CONSCIOUS ANALYSIS VERSUS HABIT HIERARCHIES IN THE LEARNING PROCESS

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It is the two-fold purpose of this paper to submit certain criticisms of an assumed function of consciousness in learning, and to emphasize habit groups or hierarchies as an important explanation principle in the learning process. The criticisms are based directly upon experimental data. The theory of learning was suggested by the experimental evidence, but it is offered as an independent consideration. The implication is clearly made in many of our standard texts that the rôle of consciousness is analytical—that the learner first analyzes the learning situation and then proceeds to master it. It is against this interpretation that the criticisms are directed. As opposed to this or to any attempt to read consciousness into the learning process, stand a number of behavioristic theories. The one now presented stresses certain behavioristic principles.

We are thoroughly familiar with the point of view which ascribes to consciousness a function, particularly in the initial stages of the learning process. It works as a directing agent. The beginner at typewriting is asserted to initiate his attempts at the expense of an increased or heightened amount of conscious activity; later, as an expert typist, he is supposed to perform with a minimum of conscious direction. Our concern is possibly not so much with the truth of this general statement as it is with its implications and concrete applications.

The success with which the behaviorist has explored (and exploited) the human learning process has resulted in the side-tracking of this issue. The modern investigator has been busy with graphs and tables, with plateaus and steeples. He has either dismissed consciousness altogether from his scheme of

things, or he has acquiesced unprotestingly with this theory, and then ignored it as a small matter. The conclusions advanced in this part of the paper, in themselves, argue neither for nor against behaviorism. But they are frankly directed against the belief that consciousness directs affairs in the beginning stages of learning and then relinquishes them as automaticity appears, on the grounds that this explanation, however plausible it may sound as a generalization, breaks down upon concrete application.

In order to discuss with some degree of definiteness this alleged rôle of consciousness, invariably stated in the broadest possible way, it might be well to raise a few preliminary questions. In the first place, it may or may not be true that conscious activities are unusually in evidence during the first periods of the learning process. The point is at least debatable. If consciousness is present, however, to an intensified degree, it may be emotional rather than ideational—a possibility not provided for in the accounts ordinarily given. And as such, it may inhibit rather than facilitate the learning process. But, assuming that this over-production of consciousness is in evidence, and that it is ideational, does it constitute a particularized consciousness, not observable in non-learning situations? While none have made this specific claim, many have implied as much in their statements. Again, we should like to know the exact nature of this initial learning consciousness. Does it function by selecting the correct reactions and eliminating the incorrect? And finally, we are interested in the exact conditions under which heightened conscious processes are stimulated. Are they aroused in connection with new, or with difficult, or with complex situations? We are informed that consciousness becomes heightened in times of difficult or inadequate adjustment; yet common observation would lead us to believe that it also attains its maximum degree of intensity during periods of hunger or of sexual gratification. One reads both the theoretical and experimental literature in vain for satisfactory answers to these questions.

The conclusions now offered are assuredly not final, but they do attempt to face these issues squarely. Our data would seem

to show, in the first place, that the heightened initial consciousness of the human adult learner is a phenomenon which has been considerably over-stressed; and that it has been erroneously placed in the cognitive category, where it should have been described as essentially emotional. Furthermore, the evidence indicates that conscious analysis follows, rather than precedes, the act of learning; and that it by no means follows, even, the retention and selection of new and difficult coördinations with any degree of consistency. In short, reasons exist for believing that the human learning process, stripped of its accessory accompaniments, is necessarily an unconscious process.

These conclusions, as just formulated, of course demand explanation and evidence. As a matter of fact, they are not particularly radical. If they are apparently so, the impression may be due in part to difficulties of terminology. It may be urged, for instance, that "non-deliberate" should be substituted for "unconscious," in the above statement. Yet the question, as a whole, is something more than a verbal one. Nor can it be disposed of as a metaphysical issue. Our data are largely introspective, and in minimizing the importance of "ideas," therefore, we are likewise assigning less importance to the "neural correlates of ideas." But it should be acknowledged that the question is a relative one. Other writers have called attention to the fact of unconscious learning, and it remains to be seen if the emphasis placed upon that principle in this paper is justified.

The investigation now reported consisted of a series of tests of motor ability, given to a group of 100 adult subjects. Since a number of trials were made by the subjects in each test, it can properly be regarded as an investigation of the initial phase of the learning process. Some of the results were obtained from a group of five adults, who practiced at card sorting over a period of three months, meeting five times a week. Particular reference will be made in this discussion to three of the seventeen motor tests—the Bogardus fatigue test, a group of balancing tests, and a "coordination" test. The apparatus for the last named consisted essentially of a triangle and a quadrilateral, cut as grooves in an aluminum plate. The subject, with a stylus in

his right hand and a corresponding one in his left, was required to describe these figures simultaneously, at a standard speed, regulated by a metronome. It was in substance a test which interfered with the habitual coördinations of the two arms. The responses elicited by these three tests seemed to be fairly representative of the human learning process. Both introspective testimony and systematic notes on learning behavior were recorded, and both were used as a basis for the views now submitted.

