discussed but special emphasis as to the importance of observation as a means of favoring the learning process should be made. We learn because we can sense; we sense because of our bodily structure and because of our external environment. Without good ability, willingness, and practice in observation - that is, inability to perceive - our learning efficiency is greatly handicapped. We need to be accurate and extensive observers if we expect to favor our learning process.

Trial and Error

If a new problem arises to which the learner is not well adapted either in experience or ability, the solution will be arrived at in a hit and miss fashion. The new correct response will be made by chance after a series of repeated trials. The number of trials will, of course, depend upon the more or less specific habits and skills the learner already has and upon the more or less general experiences and knowledge possessed by him.

Just how the correct and desired response is developed is not known. It is known, however, that whether or not the correct response can be successfully repeated depends upon the accuracy and continuity with which each trial response is checked by the learner in the light of the correct response. The checking can be done on either the physiological or the more conscious levels.

There have been many experiments to show this type of learning. Among these is the one made by Woodworth (50):

The rat, placed in a maze, explores. He sniffs about, goes back and forth, enters every passage, and actually covers every square inch of the maze at least once; and in the course of these explorations hits upon the food compartment. Replaced at the starting-point, he proceeds as before, though with more speed and less dallying in the blind alley, till he finally passes the entrance to it without even turning his head. Thus eliminating the blind alleys one after another, he comes at length to run by a fixed route from start to finish.

At first thought, the elimination of the useless moves seems to tell the whole story of the rat's learning process; but careful study of his behavior reveals another factor. When the rat approaches a turning-poing in the maze, his course bends so as to prepare for the turn; he does not simply advance to the turning-point and then make the turn, but several steps before he reaches that point are organized or coordinated into a sort of unit.

The combination of steps into larger units is shown also by certain variations of the experiment. It is known that the rat makes little use of the sense of sight in learning, guiding himself mostly by the muscle sense. Now if the maze, after being well learned, is altered by shortening one of the straight passages, the rat runs full tilt against the new end of the passage, showing clearly that he was proceeding not step by step, but by runs of some length. Another variation of the experiment was made by placing a rat that has learned a maze down in the midst of it, instead of at the usual starting-point. At first he is lost, and begins exploring, but hitting on a section of the right path, he gets his cue from the 'feel' of it, and races off at full speed to the food box. His cue therefore cannot have been any single step or turn, for these would all be too much alike; his cue must have been a familiar sequence of movements, a sequence that functions as a unit in calling out the rest of the habitual movement.

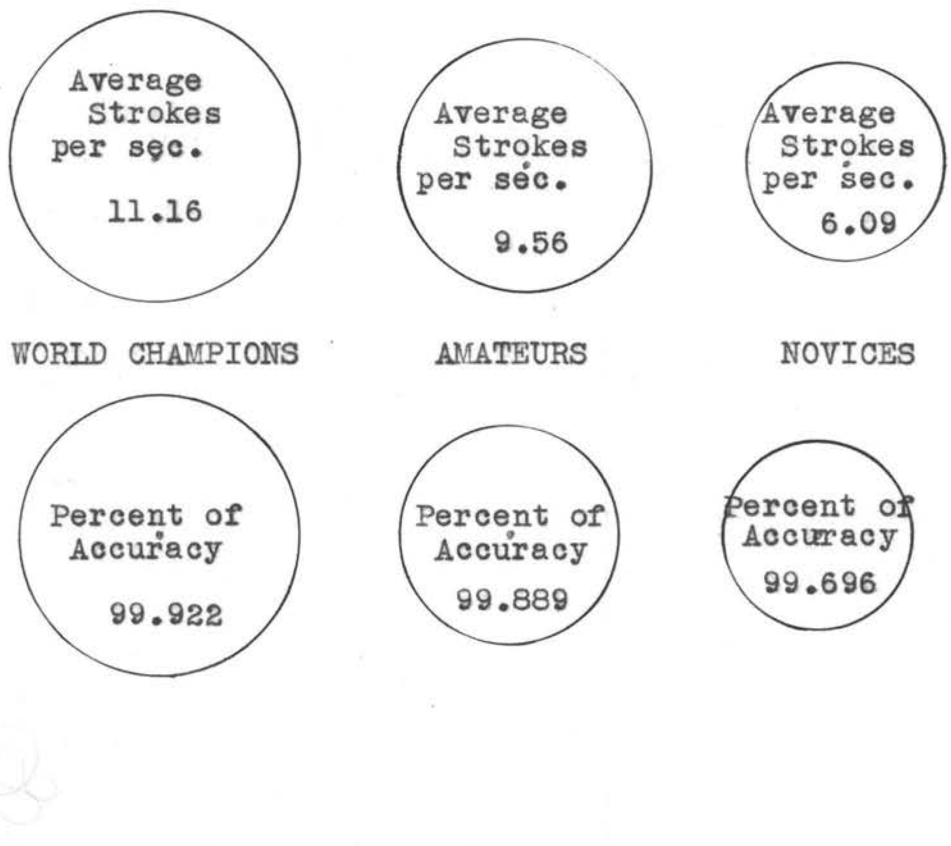
> It would therefore seem that the rat learns the path by the elimination of false reactions and by combination of single steps and turns into larger reaction units.

Speed versus Accuracy

Effective speed in learning depends on the accuracy and ease with which the lower-order habits can be used. Book (9) shows this very well in illustrating the relation between speed and accuracy among world champions, amateurs and novice typists:

Fig. 15

General relationship between Accuracy and Speed for each of the Various Classes of Contestants



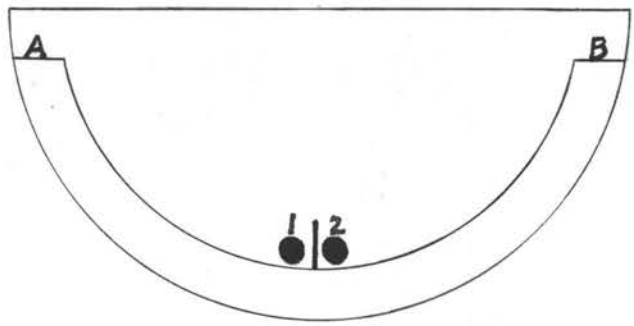
It must not be inferred, however, that accuracy will insure speed. A person may make a perfect score in typing, for instance, and make only a very few strokes per minute or per hour. Accuracy should never be sacrificed for speed in the early stages of a learning process because speed can be acquired rather easily if accuracy is held to a high level from the first, but accuracy cannot be brought to a high level nearly as easily nor will the practice yield the same satisfaction if speed has been emphasized from the first. The nice balance of speed versus accuracy is an individual problem for each person in each task which he undertakes.

Insight

Insight is the intelligent use of knowledge and appropriate experiences in making new adaptive responses. These new adaptive responses are selected and linked at once to the new stimulus because the learner can make a correct meaning response to it. This meaning is nothing more than the recalling of the appropriate knowledge and experiences that are necessary to make the new adaptive response. This can be shown by the simple laboratory device as shown in Fig. 16.

Fig. 16

Whirling Device showing the Principle of Insight



The device is shaped like a half-circle with a projecting partition in the center. It is enclosed on all sides by heavy celluloid. Inside the structure are two steel balls (1 and 2) of equal weight. The object of the experiment is to get these two steel balls, 1 and 2, up on the platforms A and B so that each rests on a platform at the same time.

A person can see what is to be done but at first he cannot see the way to accomplish the task. Finally he recalls some of his past experiences or by accident hits upon the solution, which he has known all of the time, i.e., the principle of centrifugal force.

The steps in the insight process are longer than usual or are quite new to the individual in that situation. Otherwise, they are classed as ordinary thought. They depend in part on intelligence, experience, accident and freedom from conflicting or confusing stimuli or ideas. A good illustration of the recalling of past knowledge and experiences to make the new adaptation is that offered by some of Koehler's (29) sixteen experiments with champanzees. In Experiment One a basket of fruit was suspended from the top of a cage so that it was impossible to reach it from the floor. Koehler then swung the basket close enough to a scaffold so that, an ape upon the platform, could grasp the basket as it came near him.

In Experiment Two the basket was placed outside the cage. A string was attached to the basket which led to the cage so that by pulling the string the ape could pull the basket to him. Later several strings, only one of which was tied to the basket, made the problem more difficult. This proved too difficult for the ape to solve.

In Experiment Six the basket of fruit was placed outside the cage with a stick within reach so that the fruit could be successfully reached. The problem was made still more difficult by placing a wooden box in the cage in such a way that the box would have to be removed in order to reach the stick.

In Experiment Eight a rope was swung suspended from a bar over a bar three times. In order to reach the goal, this rope had to be used to swing over to the basket, after it had been uncoiled from the bar.

In Experiment Nine the rope was unhooked and laid upon the floor. Before it could be used to swing to the fruit, it had to be rehung.

In Experiment Thirteen the problem was made still more difficult. In this experiment the animal sat close to the bars of his cage and opposite the basket of fruit which was outside. A short stick, not long enough to reach the goal, was placed in the hands of the ape. About two yards to one side of the basket, but lying outside the bars, a longer stick was placed. This stick could only be reached with the aid of the shorter stick. The problem was to use the shorter stick to secure the longer one which in turn was used to reach the basket of fruit.

Thus it seems that the change in each stimulus-situation made the apes able to use certain parts of their past acquired knowledge, intelligence, and experience in solving the new problem in hand.

Emotional Set

Learning is also conditioned upon the affective or emotional effects that are produced. If the affective accompaniments to a set of reactions are satisfactory, the learner's activity will probably continue and even increase, but if the accompaniments are unsatisfactory they will tend to reduce or inhibit further activity in the direction of the response because the total mental states that are produced seem to counteract the motivating forces aroused by the stimuli. This includes more than the law of effect as it includes appreciation of the worth of the activity, approbation by some sort of public, and individual variations of the problem, connected with or apart from the task itself.

> Success (8) breeds confidence, and confidence is conducive to persistent effort. Failure tends to destroy the stimulating effect produced by the regular stimulus, because unpleasant sensations have been aroused by the wrong responses. These normally inhibit further activity in that direction. In fact, these movement-produced sensations soon come to act as another stimulus that is substituted for the original one. A child that has regularly succeeded with its tasks can easily put all its strength and efforts into any learning situation that confronts it and hence will usually succeed; but a child that has established a habit of failure with most of its tasks cannot even try.
>
> It therefore appears that a learner reacts because some motivating condition or problem is acting as a successful stimulus to elicit a series of varied responses. The action of the external stimulus is augmented by an inner desire or need that acts as a regular intro-organic stimulus to urge the learner on to more vigorous and continued activity. The learner persists because his problem and the internal motivating condition persist and drive him on to continued activity. As soon as this motivating condition is satisfied, the experimenting

activity and the learning come to an end.

The problem is not as simple as this, however, because parts of almost every task are unpleasant while other parts are pleasant. Unpleasantness in the present may be borne for the promise of future greater pleasantness. Equally pleasant or unpleasant tasks vary in their effects on different people and with the ages, intelligences, experiences, training and interests of people.

Concerning the emotional element in more predominantly mental learning, it can be said that there is a conflict of theories as to the value of this factor. In the case of intellectual functions, it is generally agreed upon that strong emotions offer a distracting influence. In the case of moral functions, such as learning to tell the truth, or to be honest, et cetera, it is generally agreed that they offer an added impetus. Violent hate is supposed to stimulate one on to work. In improvement of skill it is generally agreed that to improve the most, strong emotional elements must be absent. In answer to this conflict Thorndike (46) presents a short explanation:

> All the facts concerning the relation of emotional excitement to improvement seem to be explained best by supposing that the interest in the function's exercise and improvement is the active force - emotional excitements being indirectly of value if they produce interest, and of value as symbols

> insofar as they are produced by it. They probably do not produce effective interest so often as has been supposed, the dynamic power of each emotion over behavior being able to exist without the crude inner excitements. When without them, the interest is less tiring and distracting, and so more efficient.

