EDUCATIONAL PSYCHOLOGY

VOLUME II

THE PSYCHOLOGY OF LEARNING

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PREFACE

This volume presents the results of psychological studies of human learning and organizes and interprets them for students' use. It is not a complete summary and criticism of the experimental work on this topic; for such a summary and criticism would be too heterogeneous and too complicated by intricacies of method and argument. On the other hand it is not a dogmatic account of the facts as I myself see and judge them; for such an account, though of merit in respect to clearness, brevity and straightforwardness, would not supply the training in first-hand examination of quantitative methods and results which advanced students of educational psychology need.

It is desirable that students of this volume should have read Chapters I, II, IX and XII of the previous volume, especially Chapters IX and XII.

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CONTENTS

Chapter		Page
I.	Introduction	1
II.	The Laws of Learning in Animals	6
	Samples of Animal Learning	
	Characteristics of Animal Learning	
III.	Associative Learning in Man	17
	Varieties of Learning	
	The Laws of Habit	
	The Operation of the Laws of Habit in Man	
IV.	Learning by Analysis and Selection	32
	Analysis and Selection in General	
	The Subtler Forms of Analysis	
	The Higher Forms of Selection	
V.	Mental Functions	54
	The Organization of Connections	
	The Description of Mental Functions	
	Characteristics of Mental Functions	
	The Concepts of Efficiency and Improvement	
	The Measurement of Efficiency	
	Summary	
VI.	The Improvement of Mental Functions by Practice: Sample Studies	85
	Improvement in Telegraphic Sending and Receiving	
	A Sample Measurement of the Effect of Exercise upon the Ability to Typewrite	
VII.	The Amount, Rate and Limit of Improvement	116
	Experimental Results	
	The Frequency of Improvement	

CHAPTER PAGE

The Rapidity of Improvement under Experimental Conditions
Differences amongst Individuals in the Rate of Improvement in the Same Function
Differences in Functions in the Rate of Improvement
The Commensurability of Gains by Different Individuals and in Different Functions
The Limit of Improvement

VIII. THE FACTORS AND CONDITIONS OF IMPROVEMENT 186
The Elements in Improvement
External Conditions of Improvement
Physiological Conditions of Improvement
Psychological Conditions of Improvement
Educational Conditions of Improvement

IX. CHANGES IN RATE OF IMPROVEMENT..... 235
Illustrative Cases
Facts concerning Changes in Rate of Improvement
Rapid Early Rise and General Negative Acceleration in Improvement
The Causes of the Form of Practice Curves
Long-time Fluctuations in Improvement
Short-time Fluctuations in Improvement
The Proper Representatives of the Amount of Practice of a Mental Function and of the Efficiency Reached at Any Stage of Practice

X. THE PERMANENCE OF IMPROVEMENT..... 300
Deterioration by Disuse
Results of Experimental Studies
General Conclusions

XI. IMPROVEMENT IN INFORMATIONAL, APPRECIATIVE, ANALYTIC, AND SELECTIVE FUNCTIONS..... 332

CHAPTER PAGE

XII. THE INFLUENCE OF IMPROVEMENT IN ONE MENTAL FUNCTION UPON THE EFFICIENCY OF OTHER FUNCTIONS 350

Facilitation and Inhibition
Changes in Expectation of Mental Discipline
Cross Education
Experimental Data on the Spread of Improvement
The General Rationale of Mental Discipline
Mental Discipline in Schools
Present Opinion concerning Mental Discipline

BIBLIOGRAPHY OF REFERENCES MADE IN THE TEXT..... 434

INDEX 443

The Psychology of Learning

CHAPTER I

INTRODUCTION

The intellect, character and skill possessed by any man is the product of certain original tendencies and the training which they have received. His eventual nature is the development of his original nature in the environment which it has had. Human nature in general is the result of the original nature of man, the laws of learning, and the forces of nature amongst which man lives and learns.

In a previous volume* the original tendencies of man as a species were listed and described. It was shown that these constitute an enormous fund of *connections* or *bonds* of varying degrees of directness and strength between the *situations* furnished by physical forces, plants, animals and the behavior of other men and the *responses* of which the human creature is capable. Many of these tendencies are notably modifiable; and some of them—such as vocalization, manipulation, curiosity, 'doing something to have something happen,' and 'making a variety of responses to an annoying state of affairs which continues in spite of this, that and the other responses'—are veritable hot-beds for the growth of learned habits.