Two facts, clearly brought out by the introspections and to all appearances by the observations on behavior, are chiefly responsible for these views. It is certain that difficult motor coördinations may be acquired which more or less completely baffle all attempts at analysis on the part of those who acquire them. And it seems quite patent that coördinations may be selected and retained unconsciously, in the sense that the individual who selects and retains them does so with no memory of the first time the act was performed, and with no memory of a conscious plan to perform the act. That these two principles have something in common is suggested at once. They are, however, quite distinct, inasmuch as they were demonstrated under different objective conditions.

Introspecting upon the coördination test proved to be an exceedingly difficult task. Mastery of the test itself, for that matter, was by no means easy. And it should be recorded that the subject showed all symptoms of close attention to his learning problem. In fact, the first part of Angell's description of another learning process is equally applicable here: "While one is *learning* to write, consciousness is involved in the most alert and intense manner." But the analogy between the mental processes of one who learns to write, as given by Angell, and the mental activity of the learner at the coördination test is not so apparent. To quote the ensuing account: "The position of the hand, the mode of grasping the pen, the model to be copied, the movement necessary to form each part of the letter—all these things, one after the other, are the objects of vivid attention" (1). All of these items, even the movements involved, are fairly objective

and concrete; and the learner, presumably a child in the grades, *aided by detailed and definite instruction*, undoubtedly attends after the manner described.

The difference between the two processes is due to the fact that no model of the essential aspect of the coördination test was given to the subject. The test calls for a definite series of simultaneous arm movements. Its difficulty may be ascribed to two facts: that these synchronous movements are neither symmetrical nor similar; and that they must be performed in a definite and varied sequence. Moreover, they must be executed, according to the directions, with free movements—an error was recorded each time the stylus came in contact with the metal plate. Now, when the subjects were asked to describe the objects of their attention, they mentioned the aluminum plate, the stylus, the metronome, the electric buzzer, which warned them of contacts with boundaries of the figures, and the fact that they were moving their arms; but they made no mention of anything resembling a conscious analysis of the coördination itself. Their attention, to summarize the testimony, was upon stimulus, and upon warnings of erroneous movements. It was not directed towards anticipatory ideas of the movements to be performed. To put it in another way, the subjects did not deliberately form an idea of a movement-to-be-performed, and then proceed to express that idea in action.

These introspections—assuming, for the present, their reliability—have a negative value. They argue against the hypothesis which would make the acquisition of a motor habit depend and follow upon a clear-cut anticipation of the act, or upon a copying process of any definite sort. They also suggest an alternative and a positive explanation, so far as this particular test is concerned. Since the figures were grooves, cut into the plate, the movements of the subjects were physically restricted and guided by these grooves. The situation resembles, then, the problem confronting the individual or animal in the maze; and Watson's explanation of frequency of response, with the probabilities favoring the correct reaction as the one most frequently performed, would seemingly apply to the coördination test (2).

According to our interpretation, this theory, subject to certain important modifications and additions, does explain the human learning process in the coördination test. It does not, however, furnish a satisfactory account of the discovery of the correct reaction. Some more specific factor evidently functions. Psychological theory would be happily simplified if we could establish this factor as cognitive in nature—if it should turn out to be, for instance, the mental image. It happens, however, that the subject who found the task impossible was an advanced student in psychology, best fitted by training and by intelligence to analyze the process. It happens, too, that no correlation obtains between ability to introspect upon the process and ability to attain distinction in the test itself. If, therefore, the mental images, kinaesthetic processes, and anticipatory ideas *reported* by a few subjects were the mental process which actually functioned in learning, we must admit that they rendered feeble and fairly ineffective service. The factor, or group of factors, which must account for individual differences, is not the conscious analysis made by the learner of the learning problem.

A second example of the difficulty attending the attempt to read conscious analysis into the learning process is to be found in either of the two balancing tests employed in the motor test series. The subject was required to walk on the edge of a board, secured edge-up to the floor. He was asked to walk forwards and backwards, and to make a complete turn on this narrow footing—to learn, in a crude way, the art of tight-wire walking. He was also required to balance himself on one foot, Mercury-like, on a pedestal constructed of a piece of 2 by 4 inch plank, 16 inches in length, with a rectangular board at one end, serving as a foot-rest. Since this pedestal was not attached to the floor, the subject was forced to maintain an almost perfect balance. Both tests were conducted by trials. Errors were recorded for the first, time for the second. Introspections were called for in both.