Attention and Learning

Attention may be defined as an aspect of all states of consciousness in which a part of the field is emphasized and a part ignored. We have in attentive consciousness an object or objects 'attended to' and an object or objects 'attended from.' These two forms of every conscious state are represented on the objective side by differences in adjustment. We always adjust ourselves to the object of attention but do not adjust ourselves to the field of inattention.

There are perhaps three recognized forms of attention, namely (a) voluntary or active, (b) involuntary or passive, and (c) nonvoluntary or secondary passive. The objective difference between voluntary and involuntary attention is that in voluntary attention there are adjustments that lie outside the situation while in involuntary attention the adjustment is within the situation itself. Voluntary attention is short and effortful and is given by reason of some incentive outside the task itself or because of a difficulty that has been met. Involuntary attention is short and comparatively effortless and is given to sudden, extreme or certain stimuli of natural appeal. Nonvoluntary attention is long and comparatively effortless and is given by reason of habit or interest. Invòluntary attention is primitive attention but it is still useful. Nonvoluntary attention is the most valuable today, but can be reached only through the voluntary attention.

It becomes obvious that attention is closely correlated with learning. To be an efficient learner one must be able to attend to his problems. He must be able to exclude all outside distractions, feelings of annoyance and must be able to keep his mind on his work. The exact relationship between attention and learning and the details of their interdependence are not, however, known.

Interest, Motives and Incentives in Learning

Interest involves a purposive activity which brings its own reward and satisfaction. These not only serve as inner stimuli but also give some direction to the learner's reactions. Thus fear of failure, or belief that much effort will not be compensated may prevent him from making any noticeable advancement, or it may drive him to greater effort to avoid embarrassment or ridicule.

Too often the mistake has been made in thinking that interests are always positive. The fact is that they may be either negative or positive. Sometimes the inner drive that stimulates us to action may be the desire to escape some punishment rather than to gain a reward. This is proven by the fact that in animal psychology a painful stimulus is more effective in securing attention than are pleasant stimuli.

A motive may be defined as a persistent and dominating drive that produces conduct of a certain nature. It is an organic or mental condition of a learner that stays with him until a response is produced which satisfies or lessens the motivating condition. An incentive is a reward that lies outside of the individual and, often, outside of the activity itself. The effects of motives and incentives operate in similar or identical manners.

The first thing that is necessary in motivating a learner is to make him see and feel the real practical and personal need for the learning. Every learner is interested in himself and will become interested in anything that he is able to comprehend and which he believes will help him.

Another thing that should be done is to show the learner the improvement he has made after attempting the problem. It has been found that a learner who knows that he is progressing will increase his rate of progress. A number of experiments have been made on this point, one of which is the experiment conducted by Book and Norvell (10) on "the will to learn, an experimental study of incentives." They arranged four widely different types of learning experiments, using 124 college students (48 men and 76 women) as their subjects. The 124 college students were then divided into two sections. One section was made the stimulus group and interested as much as possible in the improvement that they were making from test to test. The other section was made the control group - no effort being made to interest them in their improvement. At the end of the fiftieth practice, the conditions were reversed, the stimulus group became the control group and the control group became the stimulus group for the next and remaining twenty-five practices.

The effect of each type of attitude on learning was measured and the results compared. These results show: (1) the stimulus group made more gains within a given amount of practice than did the control group; (2) the stimulus group continued to gain in performance as long as it was interested but ceased to gain thereafter; (3) the control groups, which had not been interested, not only failed to show improvement under the indifference of the experimental set-up but showed a sudden improvement as soon as they were made interested. They continued to improve rapidly while the former stimulus group, now made the control group, showed a rapid decline during this period. The results are given in Figures 17 and 18:

Fig. 17

Shows effect of interest in improvement as such upon the rate of gain made in learning (men)

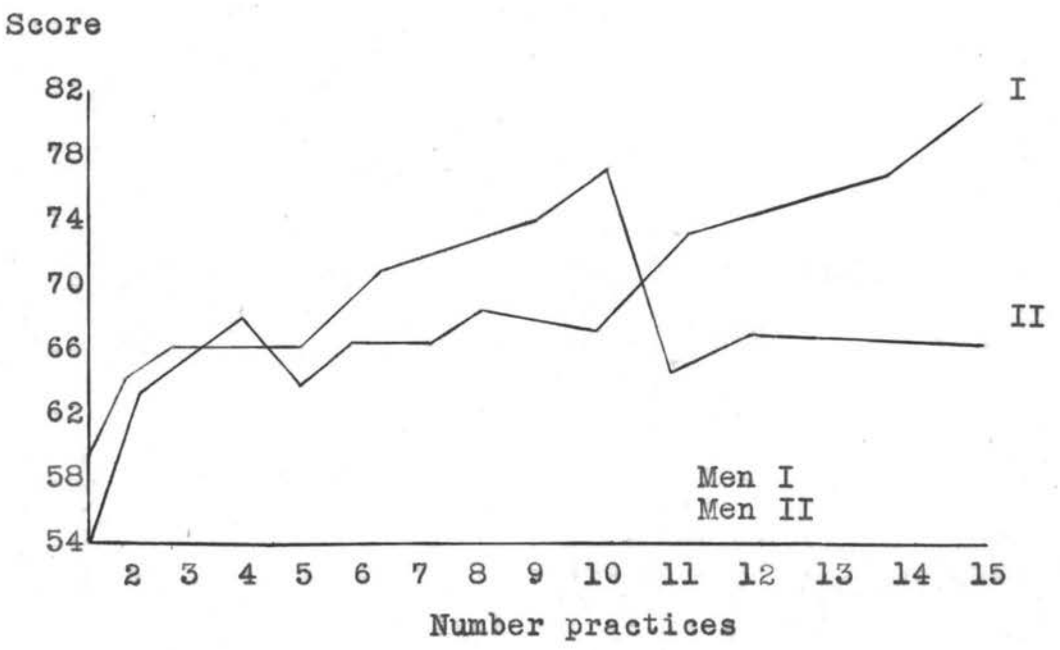
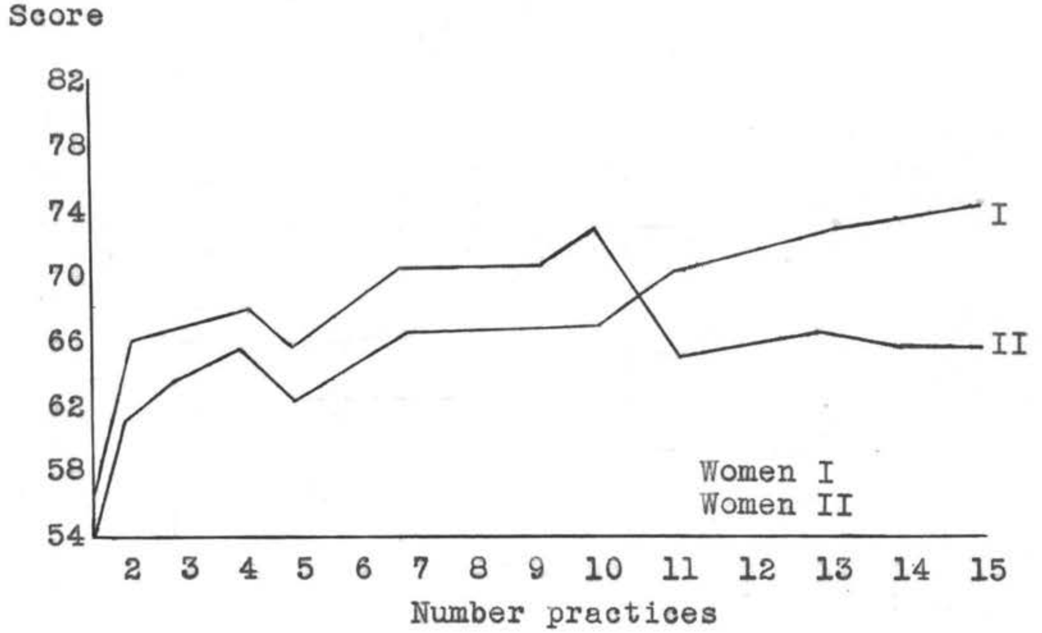


Fig. 18

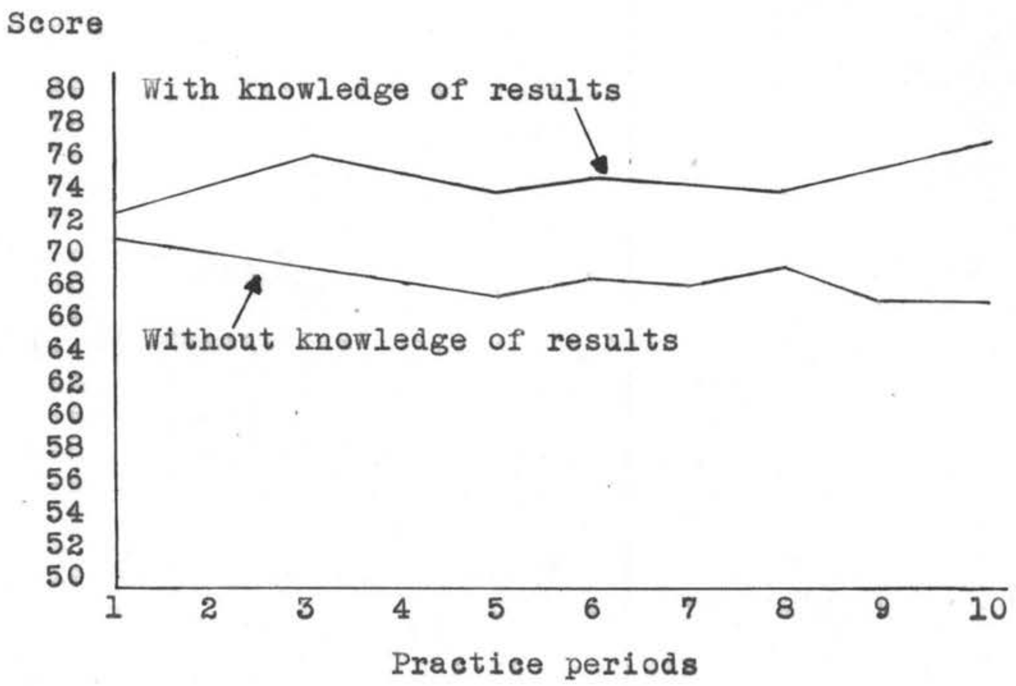
Shows effect of interest in improvement as such upon the rate of gain made in learning (women)



Like results were obtained by Book and Norvell (10) when one hundred practices were given alternately, first with a knowledge of the score and then without a knowledge of the score. This experiment is similar to the one preceding except that, in the first one, the students were not only more informed about their scores, but were also urged (a) to improve their scores, (b) to keep a sharp lookout for short cuts, and (c) to keep in mind that even the best students encountered periods of no improvement. In the second experiment the students were told their scores and nothing else. Figure 19 shows the results of the second experiment:

Fig. 19

Curves showing effect upon a learner's score of interest in improvement



Rewards also serve as incentives for learning. Most of the studies show that giving some kind of reward as an incentive stimulated the learner's or worker's activity so that he accomplished more in less time. Tolman and Honzik (48) conducted a study with four groups of rats on maze learning - one hungry group, one non-rewarded group, one less hungry group, and one less hungry-non-rewarded group. The results of their study show that the hungry-rewarded rats took less time and made fewer errors than the other groups. The less-hungry-non-rewarded rats made the poorest time and most errors.