These original human tendencies include also certain ones whereby modifiability or learning itself is possible. These are best thought of in the form of the three laws of Readiness, Exercise and Effect. The Law of Readiness is: When any conduction unit is in readiness to conduct, for it to do

* *Educational Psychology, Vol. I, The Original Nature of Man.*

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 the animal does nothing to avoid, often doing things which maintain or renew it. By an annoying state of affairs is meant one which the animal does nothing to preserve, often doing things which put an end to it.

The Law of Exercise comprises the laws of *Use* and *Disuse*.

The Law of Use is: When a modifiable connection is made* between a situation and a response, that connection's strength is, other things being equal, increased. By the strength of a connection is meant roughly the probability that the connection will be made when the situation recurs. Greater probability that a connection will be made means a greater probability for the same time, or an equal probability, but for a longer time.† This probability in any case would be for the recurrence of the connection, supposing all other conditions—of general health, general or special fatigue, interest, time of day, distraction by competing tendencies, and the like—to be equal. Furthermore, in certain cases, where the probability that the connection will be made as the result of the mere presence of the situation is zero, the connection still may exist with a measurable degree of strength, shown by the fact that it can be re-made more readily.‡ Also, in certain cases in each of which the probability that the connection will be made is 100 per cent, the connections still may exist with

* The vigor and duration of each 'making' of the connection count, as well as the number of times that it is made.

† Thus, a certain greater strength of the connection between the situation. *'What is the square of 16?'* and the response, *'256,'* may mean that the probability of that response to that situation is now ninety out of a hundred instead of sixty out of a hundred; or that it is ninety-nine out of a hundred for fifty days hence instead of for twenty days hence.

‡ Thus, though a man was utterly unable to give the English equivalents of a hundred Greek words, both on January 1, 1905, and on Jan. 1. 1910, he might have been able to relearn them in thirty minutes in 1905, but only in sixty minutes in 1910.

different degrees of strength, shown by the fact that the probability of 100 per cent will hold for a week only or for a year; will succumb to a slight, or prevail over a great, distraction; or will otherwise show little or much strength. Thus, if the reader will read and repeat *miscob raltof* once or twice he may be apparently as able to supply the *raltof* when *miscob* is presented as if he had read and repeated these words a thousand times: but the future history of the two connections would reveal their differences in strength.

Ultimately degrees of strength of a connection in behavior will be defined as degrees of some anatomical or physiological fact whereby synapses between neurones differ in intimacy.

Varying symptoms that we now refer to the 'strength' of a connection will then each appear as a consequence of this difference in the neurones concerned. For the present, greater strength has to mean either a greater percentage of occurrence under equal conditions outside of itself; or an equal percentage of occurrence for a longer time, or against greater competition; or a readier reëstablishment to equal strength (tested in any of the above ways); or some even more subtle and indirect effects on behavior.

It should be borne in mind also that the connection is often a compound of several connections each having possibly a different degree of strength. Thus, the connection between the situation, *Understanding of and desire to fulfill the command, "Write that man's full name,"* and the response of writing *Jonathan Edwards Leighton* is multiple. One of the names may be remembered and the other not; the bond productive of the general structure of the name may be strong, but all the others very weak, with the result that *Timothy Williams Damon* is the best that can be done; similarly for many variations in completeness, spelling, and so on. The actual physiological bond in even the apparently most single connections is doubtless a compound, and subject to variation by varying unevenly in its different parts as well as by an equal strengthening or weakening of them all.

The Law of Disuse is: When a modifiable connection is *not* made between a situation and a response during a length of time, that connection's strength is decreased. The explanations and qualifications stated in connection with the Law of Use apply here also.

The Law of Effect is: When a modifiable connection between a situation and a response is made and is accompanied or followed by a satisfying state of affairs, that connection's strength is increased: When made and accompanied or followed by an annoying state of affairs, its strength is decreased. The strengthening effect of satisfyingness (or the weakening effect of annoyingness) upon a bond varies with the closeness of the connection between it and the bond. This closeness or intimacy of association of the satisfying (or annoying) state of affairs with the bond in question may be the result of nearness in time or of attentiveness to the situation, response and satisfying event in question. 'Strength' means the same here as in the case of the Law of Use.