Simple as these tests are, they do not lend themselves to introspective dissection. The instructor may demonstrate them, and he may give a few valuable hints, such as those regarding visual fixation points and the position of the feet; but his responsibility

must cease with these meagre aids. The selection of the effective reflexes must be left to the learner. But how they were selected and permanently retained none of the subjects—including the writer—could tell. Certainly, not by any direct conscious process. It is true that these tests, involving equilibrium, place more of a premium upon inherited coördinations than tests such as the Bogardus. But they were none the less difficult, and none the less subject to improvement; they were, therefore, true learning problems.

Moreover, they elicited intense and definite conscious reactions. But this is just the point of the discussion; the fact that a type of consciousness is aroused, in connection with an initial learning situation, which is clearly not engaged with the analysis of that situation, logically argues against the function usually ascribed to consciousness as a universal law. The nature of that consciousness will be discussed subsequently.

By way of contrast with coördination and the balancing tests, the Bogardus fatigue test affords an instance of a learning problem which permits, and to an extent demands, the fullest conscious approach possible. Its technique can be described verbally and demonstrated visually. The complete reaction elicited by it consists of a number of definite acts: the operator reaches for and grasps a small wooden cube with his right hand, places this cube on a marked square (a small platform, devised for the occasion, in this experiment), catches the cube with his left hand when it is knocked off by the revolving arms, etc. In this test we should expect the process of learning to write, referred to above, most closely to be duplicated.

In just this test, however, we find only an ambiguous support of this theory of learning. For, in the first place, some of these specific habits were acquired with a minimum, at least, of conscious direction; and in the second place, the habits which were consciously directed at the start continued to call for conscious supervision—prolonged practice failed to place them in the automatic class. The first point is advanced against the universality of the principle, even when overt acts are involved;

the second point is opposed to the assumption that the learning consciousness is a particularized or a unique consciousness.

One particular reaction made in the Bogardus test will serve to illustrate the principle of unconscious (at least, "non-deliberate") habit formation. In giving the preliminary directions to the subjects, no reference was made to the device of looking at the supply box, or tray, containing the wooden cubes. The discovery or employment of this was left entirely with the subject. It happens to be, however, a decidedly efficient method, and it was adopted by practically all of the subjects who made good records in the test. In a few instances, the anticipatory idea of looking at the tray was reported as preceding the act; in a greater number of cases, act and awareness of the act were simultaneous; but in as many other instances the acquisition of this act as a habit was accomplished without definite awareness. By this is meant that the subject had no memory of the first time the act was performed, and no memory of a pre-formed plan to adopt it.

Similar results were obtained from many other tests. In card sorting, the extremely useful device of employing the thumb and finger in the left hand, holding the deck, was acquired unconsciously by several of the subjects who were unaccustomed to card games. In the familiar ball tossing experiment, unconscious acquisitions of essential habits of manipulation were demonstrated by practically all of the subjects who practiced at this performance.

Acknowledgments should be made at this point of possible criticisms, directed against the introspections reported, and of the difficulty, in general, connected with the attempt to introspect under the conditions of the experiment. The subjects were, in the main, "untrained" in introspective technique. It has already been stated, however, that the few who did describe their conscious experiences failed, in so doing, to explain their learning process. They merely enumerated the sensory experiences which necessarily accompanied the movements involved in learning. The fact that no correspondence exists between ability to introspect and ability to learn is significant, since it indicates that the subjective processes capable of being observed

and described were psychological by-products, of no real value in the learning itself. If this were not the case, it would follow that the professional psychologist should be able to distinguish himself in feats of skill. His ability, however, to assist himself or others in such accomplishments as dancing, swimming, or driving a car seems to be limited to his knowledge of general principles (fatigue, temporal distribution of effort, and the like) and to his analysis of specific efficient methods. But these are obviously empirical and objective affairs, and the psychologist, therefore, may be of service just to the extent that he is an efficiency expert.

One particular introspective difficulty, however, should be noted. It may be urged that our subjects, in the Bogardus test, were aware of the act of fixating on the tray, and that they merely lapsed into forgetfulness. But this explanation seems to be a bit gratuitous. It is based upon either an a priori theory that such attention is pre-supposed, or upon the facts that some of the subjects did report this definite awareness. The accumulating body of experimental evidence (Book, Swift, and others) corroborates the testimony of the subjects.

These instances have been cited, not for the purpose of maintaining the thesis that a state of inattention is the one best suited for the acquisition of motor habits, but with the end in view of emphasizing the reaction, rather than the idea of the reaction, as the most obvious feature of motor learning phenomena. The overt movements made by an individual to a motor test situation are largely independent of either his anticipatory ideas or of his full awareness of these movements. So far as the Bogardus test is concerned, it can only be said that definite and immediate awareness of the act described was conditioned by antecedent and rather incidental circumstances. It may be that a preliminary statement of instructions to the subject would facilitate his progress with the test; but in this event we would obviously have a different learning problem.