That praise or rebuke has some influence on a learner's improvement is well illustrated by a study made by Hurlock (23). She tested the effect of ordinary praise and reproof over a long period. She used as her subjects 106 children from the fourth and sixth grades. Four equivalent groups were formed: a control group, a praised group, a reproved group, and a group that was neither praised nor reproved. The selected groups were equal in initial ability, in age, in number of girls and boys, and in the performance for which they were tested. The Courtis Research Tests in arithmetic was the subject matter given to all groups. The control group was separated from the others after the first test was given. This group was merely asked to add the examples given them at the beginning - a modification of the Courtis arithmetic test was given to the three remaining groups. One group was praised, another was reproved, and the third ignored. The results are shown in Table IV:

Table IV

Average scores made by pupils who were praised, reproved, or ignored for their work

Grade	Group	Average Score				
		1st day	2nd day	3rd day	4th day	5th day
IV	Control	9.00	9.14	8.21	7.86	9.14
	Praised	9.06	14.40	16.00	15.06	16.26
	Reproved	9.06	13.60	11.06	9.80	11.26
	Ignored	9.00	10.93	9.14	8.93	8.79
VI	Control	15.08	16.08	15.66	13.58	13.91
	Praised	15.25	19.33	22.42	23.50	25.16
	Reproved	15.33	20.33	18.33	17.58	17.83
	Ignored	15.16	17.99	18.16	17.58	16.58

Gilchrist (19) also studied the extent to which praise or reproof affected the progress made by students. He gave Courtis English Test 4B to a group of fifty students in educational psychology at George Peabody College for Teachers. He then separated the class in two sections. One group he praised by saying, "A hasty examination of the papers in the test just given shows that the members of this group did exceptionally well. I ask you to take the test again." The other group was reproved in the following manner, "A hasty examination of the papers in the test just given shows that the members of this group did not do as well in the test as the average twelve-year-old child would do. I ask you to take the test again."

The group that was praised made an improvement of seventy-nine per cent while the group that was reproved showed a six per cent reduction in its score. Gilchrist explains these results as due to the attitude set up by his words of praise and reproof.

Sullivan's (45) experiment shows the influence of different attitudes in connection with praise and reproof. Sullivan gave a series of laboratory tests to a number of Stanford instructors and graduate students. These tests were given to these people individually. After each practice period she told each one, individually, that he had made the best score of the entire group the day before. After an interval of a few days, she next told each one, individually, that he had made only an average grade. After another interval, she then told each one that he had made the lowest score of the entire group on the preceding day. Her results are as follows:

(a) When she told them that they had made the best score they did not exert any extra effort to improve.

(b) When she told them that they had made an average score they all began to try harder to improve.

(c) When she told them that they had received a poor score they really did try very hard to improve.

She then repeated her experiment using a number of Whittier State School boys as her subjects. Her results follow:

(a) When the boys were told they had made the best grade they worked hard to maintain this new and pleasing standard.

(b) When the boys were told that they had made an average grade they did not work as hard.

(c) When they were told that they had made a poor grade they assumed an attitude that they knew they could not do any better if they did try.

These two experiments, even though the same procedure was followed, show the influence of different attitudes. The experiments show diametrically opposite results even though the experimental set-up was the same in each.

Praise as shown in these studies was an important factor in improvement. Reproof seems to serve as a motivating force at first, but when continued over a long period of time it tends to act as an inhibiting force. Indifference has less motivating influence than either of the other two.

Many times the stimulus-situation will be so presented as to cause a conflict among motives. When this occurs one of two things will happen: (a) either the two motives will combine and thus give a reinforced response, or (b) they may antagonize each other, producing either a compromise result, a fluctuating attitude, or an inhibiting effect.

Perhaps the most effective means of stimulation is in the goal to be achieved and the value to be derived therefrom. Without knowledge or understanding of the value of the things to be done, or the end-result really desired, the learner will be forced to use the trial and error method which is a costly procedure to undertake if one is considering the efficient and economical side of learning.

Facilitation by the Environment

Experiments have been made to determine the influence of the learner's environment upon the learning process. It has been found that such things as (a) bad air, (b) improper temperature and humidity, (c) poor distribution of light, (d) general bad appearance of the schoolroom, and (e) auditory distractions, all have a noticeable effect upon the learning situation.

For instance, Benedict (5) and Johnson and Paschall (37) found that bad air affects the willingness to work but not the ability to work - unless the degree of oxygen loss is so great that the body cannot operate. This is never found in nature except in extreme altitudes or in gaseous pollution of the air. If air is kept moving by a fan, a person can use it over and over without loss of either ability or willingness. Benedict also found that humidity affects the willingness to work much more than the quality of air does. Not much is known of the effects of humidity on ability to work because its effects on willingness are so pronounced. Temperature was found to affect willingness but not ability except at great extremes - rarely found in nature.

It has been found that poor distribution or quality of lighting affects both the ability and willingness to work because of the eye and general muscle tension required to compensate for poor light.

Tinker (47) made investigations to determine the effect of auditory distractions on work. His results show that regular auditory distractions are aids to work rather than harms if they are not too harsh or loud. Irregular auditory distractions were found to be much harder to work against because of their irregularity even though they are neither loud nor harsh. Working with distractions requires more energy expenditure in both cases but more work is done per unit of time under the first condition than under conditions without distractions.

All of these conditions, except regular auditory distractions, tend to retard and disturb the learner's physiological or psychological condition so that learning becomes harder and less efficient. Even regular auditory distractions are difficult to resist if they attract attention or arouse annoyance or antagonism. Because of these distracting influences the learners use up energy to adapt themselves to the distracting situations which otherwise could be used to strengthen the learning process. It thus becomes quite important that all serious or affecting external distractions must be removed, as much as possible, if learning is to be most economical and efficient.

Background Knowledge

It is an important educational principle that, if an individual is to learn, the learning situation must be so arranged that all the pertinent habits, skills, and knowledge which he already possesses may be used in solving the new problem. If the learning situation is so arranged and if he has a large fund of previous related knowledge and skill at hand, the new problem will be solved with comparative ease and efficiency. On the other hand, if the problem is not one in connection with which he has a normal fund of related knowledge, his learning will either not take place or if it does, it will be slow and wasteful. This slow and wasteful learning may eventually destroy the motivating force which is so necessary in stimulating one in beginning and in continuing to learn. New major habits can only be learned when they are associated with something a person already knows, and, for this reason, automatization of elementary skills plays an important part in the learning process. If the elementary skills needed to solve a more difficult problem are not made automatic, then any complex problem will result in confusion and waste of time; for example, in writing a thesis, if one has not learned to spell the most common words and has not learned to make the conventional marks of punctuation, his attempt to write a thesis would be immensely laborious if not impossible.

Imitation in Learning

The term 'imitation' as generally used refers to a conscious attempt to reproduce anything that has been observed or done. The general concensus of opinion among psychologists is that imitation among animals is very rare. To prove this point Woodworth (50) conducted an experiment with two cats. One cat mastered a puzzle box while another cat observed the mastery. The first cat performed repeatedly for the second cat before the second cat was placed in the puzzle box. It was found that the second cat had derived no benefit from what he had observed and was forced to solve the puzzle by the trial and error method, much as the first cat had. Similar results were obtained with monkeys but better success was obtained with the most intelligent animals below man, that is, the man-like apes.

Although such learning (by imitation) is quite rare among animals, it is more common among human beings. This is because human beings are more observant, are more intelligent, and are more adaptive. The amount of learning that is done by imitation is, however, not as extensive as was formerly believed. About all that comes from imitation is (1) comprehension of principles, (2) establishment of standards of performance, and (3) copying of mannerisms.

FORGETTING, OR LOSS OF LEARNING

Chapter IX

Methods of Measuring

There are three important methods of measuring the amount of forgetting that occurs: (a) the method of retained members, (b) the saving method, and (c) the method of right associates. These will be discussed in this order.

The method of retained members, the most common method, is determined by ascertaining the amount or the percentage of the original material learned which can be reproduced immediately or after a definite interval; for example, if a person has memorized a series of words and is able to reproduce one half of them, the fraction, fifty per cent, represents the completeness of his retention at that time. It is quite possible, however, to have a learner unable to reproduce a single one of the words learned, due to the fact that the consciousness of the learner has been modified by competing interests, competing ideas, blocking, or by present stimuli.

It is thought, however, that what has once been learned can, under certain conditions, be revived. It becomes necessary, then, to find some other way of testing memory to prove that all traces of what has been learned have been forgotten.

To accomplish this another method has been devised and used. This is known as the saving method of learning and consists of learning anything at a fairly uniform rate of speed, the readings necessary for learning repeated until the first correct repetition occurs. The number of readings required for the original learning is then recorded. After the material is learned and a definite interval of time has elapsed, the material is relearned and the time saved recorded. Myers (35) gives a record of this method:

Table V

A record of 163 experiments, nearly all of which consisted in learning eight thirteen-syllable series and in relearning them at a prescribed rate of reading after a varying interval, the economy of time spent in relearning being in each instance noted.

Relearning after x hours x =	Percentage of Time Saved	Percentage of Time Lost
0.3 hours	59.2	41.8
1.0 "	44.2	55.8
8.8 "	35.8	64.2
24.0 "	33.7	66.3
2x24 "	27.8	72.2
6x24 "	25.4	74.6
31x24 "	21.1	78.9

The third method of testing memory is known as the right associate method. This is a method much used in the psychological laboratory and consists of reading a series of nonsense syllables a number of times rhythmically. Then after a certain interval of time, the first syllables are presented and the time taken to recall the corresponding second syllables is measured and recorded. From the use of this method it has been found that the associations which are made the most quickly are the most lasting.

There are several other methods of less importance which are taken up by Colvin (15):

> (a) The Prompting Method. In this method the material is imperfectly learned and the accuracy of the memory measured by the amount of prompting required. It is difficult to bring this method under exact experimental determination, but it is one that is, of course, familiar in the schoolroom and has a certain value; (b) The Recognition Method. In this method the material for memorization is presented and learned, and later the same material, together with other material of a similar nature, is shown. The test of memory consists in picking out from the total mass of material that which was previously presented. It is clear that in certain phases of school work this is the test of memory that is ordinarily employed; (c) The Reconstruction Method. In this method, the memory material is given in some sort of order, and later it is presented in a different order. The memory test consists in restoring it to its original arrangement.

Usual Curves of Forgetting

The usual curves of forgetting are those of

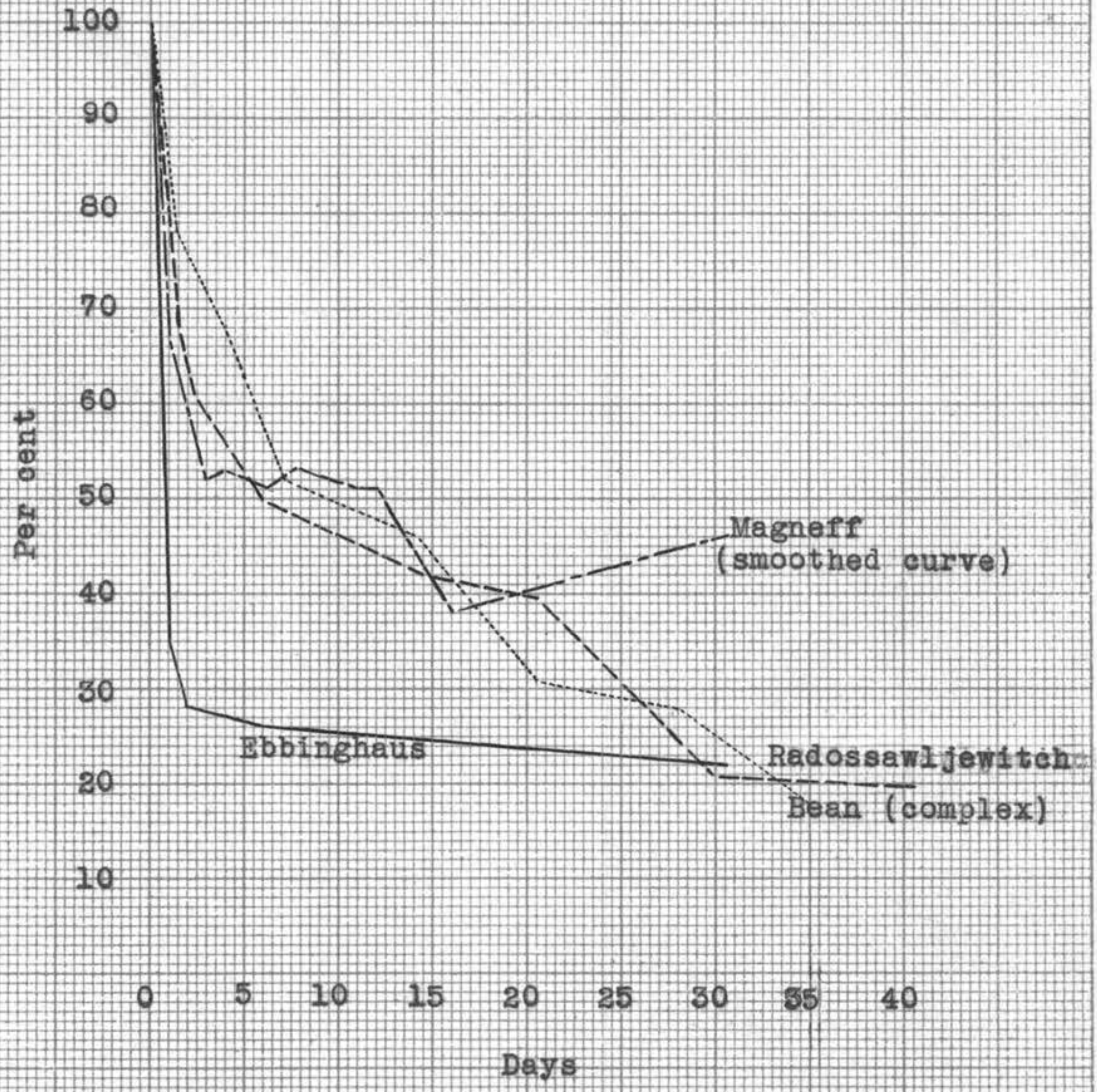
Ebbinghaus, Bean, Radossawljewitch, Magneff and Miss Land.