These laws were briefly explained and illustrated in the previous volume. By their action original tendencies are strengthened, preserved, weakened, or altogether abolished; old situations have new responses bound to them and old responses are bound to new situations; and the inherited fund of instincts and capacities grows into a multitude of habits, interests and powers. They are the agents by which man acquires connections productive of behavior suitable to the environment in which he lives. *Adaptation, adjustment, regulative change,* and all other similar terms descriptive of successful learning, refer to their effects. The consideration of their action in detail and of the results to which it leads is one task of this volume.

A man's intellect, character and skill is the sum of his tendencies to respond to situations and elements of situations. The number of different situation-response connections that make up this sum would, in an educated adult, run well up into the millions. Consequently, in place of any list of these

detailed tendencies to make responses r_1, r_2, r_3, etc., to each particular situation, we may summarize the man in terms of broader traits or functions, such as 'knowledge of German,' 'honesty,' 'speed in writing,' 'love of music,' 'memory for figures,' 'fidelity of visual images of faces,' and the like.

In educational theories of human learning, and still more in the actual control of it by school practice, these larger traits or functions—these knowledges, powers, conducts, interests and skills—rather than the elementary connections and readinesses of which they are composed, are commonly the subjects of discussion and experiment. Psychological theory and experimentation have also been engaged with traits or functions each of which denotes a group of elementary tendencies, though the traits or functions or abilities which have been investigated by psychologists are usually narrower than those just listed. For example, amongst the functions which have been somewhat elaborately studied are 'rapidity in tapping as with a telegraph key,' 'the delicacy of discrimination of pitch,' 'ability to grasp and retain a series of nonsense syllables,' 'skill in tossing balls,' and 'interest in puzzles.'

Facts concerning the nature of such 'traits' or 'functions' or 'abilities' and their improvement by practice have been accumulating very rapidly in the course of the last fifteen years. To present and interpret these facts is the second task of this volume, and the one to which the majority of its pages will be assigned.

CHAPTER II

The Laws of Learning in Animals

SAMPLES OF ANIMAL LEARNING

The complexities of human learning will in the end be best understood if at first we avoid them, examining rather the behavior of the lower animals as they learn to meet certain situations in changed, and more remunerative, ways.

Let a number of chicks, say six to twelve days old, be kept in a yard (YY of Figure I) adjoining which is a pen or maze (A B C D E of Figure I). A chick is taken from the group and put in alone at A. It is confronted by a situation which is, in essence, *Confining walls and the absence of the other chicks, food and familiar surroundings.* It reacts to the situation by running around, making loud sounds, and jumping at the walls. When it jumps at the walls, it has the discomforts of thwarted effort, and when it runs to B, or C, or D, it has a continuation of the situation just described; when it runs to E, it gets out and has the satisfaction of being with the other chicks, of eating, and of being in its usual habitat. If it is repeatedly put in again at A, one finds that it jumps and runs to B or C less and less often, until finally its only act is to run to D, E, and out. It has formed an association, or connection, or bond, between the situation due to its removal to A and the response of going to E. In common language, it has learned to go to E when put at A—has learned the way out. The decrease in the useless running and jumping and standing still finds a representative in the decreasing amount of time taken by the chick to escape. The two chicks that formed this par-

ticular association, for example, averaged three and a half minutes (one about three and the other about four) for their first five trials, but came finally to escape invariably within five or six seconds.

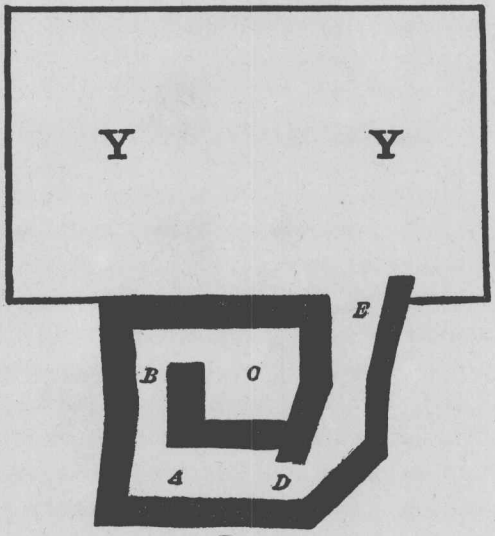

FIG. 1.

The following schemes represent the animal's behavior (1) during an early trial and (2) after the association has been fully formed—after it has learned the way out perfectly.

(1)

BEHAVIOR IN AN EARLY TRIAL.