The first experiment to determine the rate of forgetting was made by Ebbinghaus about forty years ago. He used himself as the subject and memorized nonsense syllables. The method employed was the saving method. His results show that there is a rapid loss of memory during the first few hours after learning, with a gradual tapering off as time elapses. At the end of one hour, over one-half had been forgotten; at the end of the first day two-thirds had been lost, and at the end of the month about four-fifths had been forgotten. Experiments since the one performed by Ebbinghaus have shown that the rate of forgetting is not quite as rapid as Ebbinghaus would have us believe. Some of the curves, including Ebbinghaus', are illustrated in Figure 20, page 113 (44).

They all agree, except Miss Land, in showing a rapid rate of loss at first, followed by a gradual decline thereafter. In their several experiments, Ebbinghaus used nonsense syllables; Bean used series of letters; Magneff and Land used poetry; and Radossawljewitch used nonsense syllables and poetry. The differences in their curves are due to the fact that those who used poetry or nonsense syllables plus poetry (sense material as contrasted with nonsense material) showed less effect of the competing

Fig. 20

Representative Curves of Forgetting



influences inherent in the present interests and past experiences of individual subjects.

Miss Land (4) conducted an investigation and found somewhat different results than did the four previous investigators. She had fourteen classes of fourth grade children learn sense material (poetry) in the usual classroom procedure. After they had learned the poem, she then had each class write it once on successive days. Her results show that there is a gradual increase in retention on the first three days with a very gradual decline thereafter. She attributes the gradual increase, at first, to what is known as assimilation. Her curve differs considerably from Ebbinghaus' but it may be accepted that each shows the influence of age, competing ideas, and the influence of the kind of material memorized.

Influence of Recitation

Recitation is a very important procedure in instruction although it should not be taken strictly as a measure of grade placement. Its main function is to serve as a measure of recall, telling the learner where he is weak and where he should relearn in light of the errors made. This principle is very much overlooked in a great deal of formal learning of all types. As an indication of hazy and uncertain learning, it can do much to assist in the material to be relearned by pointing out just where relearning needs to be undertaken. A good illustration of the value of recitation is given by Gates (17):

Table VI

The Value of Recitation in Memorizing

Material studied	16 nonsense syllables		5 short biographies, totalling about 170 words	
	Percent remembered		Percent remembered	
	immediately	after 4 hours	immediately	after 4 hours
All time devoted to reading.......	35	15	35	16
1/5 of time devoted to recitation....	50	26	37	19
2/5 of time devoted to recitation....	54	28	41	25
3/5 of time devoted to recitation....	57	37	42	26
4/5 of time devoted to recitation....	74	48	42	26

Thus recitation always has an advantage of fixing the material more firmly. Perhaps the main advantage is that the learner is actually performing the act which he is trying to learn.

<u>Intent to Remember</u>

Some years ago in a Swiss laboratory (50) there appeared a little incident that seems to have one believe that one only learns if he has the intent to learn. A series of nonsense syllables were repeatedly passed before a foreign student who was supposed to be learning them. After the series had been passed before him many times, he was asked to repeat them. A look of surprise came across his face as he said, "Oh, I didn't know that I was to learn them!" There are many such incidents to show that learning will not take place without the learner first knowing that he is to learn. But this does not tell the whole story. An event that passes before our eyes may yield certain facts that later can be recalled with exactness and ease - thus, children and adults learn to do many things without intentionally trying to learn them. We can often repeat a melody after hearing it most casually several times.

There is a difference between the two cases. The difference lies in the fact that in the first case the facts would not be learned because it was not seen that they would serve some future purpose. In the second case, the songs were learned for reasons of play or social use.

Point of Learning

This chapter would not be complete unless some mention was made as to the 'point of learning.' The explanation of this term is simple, it being the point at which a learner can restate the material learned, completely, unassisted, for the first time, and without making an error. Any learning thereafter is called over-learning.

Overlearning is very important in connection with school work. Some phases of school work and some phases of subject matter need to be overlearned and emphasized while other phases do not need overlearning or special emphasis. To know the things that need to be overlearned taxes the teacher's philosophy of education and reflects back on his subject matter training. To know what to overlearn is just as important as to know what not to overlearn.

FATIGUE AND BOREDOM IN LEARNING

Chapter X

There have been many studies and theories formulated regarding the nature and reasons for fatigue. There is no reason for stating them all so only several of the most representative ones will be included in this chapter.

Distinction between Mental and Physical Fatigue

Whether or not there is such a thing as 'mental fatigue' is not generally agreed upon. It is known, however, that the term is used with great inexactness. Granted that there does exist 'mental fatigue', however small, that accompanies some mental exercise, it can be said that 'mental fatigue' may be taken to mean that sort of fatigue that accompanies mental work. We thus have at least one distinction in the fact that physical fatigue results from physical work. Mental fatigue, if it does exist, like physical fatigue, denotes muscular and nervous fatigue. A great deal of so-called mental fatigue is perhaps due to sensations of muscular strain that accompany attention. Whether any actual sensations arise from nervous fatigue is debatable at the present time. When we feel tired as the result of mental work it is perhaps because we sense the weariness of the muscles of all parts of our body but especially the muscles of the eyes and neck. This fatigue is not as noticeable as in the case of physical work but the difference is in degree rather than in kind. It is also true that a large part of what we call fatigue is no more than distaste for work. Ordinarily, we are not so much 'tired by' our work as 'tired of' our work.

Common Theory of the Cause of Fatigue

The most common theory of fatigue, whether muscular or nervous, is the one that suggests that fatigue is due to the deposit of poisonous by-products arising from the metabolic processes in the muscles and nerve cells. These poisons are supposed to act as a sort of a protection, especially in the case of muscular activity, preventing the expenditure of excess physiological energy, which would become dangerous to the organism if allowed to continue. In relation to this Colvin (15) states:

> If a muscle has been active continuously for some time, fatigue sets in, and it is incapable longer of contracting in response to the innervation of the nervous centers. If this same muscle, however, is washed out, so that the products of metabolism are

> carried away, it recovers from its fatigue, and is able again to perform work. Thorndike has suggested an interesting parallel to this washing out of the muscle in the case of so-called mental fatigue. Here the mind is capable of continuing its work when attention begins to flag by ignoring the sensations of weariness and various affective states accompanying them, and in this way, by refusing to pay attention to these distractions, in a sense washing them out of consciousness.

Theory of Sherrington

Within the past two decades another theory has been advanced by Sherrington, McDougall, Yoakum and others. They maintain that all fatigue is neuro-muscular; that is, involving both nerve cells and muscles. It consists in the blocking of the paths of discharge in the nerve tracts at the joining of the neurones. This is supposed to result in shifting of attention in the conscious processes and, thus, relief to the fatigued areas. These shifts relieve the fatigue but if they do not appear in a rhythmic system and are scattered in many different and unrelated fields, a high quality of mental work will not result. On the other hand, if any slight attention fluctuations occur within a narrow rhythmic system, the thought processes may be injured. This theory is better suited to an explanation of mental fatigue and fits the facts brought out in connection with it better than the preceding theory.

Some Mental and Physical Tests used to Determine Fatigue

The mental tests that are used aim to measure quality and quantity of predominantly mental work. The more frequently used of these are the addition test, dictation test, memory test, subtraction test, substitution test, and the multiplication test. These tests are not exact measures of fatigue, however, as they do not show the effects of unwillingness, shift of attention, loss of interest, and similar factors separately from the effects of true fatigue.

The physical tests are concerned with the pulse volume and pulse rate, the breathing, the blood pressure, et cetera; the algometer, which is a pain-sensitivity test; the ergograph and dynamometer which are muscular work and strength tests; the tapping test which is a rate and accuracy test; and the aesthesiometer-compass test. None of these has been valuable in the study of mental fatigue and, therefore, are of little use in the study of fatigue or learning ability.

Blocking

A study was made by Bills (6) in which he attempted to make clearer the following problems:

(a) the failure of investigators to find large decrements from continuous mental work despite subjects' introspective reports of fatigue.

(b) the suspicion that it is because subjects get frequent rests, somehow, while working; yet no such rests show up in the objective records.

(c) the known fact of a cumulative refractory phase in nerves, which should have its counterpart in periodic blocks in the flow of responses, especially in homogeneous work.

Bills carried on a series of studies, covering a year's time, on five homogeneous tasks; continuous addition and subtraction, voluntary perspective reversal, color naming, opposites and substitution. The responses were automatically recorded by a special kymographic technique, making it possible to show the exact time elapsing between each response. Over fifty advanced students in the Chicago laboratory were chosen as subjects. After the experiment was completed and the records completed they were studied to discover: (a) the frequency and duration of the blocks or pauses, and their rhythmic expression, (b) the increase or decrease in frequency and the length of blocks resulting from fatigue and from practice, (c) the relation of errors to blocks, and lastly, (d) the differences in the blocking rhythms of fast and slow individuals.

The results are pictured graphically and may be summarized as follows:

(a) In all forms of mental work there occur, with almost rhythmic regularity, blocks or pauses during which no response occurs. These blocks occupy the time it takes to make from two to six responses. They have an average frequency of about three per minute, although individuals differ in rhythm.

(b) Practice reduces the frequency and size of the blocks.

(c) Fatigue increases their frequency and size, producing much greater irregularity in the flow of responses, after an hour.

(d) The responses between the blocks tend to bunch toward a center, such that a wave-like effect of an alternate crest and trough, or condensation and rarefaction, results. Fatigue exaggerates the bunching.

(e) Individuals who respond rapidly tend to have fewer and shorter blocks than slow individuals.

(f) Errors occur consistently opposite blocks, suggesting that the same cause is responsible for both; that is, a refractory phase of mental functioning.

On Weichardt's Supposed Fatigue Toxin

Lee and Aronovitch (32) proposed to test the validity of Weichardt's claim that fatigue is occasioned not simply by the usually accepted toxins but by a more specific substance, a true fatigue toxin, which they called "keno-toxin." Animals were fatigued and the juices were pressed out of the skeltal muscles, filtered, and injected into other animals or administered to excised muscles with the purpose of observing the effects produced. Cats were used chiefly as the source of juice animals and guinea pigs as the ones injected. The injection of such juices into the guinea pigs induced stupor, and a constant effect upon respiration, accompanied by a temporary drop in body temperature and occasionally death.

When administered to excised muscles such juices effected a marked decrease in the working power of the muscle. All of the effects which were produced by injecting the fatigue juices thus obtained into the other animals, and by administering them to excised muscles, are also obtained by the use of juices taken from non-fatigued animals. Thus Weichardt's theory is disproven, according to Lee and Aronovitch.

On Physical and Mental Fatigue

Mosso (34), in his study on 'Fatigue'; Smith (43), in her 'Contributions to the Study of Fatigue'; Arai (2), in her study on 'Mental Fatigue'; Thorndike (46), in his study of 'Mental Fatigue'; and Pyle (40), in his article on 'Economical Learning' agree that fatigue reduces the willingness, and to a lesser extent, ability, to learn or do work. These investigations show that efficiency increases after working thirty or forty minutes upon a problem and that a sudden collapse in production occurs after a period of continuous work.

Miss Smith suggests, in her article, that the organism may produce antitoxins that seem to neutralize the effect of fatigue, i.e., neutralize the toxin produced in the organism and thus not only eliminating body toxins but also counteracting them with antitoxins. Only when the body has accumulated more than can be eliminated or neutralized does exhaustion result.

Effects of Fatigue on Mental Efficiency

A study was made by Dockery (16) who recognized three possible effects of fatigue on mental efficiency: (a) it may decrease mental efficiency in speed or accuracy or both, (b) it may increase mental efficiency, acting as a stimulus for greater effort, and (c) it may not have any effect. Dockery attempted by means of a series of four tests (association test, sounder test, multiplication test, and addition test) to discover the effect of physical effect on mental efficiency. These last mentioned tests were given to a group of students and the results recorded and analyzed. The results show that the effect of physical fatigue upon mental fatigue is very irregular. A subject may show an increase in mental efficiency after he has performed physical work or he may show a decrease. The sounder and association tests present fairly uniform results, however. They show a decrease in mental efficiency with increase in mental fatigue. Dockery presents two theories to explain his results:

1. It may be that the fatigue products generated by the physical work, either in the motor neurones or in the muscles, spread through the circulation to the association centers and cause directly a diminution in the efficiency of the association processes.

2. It may be that the sensations that accompany fatigue serve as distractions and thus cause a decreased attention.

Important Results of Studies in Fatigue

Perhaps the most important conclusions connected with the learning process are the following:

1. Neither physical nor mental fatigue is as common among school pupils as it is generally believed.
2. Mental fatigue can best be minimized by producing better attention to the work at hand, ignoring distractions and sensations of weariness.
3. Pleasant work is much less fatiguing than unpleasant work.
4. Physical work is more fatiguing than mental work.
5. Automatic learning is less fatiguing than learning that requires attention.
6. Associative bonds are weakened during fatigue.
7. A well organized plan of work minimizes fatigue.

ANIMAL LEARNING

Chapter XI

Can Animals Learn?

A simple and exact answer can be given to this question only when learning is defined as modification and retention. Defined in this way it can be said that animals do learn. The fact that they can learn has led many psychologists to experiment with various species. Perhaps the most significant reason for studying animal learning, however, lies in the fact that they learn less than men and more slowly. This makes the learning process of animals easier to follow.

Lloyd Morgan's Canon of Animal Behavior

Lloyd Morgan was one of the first founders of animal psychology. In 1894 he formulated this principle which has since influenced all those who have engaged in animal behavior studies. His principle is stated as follows (33):

> In no case may we interpret an action as the outcome of the exercise of a higher psychical faculty, if it can be interpreted as the outcome of the exercise of one which stands lower in the psychological scale.

This means that we should not attempt to explain an animal's solution of a problem because of reasoning if it can be explained in terms of trial and error learning. It means that we should not credit animals with abstract thinking if they are driven to act, more or less blindly, by some motivating force. "It means (50), in general, that we should avoid 'anthropomorphism' or the reading of human characteristics into animal behavior."

Why Study Animal Learning?

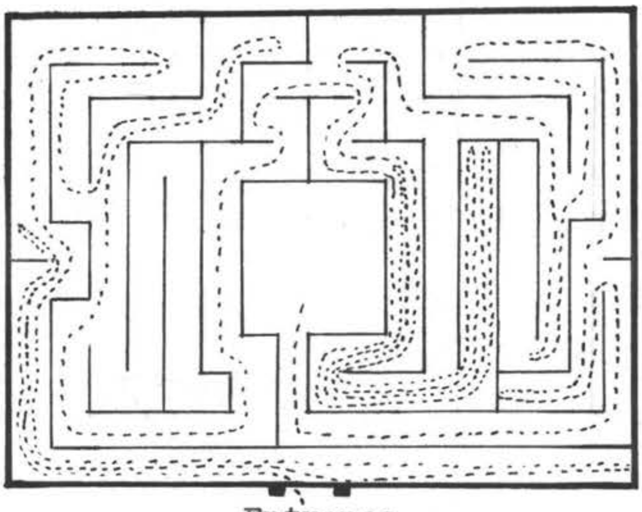
It would not be deviating too much to state why there have been so many studies in animal learning. As was stated in the first part of the chapter, animals learn more slowly and in lesser amounts than do men. This makes animal learning easy to follow and record. From the studies of animal learning have come most of our knowledge concerning human learning.

Studies in Animal Learning

One experiment is that of a white rat in a maze. A white rat (any animal will do) is placed in an enclosed maze which contains food. This food may be obtained after the rat has followed a somewhat complicated path. The rat runs back and forth, into blind alleys, out again, sniffs, et cetera, until it has covered about every square inch of the maze. It finally solves the maze. Now by taking the rat out and then replacing it, it is found that it will take less time to reach the food. If the experiment is repeated enough times there will finally come a time when the rat will reach the food without making many errors. Woodworth (50) shows the plan of a maze used:

Fig. 21

Ground plan of a Maze used in Experiments on Rats

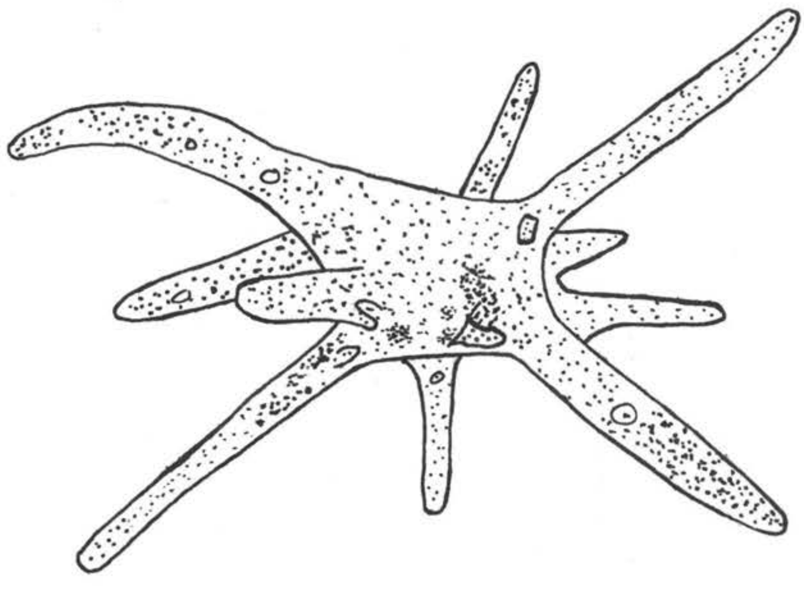


The central square enclosure is the food box and the dotted line shows the path taken by a rat on its fourth trial. Time was four minutes and two seconds to reach the food. The learning curve for a rat in the maze is given by Woodworth (50) and is shown in Figure 9, page 55. The figure represents the average record of four rats. The gradual descent of the curve indicates the gradual decrease in the time required to reach the food.

Perhaps the simplest example of animal learning is that offered by the amoeba. When an amoeba is suspended in water and not in contact with anything (except the water) it is unstimulated and cannot obtain food. Since the amoeba cannot transport itself well, it must rely on some method of securing food. It meets this unfavorable condition by stretching out long and slender pseudopodia. These are shown in Figure 22:

Fig. 22

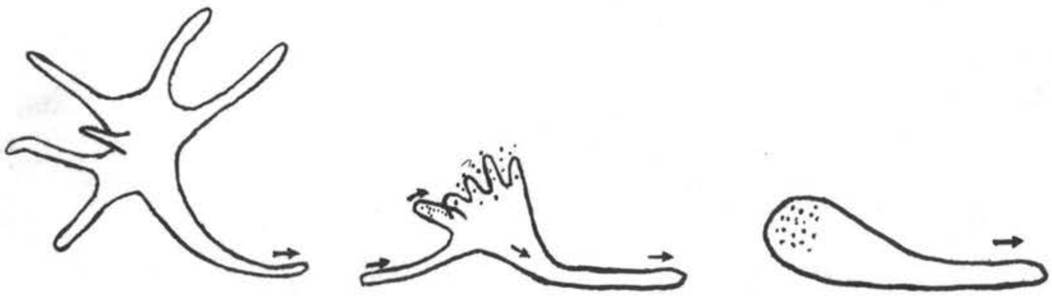
An Amoeba with its Pseudopodia outstretched



It is obvious that by extending its long, slender pseudopodia, the amoeba has a better chance to come in contact with any solid body. As soon as the end of one of the pseudopodia comes into contact with a solid body the pseudopodium spreads out and clings to the contacted substance. Protoplasm immediately starts to flow in the direction of the clinging pseudopodium and the other pseudopodia are drawn into the body while the body itself moves toward the substance. This is shown in Figure 23:

Fig. 23

An Amoeba encircling a Solid Body



In time the pseudopodia encircle the contacted material. The result is a flask-like mass.

The highest type of animal learning is that presented by the man-like apes. Examples of ape learning are given in a previous chapter and need not be repeated here.

Do Animals Reason?

There is little evidence that reasoning plays any part in animal learning due to the fact that solutions are gradual with no sudden drop in time; for instance, an animal does not observe or reason his way out of a maze but responds to visual cues, to the things seen about the maze. The learning is the result of annoyance rather than the result of any deliberate effort. In some of the higher animals, a high quality of thinking and of insight occur. If "reasoning is only a high quality of thinking", animals reason. If it is restricted to complex and abstract mental processes apart from physical activity, they probably do not. In any case, animal learning and thinking are similar to these activities in mankind but are of lesser degree of complexity and, usually, of shorter duration.

AN EXPERIMENT IN DETERMINING A CURVE OF LEARNING

Chapter XII

The writer has attempted to construct a learning curve, using a college class in educational psychology as his subjects. There were twenty students in this class. Every Monday, Wednesday and Friday, with the exception of several class holidays and individual absences, a series of two-place numbers was presented on mimeographed sheets to each member of the class. These were to be multiplied by another series of two-place numbers, for example:

45 x 73
84 x 43
96 x 62
74 x 59
57 x 62
69 x 85

These multiplications were to be done mentally; that is, without the aid of any writing. The practice periods were three minutes in length and took place at the beginning of each class period. Members of the class were asked not to practice outside of the period - no class averages were given - all competition was restrained to self-competition. At the end of the three minutes the papers were collected and scored. At the next meeting of the class the papers from the previous period were returned with the scores indicated on each paper. After each student had had a chance to observe his score, the class was asked to begin the multiplications. At the end of three minutes the papers were collected, score, and later returned as before. There were twenty-two such practice periods covering a period of nine weeks.