SITUATION.	RESPONSES.	RESULTING STATES OF AFFAIRS.
As described above, in the text	To chirp, etc.	Annoying continuation of the situation and thwarting of the inner tendencies.
	To jump at various places.	" " "
	To run to B.	" " "
	" " " C.	" " "
	" " " D.	" " "
	" " " E.	Satisfying company, food and surroundings.

(2)

BEHAVIOR IN A TRIAL AFTER LEARNING.

SITUATION.	RESPONSES.	RESULTING STATES OF AFFAIRS.
Same as in (1).	To run to E.	Satisfying as above.

A graphic representation of the progress from an early trial to a trial after the association has been fully formed is given in the following figures, in which the dotted lines represent the path taken by a turtle in his fifth (Fig. 2) and

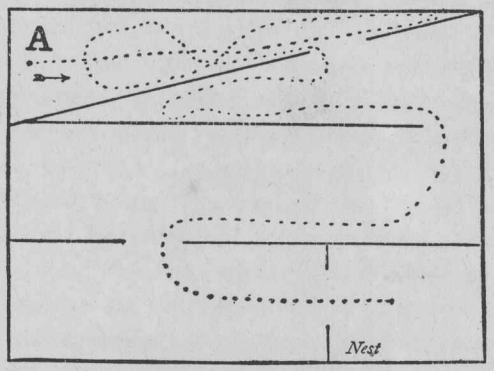

FIG. 2. The path taken by a turtle in finding his way from A to his nest, in his 5th trial.

fiftieth (Fig. 3) experiences in learning the way from the point A to his nest. The straight lines represent walls of boards. Besides the useless movements, there were, in the

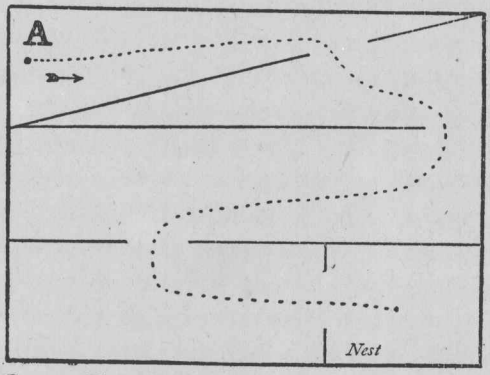

FIG. 3. The path taken by a turtle in finding his way from A to his nest, in his 50th trial.

fifth trial, useless stoppings. The time taken to reach the nest in the fifth trial was seven minutes; in the fiftieth, thirty-five seconds. The figures represent typical early and late trials, chosen from a number of experiments on different individuals in different situations, by Dr. R. M. Yerkes, to whom I am indebted for permission to use these figures.

Let us next examine a somewhat more ambitious performance than the mere discovery of the proper path by a chick or turtle. If we take a box twenty by fifteen by twelve inches, replace its cover and front side by bars an inch apart, and make in this front side a door arranged so as to fall open when a wooden button inside is turned from a vertical to a horizontal position, we shall have means to observe such. A kitten, three to six months old, if put in this box when hungry, a bit of fish being left outside, reacts as follows: It tries to squeeze through between the bars, claws at the bars and at loose things in and out of the box, stretches its paws out between the bars, and bites at its confining walls. Some one of all these promiscuous clawings, squeezings, and bitings turns round the wooden button, and the kitten gains freedom and food. By repeating the experience again and again, the animal gradually comes to omit all the useless clawings, and the like, and to manifest only the particular impulse (e. g., to claw hard at the top of the button with the paw, or to push against one side of it with the nose) which has resulted successfully. It turns the button around without delay whenever put in the box. It has formed an association between the situation, *confinement in a box of a certain appearance,* and the response of *clawing at a certain part of that box in a certain definite way.* Popularly speaking, it has learned to open a door by turning a button. To the uninitiated observer the behavior of the six kittens that thus freed themselves from such a box would seem wonderful and quite unlike their ordinary accomplishments of finding their way to their food or beds, but the reader will realize that the activity is of just the same sort as that displayed by the chick

in the pen. A certain situation arouses, by virtue of accident or, more often, instinctive equipment, certain responses. One of these happens to be an act appropriate to secure freedom. It is stamped in in connection with that situation. Here the act is clawing at a certain spot instead of running to E, and is selected from a far greater number of useless acts.