The two-place number series were obtained by Laslett (31). The following is his description of the procedure:

> In this series of problems all zeros and ones were omitted, and all problems whose answers involved fewer than four digits or which were missed more frequently than the usual number of times, were removed from the series. The remaining problems are approximately equal in difficulty since the records of performance of students show the same relative results when the students begin with any series or with any problem in a series. A tabulation of the problems missed shows that no problem was missed much more frequently than another when the factor of position near the end of the daily task was accounted for. The series of problems was divided into 15 tasks of 30 problems each. The problems were mimeographed on suitable paper, two columns of 30 problems each to a page, double spaced, with margins on either side of the columns.
>
> The weaknesses of the procedure were (1) the tendency of the students to practice similar problems outside of the learning period in spite of requests that they refrain from this; and (2) the devising of a satisfactory scheme for equitable scoring in terms of effort and accuracy.
>
> When I first began to use this series of problems, I considered scoring only the entire answer as either right or wrong. These made an index that was too coarse to show

> well the gains and losses in accomplishment. As a result I scored every digit of the answer - the score for the day being the number of correct digits in the answers obtained. It is obvious, however, that the processes involved in finding the different digits are of very different degrees of difficulty. I am therefore now using a system of weights to equalize the errors that occur within the different digits. I indicate an error, beside the answer in which the error occurs, in the thousand column by 'a', in the hundreds column by 'b', in the tens column by 'c', and in the units column by 'd'. These symbols can be counted quickly and the number of each multiplied by a constant that was empirically determined. These constants were found by tabulating 6,866 errors according to their places in each of the four columns (units, tens, etc.). These numbers were then reduced to percentages of the entire number of errors, and the reciprocal of each was found and designated as the constant for the errors in that column of answers. The number of errors by columns was: thousands, 1171; hundreds, 3386; tens, 2125; units, 184. The constant or weight that was used for the errors in the column of thousands was --0.8; of hundreds, --0.5; of tens, --0.7; and of units, --1.0.
>
> The amount of work involved in scoring a number of papers by this method is slightly greater than that involved in the simpler methods of scoring each incorrect digit in the answers as 1., but gives scores that seem to be more nearly in accord with the amount of effort and attempted accuracy involved. The virtue of the method lies in the discussions that arise from comparisons of scores by the students and the discussions of working methods when they receive scores from the two methods of scoring mentioned before.

In this experiment the last mentioned scheme of grading was used; that is, evaluating the answers --1.0, --0.7, --0.5, and --0.8. The results are shown in Table VII.

Table VII

Showing Scores made by Students in 22 Practices

Stu-dents	Practice Periods 1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th
A	14	13	16	20			13	30	38	34	23
B	6	28	29	29	29	21	26	29	29	33	38
C	10	32	20	33	52		46	51	62	54	47
D	38	63	51	69	70	66	74	84	90	86	84
E	8	29	24		35	43	28	62	56	45	50
F	11	13	10	9	10	25	30	25	37	42	31
G	42	31	29	36		38	43	44		45	53
H	0	27	31	31	44	42	46	51	58	69	49
I	13	16	7	22	25	19	32	28	27	26	21
J	5	6	10	14	25	16	20	32	37	32	28
K	25	26	28	30	33	36	27	43	48	45	59
L	16	20	13	22	18	17	29	28	28	34	29
M	2	16	8	13	22		18	31		32	30
N	11	10	22	26	21	25	30	30	37	42	29
O	9	23	21	32	33	27	32		36	46	35
P	7	19	15	10	18		15	24	28	29	30
Q	11	18	14	27	42	37	32	48	61	57	49
R	15	27	29	28	41	29	38	39		49	41
S	9	27	24	30	30	18	35	42	37	55	33
T	18	24	32	24	36	35					
Ave.	13.5	23.4	21.7	26.6	32.4	30.9	32.3	40.1	44.2	45.0	39.9

Table VII
(continued)

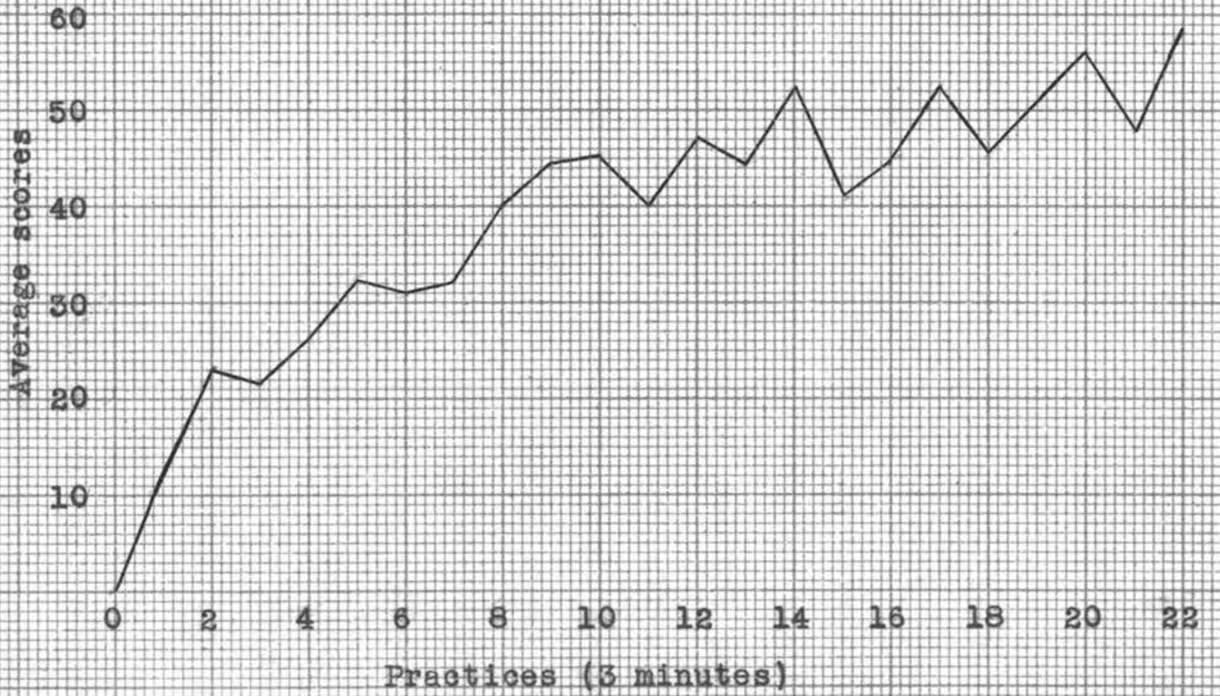
Stu-dents	Practice Periods										
	12th	13th	14th	15th	16th	17th	18th	19th	20th	21st	22nd
A	37	31	40	36	30	43	34	40	47	36	46
B	39	47	39	36	31	38	45	46	46	41	52
C	66		70	52	47	60	52	65	61	61	68
D		84	93	76	72	86	84	80	94	81	99
E	58	30	56	46	60	59	56	62	61	56	65
F	43	41	49	45	38	42	39	44	46	36	47
G	50	49	57	38	60	66	42	52	44	40	45
H	52	47	67	52	60	58	54	61	64	57	67
I	30	29	38	35	38	37	31	35		37	
J	38	33	35	24	32	36	32	37	39	38	43
K	83	74	82		74	79	84	88	78	89	90
L	31	34	38	35	27		29	34	42	36	45
M	37		39	31	34		36	44	43	38	48
N	38	44	49	36	42	54	54	49	59	45	57
O	47	43	50	45	28	39	34	35	47	44	49
P	44	30	35	28	25		30	43	41	28	42
Q	64	51	54	53	58	46	44	49	71	50	64
R		49	61	38	40	54			54	49	57
S	46	43	49	45	44	46	41	45	62	43	64
T		37	47	43		57	45	57	65	47	63
Ave.	47.2	44.3	52.4	40.8	44.2	52.9	45.3	50.8	56.0	47.6	58.4

Instead of taking each student's score separately, the writer took the average score of all the students every practice period and from these averages drew a learning curve. It was thought that, by so doing, a more representative curve would be obtained. The curve of learning representing the twenty-two averages is shown in Figure 24, page 140.

A glance at the curve reveals the several depressions that occur here and there. Another glance will reveal the fact that, true to the conventional learning curve, this one also has a sudden rise at the beginning with several spurts and drops as the curve continues. These sudden spurts and lags were explained in the chapter on learning curves; therefore, only a word needs to be said concerning them here. The sudden rise, in the first instance, is due, in part, to the newness of the task and the extra effort extended on the part of the learners. As has been explained before, fear of failure has also contributed to this initial rise. The spurts that follow the initial rise can be explained by renewed interests, favorable attitudes, development of higher hierarchy of habits, decrease of fear, satisfactory effects, increased effort and many other physiological and psychological factors. The lags which appear can be explained in the

Fig. 24

A Curve of Learning representing Multiplication of Two-place Numbers by Two-place Numbers



reversed terms just mentioned in connection with each rise. To show the effect of several factors one may notice that in trials 11, 15 and 21 there were decreases in the average scores. The first of these decreases can be explained by the fact that the tests were given a minute before it was time to dismiss all classes. As a result there was much confusion and noise out in the halls, the students were anxious to leave - in fact there were probably several other distractions that promoted unrest and decreased efficiency. This resulted in a lower score which was raised considerably at the following class period. In trial fifteen we see the result of the elapse of time. The students were not given the tests for a week with a result that the score dropped from 52.4 to 40.8. Trial twenty-one again shows the effect of distractions. At the time the tests were given several students opened the door, for some unknown reason, and made considerable noise while leaving. At the same time some person was trying noisily to start a motorcycle just below the classroom windows. Whether or not the plateau had been reached is hard to say because time would not permit the experiment to be continued. It is quite certain, however, that the psychological and physiological limits had not been reached.

To relate all the characteristic parts of the learning curve the writer also took the tests nearly every days, and sometimes two and three times a day, for a period of three and one-half months. During that time 135 practices were made possible and every part of the learning curve was shown distinctly. Table VIII shows the scores made during the three and one-half months:

Table VIII

Showing the Scores made on the Multiplication Tests

Scores made in successive trials (reading from left)													
15	28	30	32	35	39	40	41	40	38	39	42	41	39
40	42	43	39	42	41	44	43	45	43	46	48	44	50
49	53	48	47	49	48	50	53	54	52	51	39	45	45
43	44	45	44	47	49	53	55	51	54	52	53	51	55
58	61	59	58	60	59	60	63	62	64	54	57	56	58
59	60	44	51	50	59	57	65	63	67	74	77	79	78
80	81	83	84	85	86	85	87	88	85	86	84	88	89
87	89	86	87	85	87	88	89	88	87	89	88	86	87
89	88	93	91	95	96	97	95	97	99	104	101	104	105
102	104	105	103	105	105	104	105	109					

The set-up of the experiment was exactly the same as for the group, the only difference being the number of practices made available. When certain psychological or physiological factors entered into the experiment they were noted and written down so as to account for them at this time. When at the end of the 135 practices, the writer believed that he had reached his psychological and possibly physiological limit he ceased taking the tests. The curve appears in Figure 25.

It will be noted that the curve is characterized by small irregularities accompanied by larger irregularities. The small irregularities are due to daily fluctuations in interest, decreased effort and many other psychological and physiological factors already mentioned in a previous chapter on learning curves. The larger fluctuations such as occur in trials thirty to thirty-seven, forty, fifty to fifty-eight, sixty-seven, and seventy-three are due also to several similar psychological and physiological factors but of a more serious nature.