In the examples so far given there is a certain congruity between the 'set' associated with the situation and the learning. The act which lets the cat out is hit upon by the cat while, as we say, trying to get out, and is, so to speak, a likely means of release. But there need be no such congruity between the 'set' and the learning. If we confine a cat, opening the door and letting it out to get food only when it scratches itself, we shall, after enough trials, find the cat scratching itself the moment it is put into the box. Yet in the first trials it did not scratch itself in order to get out, or indeed until after it had given up the unavailing clawings and squeezings, and stopped to rest. The association is formed with such an 'unlikely' or 'incongruous' response as that of scratching, or licking, or (in the case of chicks) pecking at the wing to dress it, as truly as with a response which original nature or previous habit has put in connection with the set of the organism toward release, food, and company.

The examples chosen so far show the animal forming a single association, but such may be combined into series. For instance, a chick learns to get out of a pen by climbing up an inclined plane. A second pen is then so arranged that the chick can, say by walking up a slat and through a hole in the wall, get from it into pen No. 1. After a number of trials the chick will, when put in pen No. 2, go at once to pen No. 1, and thence out. A third pen is then so arranged that the chick, by forming another association, can get from it to pen No. 2, and so on. In such a series of associations the response of one brings the animal into the *situation* of the next, thus arousing its response, and so on to the end. Three chicks thus learned to go through a sort of long labyrinth without

mistakes, the 'learning' representing twenty-three associations.

The learning of the chick, turtle and kitten in the cases quoted is characterized negatively by the absence of inferential, ratiocinative thinking; and indeed by the absence of effective use of 'ideas' of any sort. Were the reader confined in a maze or cage, or left at some distance from home, his responses to these situations would almost certainly include many ideas, judgments, or thoughts about the situation; and his acts would probably in large measure be led up to or 'mediated' by such sequences of ideas as are commonly called reasoning. Between the annoying situation and the response which relieves the annoyance there might for the reader well intervene an hour of inner consideration, thought, planning and the like. But there is no evidence that any ideas about the maze, the cage, the food, or anything else, were present to determine the acts of the chicks or kittens in question. Their responses were made directly to the situation as sensed, not *via* ideas suggested by it. The three cases of learning quoted are adequately accounted for as the strengthening and weakening of bonds between a situation present to sense and responses in the nervous system which issue then and there in movement. The lower animals do occasionally show signs of ideas and of their influence on behavior, but the great bulk of their learning has been found explainable by such direct binding of acts to situations, unmediated by ideas.

CHARACTERISTICS OF ANIMAL LEARNING

These cases, and the hundreds of which they are typical, show the laws of readiness, exercise, and effect, uncomplicated by any pseudo-aid from imitation, ideo-motor action, or superior faculties of inference. There are certain states of affairs which the animal welcomes and does nothing to avoid—its satisfiers. There are others which it is intolerant of and rejects, doing one thing or another until relieved from them. Of the bonds which the animal's behavior makes between a situation and responses

those grow stronger which are accompanied by satisfying states of affairs, while those accompanied by annoyance weaken and disappear. Exercise strengthens and disuse weakens bonds. Such is the sum and substance of the bulk of animal learning.

These cases exemplify also five characteristics of learning which are secondary in scope and importance only to the laws of readiness, exercise, and effect.

The first is the fact of *multiple response to the same external situation.* The animal reacts to being confined in the pen in several ways, and so has the possibility of selecting for future connection with that situation one or another of these ways. Its own inner state changes when jumping at the wall at B produces a drop back into the pen, so that it then is less likely to jump again—more likely to chirp and run. Running to C and being still confronted with the confining walls may arouse an inner state which impels it to turn and run back. So one after another of the responses which, by original nature or previous learning, are produced by the confining walls *plus* the failure of the useless chirpings, jumpings and runnings, are made.

This principle of *Multiple Response* or *Varied Reaction* will be found to pervade at least nine-tenths of animal and human learning. As ordinarily interpreted, it is not universal, since, even if only one response is made, the animal may change its behavior—that is, learn—either by strengthening the connection so as to make that response more surely, more quickly and after a longer interval of disuse; or by weakening the connection so as to be more likely to do nothing at all in that situation, inactivity being a variety of response which is always a possible alternative. If we interpret variety of reaction so as to include the cases where an animal either makes one active response or is inactive—that is, either alters what it was doing when the situation began to act, or does not alter what it was doing—the principle of varied response is universal in learning.