While the writer was taking the tests from the thirtieth to the thirty-seventh practice he was afflicted with a severe cold. This made his interest, effort, attitude and physical condition unsuitable for the task. In practice forty, a friend entered the room and began to converse with the writer. The effects of this distraction are clearly shown by a decreased score for

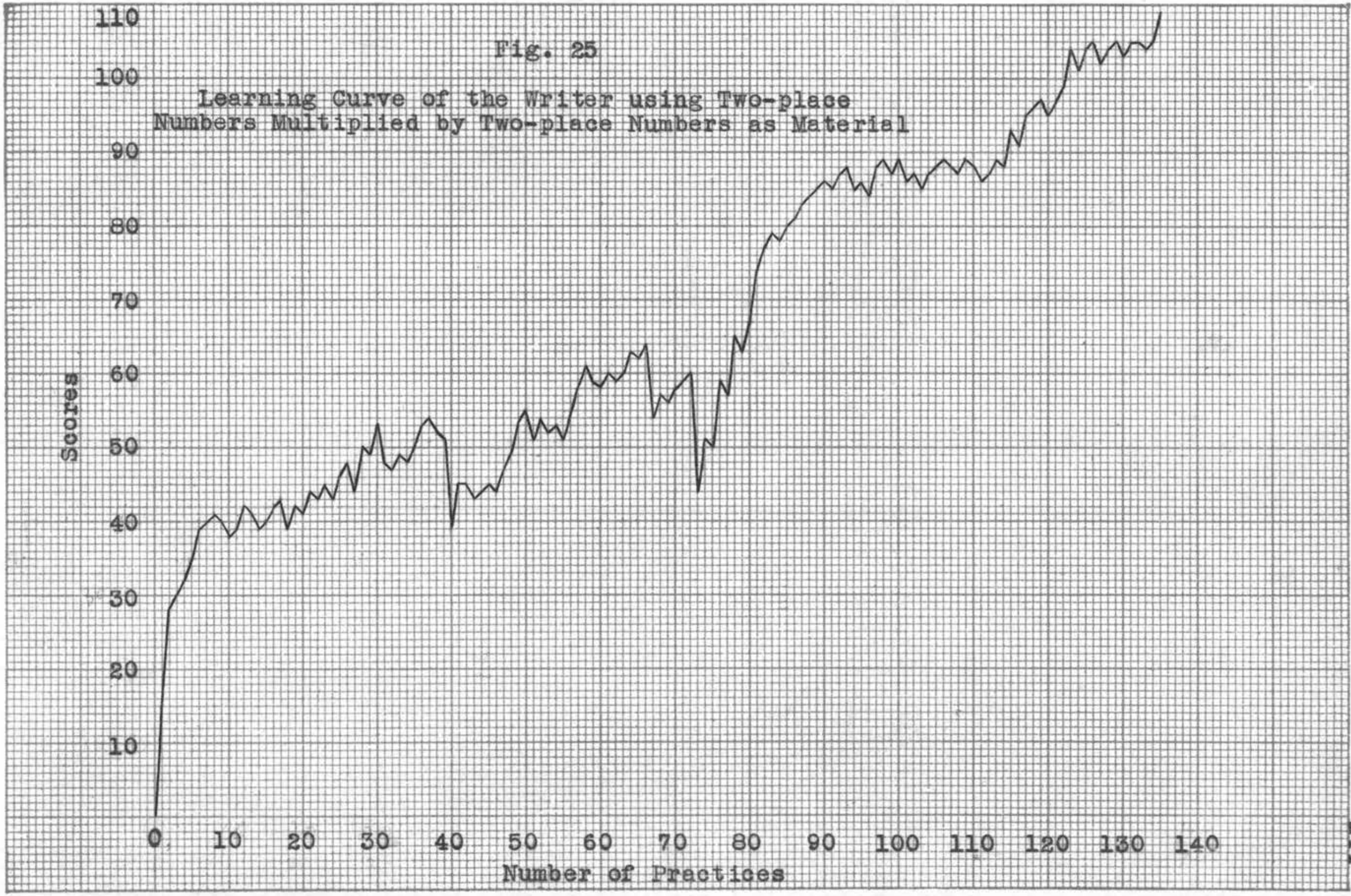


Fig. 25
Learning Curve of the Writer using Two-place
Numbers Multiplied by Two-place Numbers as Material
Scores
110
100
90
80
70
60
50
40
30
20
10
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
Number of Practices

that practice period. During practices fifty to fifty-eight, the writer was gloomy due to personal entanglements. This moody feeling resulted in internal feelings which handicapped the writer in his improvement. Practices sixty-seven and seventy-three both show the effects of no practice periods for a few days. In both instances a decreased score was followed by a sudden increase in score after the cause of the decrease was removed - showing that some learning was occurring even in a period of decreased productivity.

The curve shows the characteristic parts of the conventional learning curve in every respect. The initial spurt followed by a lag is clearly indicated. After the lag appears another spurt followed by a plateau or critical stage. Following the plateau there is another rapid rise and, lastly, there appears what seems to be the psychological and physiological limit.

GENERAL SUMMARY AND CONCLUSIONS

Chapter XIII

1. Learning is a connection of neural and of psychological content bonds of different degrees of strength and directness between the situations provided by material forces or by the behavior of human beings and the responses which the individual is capable of making to them or because of them. All learning, on the neural side, can be reduced to one relatively simple type; that is, stimulus, association, response. It can be either positive or negative; positive when the bond between a stimulus and response is strengthened and negative when the bond has become weakened by disuse or blocked because it is no longer needed or desired. There are many factors which enter in the learning process on the physiological side. These are innate energy, native ability, excess ability, social approval, sensitivity, conductivity, tendency to change, tendency to avoid monotony and several other chemical changes.

2. Because the first contact of the nervous system with outside stimuli is through the sense organs it is apparent that they play an important part in learning. There are several visual defects that are possible and

that often occur to decrease learning efficiency. The effects that accompany markedly defective sense organs are (1) strain on the weakest parts, (2) worry, (3) (frequently) pain, and (4) emotionality.

3. The first step that the young child needs to take in order to predict future events and protect himself from them, apart from the reflex activities connected with excretion, breathing, et cetera, is the development of imagery. Imagery not only covers revived experience necessary to memory and imagination, but it covers the immediate effect of stimuli upon the sense organs providing they are interpretations of objective rather than of subjective experiences.

4. Along with the development of imagery the importance of play, especially during childhood, deserves consideration. Play itself is learning of a complex and most valuable kind. It furnishes much of the factual material on which more formal and more extensive learning is based. Play is important as a learning tool since it is first-hand and voluntary and carries a great influence through its self-centeredness.

5. Both perception and apperception play an important part in the learning process. Perception means the identification and at least partial understanding

of the things that are brought to the brain through the senses. To perceive requires special motivation to define the object as of a definite pattern or group. Perception is necessary and preliminary to motor reaction because, without first perceiving, our responses would be without understanding and sometimes injurious. Perceived figures are generally taken as signs of objective facts but the connection of the sign and the meaning is due to learning. Apperception is important because without it learning on the more complex levels would be impossible. It is different from perception only in that apperception is perception of a class of objects or an abstract quality.

6. There are several so-called levels of learning, namely, (1) physiological learning, (2) perceptual learning, (3) conditioned learning, (4) ideational learning, and (5) creative learning. Physiological learning is the first and basis of them all. Because of the physiological processes that are carried on we are able to adjust ourselves to the world about us and learn. Without proper physiological adjustments learning efficiency would be greatly decreased or rendered impossible. Perceptual learning provides the material used in every other type of learning. An individual notes

and makes adjustments to stimulus-response situations and interprets these so that a desired response can be made. Conditioned learning is a process of attaching a response to a stimulus that previously did not bring about that response. Ideational learning presupposes two things: (1) the development and the use of various memory functions, and (2) the ability to generalize one's experiences through the formation and proper use of concepts that re-instate the concrete experiences one has had. Two steps must be taken to establish a new adaptive response: the first is that some stimulus must be located that will produce the desired results, and second, a problem may be solved and the response brought about by direct and intelligent use of appropriate past experiences. Just what steps are followed is not known but it is known, however, that it is an integrative process. Creative learning involves five steps that must be taken by every learner if a new adaptive response is developed. These are: (1) the new reaction pattern must be formed or the desired response made a first time; (2) this new adaptive response must then be identified as to the adequacy for attaining the goal; (3) it must then be strengthened by further repetitions; (4) all wrong responses must be eliminated; and (5) the new and correct response must usually be improved in form while it is being strongly linked to the appropriate stimulus-situation. The learner's habits condition creative learning. Care should be taken of the ways in which desirable habits of learning are developed.

7. The importance of the associative element in the learning process was recognized a long time ago. Today we recognize two laws in connection with this principle which are: (1) association by contiguity in space and time, and (2) association by similarity and contrast. Similarity and contrast are fundamentally the same thing, the only difference being the emphasis placed upon each by the person making the association. There are several common defects of the associative process which arise from: (1) insufficient attention to the things observed; (2) insufficient experience and number of ideas; (3) low retentiveness; (4) lack of imagery; (5) inability to separate the observed and inferred items and (6) the degree of suggestion which affects the associative process for the good or for the bad.

8. There are nearly a dozen laws, or statements of tendencies, of learning. These are: (1) the law of primacy; (2) the law of recency or repetition; (3) the law of vividness or intensity; (4) the law of frequency

or repetition; (5) Jost's law; (6) the law of exercise; (7) the law of disuse; (8) the law of readiness; and (9) the law of effect. The law of primacy or, more strictly, the statement of tendency toward the effects of primacy is, other things being equal, the first new experience or experiences are better remembered than those that follow. The law of recency asserts that, other things being equal, the things which are learned last are learned first and best remembered. The law of vividness states that, other things being equal, the things that make the sharpest or most colorful impression at the time they are presented are first learned and best retained. The law of frequency or repetition asserts that, the things which are most often repeated are first learned and best remembered, other things being equal, of course. Jost's law states that, when two associations or ideas of equal initial strength but of different ages since recall are re-introduced into consciousness, the older is the more strengthened both in the present and for the future. The law of exercise asserts that, when a particular stimulus arouses a certain response the bondage between this stimulus and the response is strengthened. The law of disuse states that when a stimulus-response situation is not operative or has not been operative, the bondage between the stimulus and response tends to be weakened although not totally lost for a long time. The law of readiness asserts that when the learner's original nature, structure, past experiences, present physiological state and mental attitude are satisfactory, the learning will be more effective and will be remembered for a longer period of time than if these same conditions are unsatisfactory. The law of effect states that when a particular stimulus arouses a certain response and a modifiable connection is made and when this is accompanied by a satisfactory outcome, the strength of the connection is increased. Conversely, if the connection is followed by an annoying state of affairs, the strength of the connection is decreased. No one law or statement of tendency seems to be dominant as each may exercise great influence on the others and may co-operate or conflict with them.

9. There are two main ways of presenting the material of a learning curve. The first way portrays the amount of work that can be done in a given unit of time in successive practices. The second type shows the decreasing amount of time required to solve a problem at successive periods of practice, or the reduced number of trials required to solve it.

10. All learning curves are characterized by six parts, namely, (1) the initial spurt; (2) the lag after the initial spurt; (3) the rapid rise after the initial period; (4) the plateau or plateaus; (5) the rapid rise after the plateaus; and (6) the physiological and the psychological limits. There are many causes for the appearance of each spurt and lag all of which are psychological and physiological in nature.

11. One of the important reasons for the lags, especially during the plateau, is the development of hierarchy of habits. This is a process of merging the lower-order habits with the higher-order habits so that the learner can do things he has not done before. It also makes possible greater efficiency and improvement in doing the task at hand.

12. The problem of transfer of training involves four questions, namely, (1) does transfer take place; (2) if it does to what extent does it take place; (3) to how closely or distantly related functions does transfer take place; and (4) how does transfer take place? In answer to the first question it can be said that transfer does occur. Question Two can be answered in the affirmative when due allowances are made for gains produced by practice in a new subject to be learned,

and for faulty methods of measurement. Third, it may be said, that in general, practically every investigation shows that improvement in one mental or neural function of a pair is accompanied by some modification in other functions. The amount of improvement in one function, however, is very seldom accompanied by an equal amount of improvement in the other function. Under Question Four, three theories have been advanced to account for any transfer that does take place. The first is the theory of identical elements given by Thorndike in which he states that transfer takes place because of identical material in the two activities. The second theory is offered by Bode in which he asserts that transfer of training takes place because of the flexibility of habits and the development of meanings. The third theory is one formulated by Thorndike but later enlarged upon by Judd. This theory is called the 'theory of generalization' and explains the spread of improvement in terms of the recognition of application of an experience obtained in one connection to other connections. Just what carries over and what does not is not a simple question but it is believed that six things do carry over, namely, (1) identical elements; (2) similarities in methods; (3) helpful or detrimental attitudes; (4) ideals;

(5) the feeling of self-confidence or attitude toward success; and (6) helpful methods of work.

13. There are many conditions that favor the learning process among which are: common and special elements; the activity of the learner; observation and perception; insight; emotional set; attention; interests and emotions; motives and incentives, such as rewards, praise and punishments; speed and accuracy; uniformity of environment; background of knowledge and lastly, imitation and suggestion. Each of these conditions has its part to play in the learning process, sometimes co-operating and sometimes conflicting with some or all of the others. It must not be believed that all of these conditions enter into every learning process because in most activities only several of the conditions are at work.

14. No discussion would be complete unless some mention was made about forgetting, or loss of learning. There are three methods of measuring the amount of forgetting that occurs, namely, (1) the method of retained members; (2) the saving method, and (3) the method of right associates. Of these the method of retaining members is the most common and is determined by ascertaining the amount of the original material learned which can be reproduced immediately after a definite

interval. The saving method consists of learning anything at a fairly uniform rate of speed, the readings necessary for learning being repeated until the first correct repetition occurs. The number of readings necessary for the original learning is then recorded. After a definite interval of time has elapsed, the material is relearned and the time saved recorded. The right associate method is the one most used in the psychological laboratory and consists of reading a series of nonsense syllables a number of times rhythmically. After a certain interval of time, the first syllables are presented and the time taken to recall the corresponding second syllables is measured and, usually, reduced to a percentage.

15. The usual curves of forgetting are those of Ebbinghaus, Bean, Radossawljewitch, Magneff and Miss Land. They all show, except Miss Land, a rapid rate of forgetting after the first several hours of learning with a gradual tapering off as time elapses. Miss Land used sense material in her investigation, differing from the other investigators in that the others used nonsense material or nonsense plus sense material. Her curve shows a gradual increase in retention on the first three days with a gradual decline thereafter. She

attributes the gradual rise at first to assimilation. Her curve differs considerably from the others, but the difference can be explained by the influence of age, freedom from competing ideas, and kind of material memorized.

16. One of the important factors which enters into and affects the learning process negatively is the factor of 'fatigue'. Whether or not there is such a thing as mental fatigue is not agreed upon, but if it does exist we can say that it may be taken to mean that sort of fatigue which accompanies mental work. There have been many theories formulated to account for the presence of fatigue. One theory asserts that we become fatigued because of the deposit of poisonous by-products arising from the metabolic processes in the muscles. Another theory maintains that all fatigue is neuro-muscular and consists in the blocking of the paths of discharge in the nerve tracts at the joining of the neurones. The tests which have been used to measure mental fatigue are not exact measures of fatigue as they do not show the effects of unwillingness, shift of attention, loss of interest, and other factors separately from the effects of fatigue. Important conclusions from the studies in fatigue are: (1) fatigue, either mental or physical,

is not common among school pupils; (2) mental fatigue can be minimized by ignoring distractions and sensations of weariness; (3) pleasant work is less fatiguing than unpleasant work; (4) physical work is more fatiguing than mental work; (5) automatic work is less fatiguing than learning that requires attention; (6) associative bonds are weakened during fatigue; and (7) a well organized plan of work minimizes fatigue.

17. In this summary a word needs to be said about animal learning because it is from this field that we have obtained most of our information about the learning process. Whether or not animals can learn depends upon the definition given to the word 'learning'. If it is defined as modification and retention, we can say that animals do learn. We should not, however, attempt to explain an animal's solution of a problem as a result of reasoning if it can be explained in terms of trial and error learning. In some of the higher animals, a high quality of thinking and of insight occur. If 'reasoning is only a high quality of thinking', animals reason, but if it is restricted to complex and abstract mental processes apart from physical activity, they probably do not.

APPENDIX

Appendix

Two of the Tests used in the Experiment

62 x 29	28 x 63
95 x 27	56 x 42
54 x 43	39 x 58
57 x 47	56 x 73
43 x 29	24 x 97
43 x 37	87 x 83
72 x 92	89 x 23
82 x 35	78 x 67
64 x 82	96 x 45
48 x 39	43 x 54
34 x 69	72 x 45
68 x 96	62 x 28
37 x 92	48 x 74
74 x 25	47 x 85
38 x 43	69 x 67
53 x 65	26 x 98
67 x 82	25 x 53
87 x 47	27 x 85
89 x 34	45 x 29
25 x 27	56 x 83
97 x 86	39 x 39
86 x 93	23 x 78
65 x 64	29 x 64
56 x 95	27 x 42
76 x 38	24 x 87
65 x 54	49 x 38
56 x 27	34 x 73
92 x 84	93 x 36
28 x 72	24 x 56
47 x 49	65 x 28

BIBLIOGRAPHY

Bibliography

1. Aronovitch, B. and Lee, F. S. On Weichardt's Supposed Fatigue Toxin. Amer. Journ. Physiol., 1924, 69, 92-100.

2. Arai, Tsuru. Mental Fatigue. Teachers College Contrib. to Educ., Columbia Univ. Press, 1912, no. 54, pp. 115.

3. Atwater, W. D. and Benedict, F. G. Experiment on Metabolism and Matter in the Human Body. U. S. Dept. of Agri. Exper. Sta. Bull., 1903, no. 136, pp. 349.

4. Ballard, P. B. Oblivescence and Reminiscence. Brit. Journ. Psychol. Mono., 1922, 1.

5. Benedict, F. G. and Atwater, W. D. Experiment on Metabolism and Matter in the Human Body. U. S. Dept. of Agri. Exper. Sta. Bull., 1903, no. 136, pp. 349.

6. Bills, Arthur G. Blocking: A New Principle in Mental Fatigue. Psychol. Bull., 1931, 28, pp. 208-209.

7. Bode, B. H. Conflicting Psychologies of Learning. N. Y.: D. C. Heath & Co., 1929, pp. 275.

8. Book, W. F. Economy and Technique of Learning. N. Y.: D. C. Heath & Co., 1932, pp. 526.

9. Book, W. F. Learning to Typewrite. N. Y.: Gregg Publishing Co., 1925, pp. 451.

10. Book, W. F. and Norvell, L. The Will to Learn. Ped. Sem., 1922, 29, pp. 305-362.

11. Breed, Fred S. Instincts and Habits in Chicks. Behav. Mono., 1911-1912, 1.

12. Broyler, C. R. and others. A Second Study on Mental Discipline in High School Studies. Journ. Educ. Psychol., 1927, 18, pp. 377-404.

13. Brumbaugh, J. F. Survey Stakes in Child Psychology. Corvallis: Co-op Book Store, 1933, pp. 173.

14. Byran, W. L. and Harter, N. Studies in the Physiology and Psychology of the Telegraphic Language. Psychol. Rev., 1897, 4, pp. 27-53.

15. Colvin, S. S. The Learning Process. N. Y.: Macmillan Co., 1917, pp. 329.

16. Dockeray, F. C. The Effects of Physical Work on Mental Fatigue. Univ. of Kansas Sci. Bull., 1915, 9, no. 17, pp. 197-243.

17. Gates, Arthur I. Recitation as a Factor in Memorizing. School and Society, 1917, 6, pp. 743-749.

18. Gates, Arthur I. Diurnal Variations in Memory and Association. Univ. Cal. Pub. in Psychol., 1916, no. 1, pp. 323.

19. Gilchrist, Edward P. The Extent to which Praise and Reproof Affect Pupils' Work. School and Society, 1916, 4, pp. 872-874.

20. Harter, N. and Byran, W. L. Studies in the Physiology and Psychology of the Telegraphic Language. Psychol. Rev., 1897, 4, pp. 27-53.

21. Honzik, C. H. and Tolman, E. C. Degrees of Hunger, Reward, and Non-reward, and Maze Learning in Rats. Univ. Cal. Pub. in Psychol., 1930, 4, pp. 241-256.

22. Hurlock, E. B. An Evaluation of Certain Incentives used in School Work. Journ. of Educ. Psychol., 1924, 16, pp. 145-149.

23. Hurlock, E. B. The Value of Praise and Reproof as Incentives for Children. Arch. Psychol., 1924, no. 71, pp. 78.

24. Johnson, F. M. and Paschall, F. C. Psychological Effects of Deprivation of Oxygen. Psychobiol., 1920, 2, pp. 193-236.

25. Jost, A. Die Assoziationsfestigkeit in ihrer Abhängigkeit von der Verteilung der Wiederholungen. Zeitschrift für Psychologie, 1897, 14, pp. 436-472.

26. Judd, C. H. The Psychology of High School Subjects. Boston, New York: Ginn & Co., 1915, pp. 413-414.

27. Judd. C. H. and Scholckow, --. The Relation of Special Training to General Intelligence. Educational Review, 1908, 36, pp. 28-42.

28. Kirby, T. J. Practice in the Case of School Children. Teachers College Record, Col. Univ. Contrib. to Educ., 1913, no. 58.

29. Koehler, Wolfgang. The Mentality of Apes. N. Y.: Harcourt Brace Co., 1926, pp. 342.

30. Laslett, H. R. Reverberations around the Law of Effect. (Unpublished paper, 1933)

31. Laslett, H. R. A Demonstration Method of Studying the Learning Process. Am. Journ. of Psychol., 1928, 40, pp. 168-169.

32. Lee, F. S. and Aronovitch, B. On Weichardt's Supposed Fatigue Toxin. Am. Journ. Physiol., 1924, 69, pp. 92-100.

33. Morgan, Lloyd C. An Introduction to Comparative Psychology. London: W. Scott, limited, 1894, pp. 53.

34. Mosso, A. Fatigue. London, S. Sonnenschein & Co., limited, 1906, pp. 334.

35. Myers, C. S. Experimental Psychology. Cambridge, Univ. Press, 1911, pp. 150.

36. Norvell, L. and Book, W. F. The Will to Learn. Ped. Sem., 1922, 29, pp. 305-362.

37. Paschall, F. C. and Johnson, H. M. Psychological Effects of Deprivation of Oxygen. Psychobiol., 1920, 2, pp. 193-236.

38. Peterson, J. Frequency and Recency Factors in Maze Learning by White Rats. Journal Animal Behavior, 1917, 7, pp. 338-348.

39. Pyle, W. H. The Psychology of Learning. Baltimore: Warwick and York, 1928, p. 341.

40. Pyle, W. H. Economical Learning. Psychol. Bull., 1913, 10, pp. 73.

41. Scholckow, -- and Judd, C. H. The Relation of Special Training to General Intelligence. Educational Review, 1908, 36, pp. 28-42.

42. Seashore, Carl E. Elementary Experiments in Psychology. N. Y.: Holt & Co., 1908, pp. 124-125.

43. Smith, May. A Contribution to the Study of Fatigue. Brit. Journ. Psychol., 1915-1917, 8, pp. 327-350.

44. Starch, Daniel. Educational Psychology. N. Y.: Macmillan, 1922, pp. 449.

45. Sullivan, Ellen B. Attitude in Relation to Learning. Psychol. Mono., 1927, 36, no. 3, pp. 149.

46. Thorndike, E. L. Educational Psychology. N. Y.: Teachers College Press, 1921, 2, pp. 433.

47. Tinker, M. H. A Study of the Relation of Distracted Motor Performance to Performance in an Intelligence Test. Amer. Journ. Psychol., 1922, 33, pp. 578-583.

48. Tolman, E. C. and Honzik, C. H. Hunger, Reward and Non-reward, and Maze Learning in Rats. Univ. Cal. Pub. Psychol., 1930, 4, pp. 241-256.

49. Woodyard, Ella and others. A Second Study of Mental Discipline in High School Studies. Journ. Educ. Psychol., 1927, 18, pp. 377-404.

50. Woodworth, R. S. Psychology. N. Y.: Henry Holt & Co., 1929, pp. 580.