Although estimates of the quantity of total conscious processes are necessarily conjectural, the attempt was made to ascertain such fluctuations as could be observed by the subjects. The

result of this attempt prompted the conclusion that learning consciousness is far from being unique, and that fluctuations in learning consciousness are primarily emotional. The initial decline, when it was in evidence, seemed due to the diminution of emotional activity, particularly as regards the state of embarrassment which was naturally aroused in the subjects at their first venture with the tests. The conclusion, however, is based primarily upon the testimony of three subjects who continued at card sorting during a period of six months. While they continued to exert themselves during this period, thus making it a period of continuous learning, they did reach a stage in which the actual movements involved became practically automatic. But the act of recognizing the cards remained a conscious act, and the total conscious reaction, including orientation, maintained a consistent level. If it is necessary to describe at all a *learning* consciousness, that description must be formulated in terms of effort, of conation in general.

The conclusions so far advanced have been negative in character, and possibly unjust in their disregard of certain obvious facts of daily experience. These facts will be provided for if a distinction is made between two fairly distinct types of human learning. In one of these, the problem is to establish a definite sequence of acts, no one of which, in itself, presents any unusual difficulty. Learning to drive a car is a case in point. A problem of this type lends itself readily to analysis in terms of a verbal formula, and it can be mastered by memorizing this formula. If verbal processes are essentially implicit motor habits, as Watson asserts, we have here the interesting phenomenon of one system of motor habits whose function it is to inaugurate another and a larger (explicit) system. It is this type of habit which may be acquired "consciously" and deliberately, in the sense that the learner memorizes and deliberately applies his formula. And, in due course of time, it may be dispensed with.

Closely related to this function of verbal processes is their employment for elaborating a plan of action. An excellent example of this—the reasoning process—in the field of motor adjustments is to be found in Watson's analysis of the individual

called upon to face engine trouble (3). Again we find, even in this example, a minimum of conscious *directing* of thought processes. Angell discusses this point in his text, and goes so far as to state that: "It is easy for anyone who speaks readily to gain convincing evidence that the particular words used to express a thought were often in no sense mentally anticipated just prior to their actual use" (4). Whether the word and the thought are separate entities is not made clear in this passage. If so, the thought is in all probability an incipient act, a tabloid performance of the overt act, and as such, a reaction stimulated by the learning situation. The learner meets his situation, according to this interpretation, with a double repertoire, of reaction habits and language habits. Either or both may be elicited by the problem stimulus, and it is difficult to see how any directing agent could function in this double associative process.

That no such function is operative is seen in the second type of motor learning. This includes situations requiring skill, such as those which place premiums upon steadiness, accuracy, speed, the formation of minute and complex muscular responses, and the inhibiting of habitual and interfering responses. If the Bogardus test is an example of the first type, the coördination and balancing tests are instances of the second. Swimming might be mentioned as belonging to an intermediate type. Just to the extent that the responses called for permit verbal description, conscious analysis, in the sense indicated, is possible. But in the second type of problem—and this includes most of the tests used in the present investigation—acquisition necessarily precedes; and analysis, if made at all, follows.

All theories of the learning process agree in substance that it consists essentially of the selecting and retaining of adequate reactions, and of the rejecting and eliminating of inadequate reactions, from a surplus of movements. This principle is frequently stated in terms of habit, but without the implication that any given eliminated movement has necessarily reached a definite habit stage. And it is sometimes assumed that any isolated reaction in the series, irrespective of its ultimate fate,

may be either a reflex or a habit previously formed. All of this, however, savors more of definition or description than of explanation. With this preliminary statement of fundamentals, the theories begin to diverge.

The considerations submitted in this paper have been to the effect that no anticipatory play of ideas uniformly precedes the selecting, retaining, rejecting, and eliminating activities. When such mental reactions do supervise learning, the process becomes either a reasoned problem, or one involving a step by step reliance upon a formula. After making full allowance for the rôle of verbal aids in learning, the essential aspect of the process remains unexplained; and it remains to be seen if any theory is at all satisfactory for this purpose.

One such theory holds that the successful act or group of acts usually terminates a learning trial, and that in the ensuing trial, it stands the best chance of selection because of its recency. If this explanation is to be taken on its face value, it cannot be of service so far as the present results are concerned. An arbitrary time unit distinguished the trials in the Bogardus and coördination tests, while task units (not achievement) separated the trials in the balancing, aiming, and card sorting tests. In fact, none of these tests was comparable in this respect to the maze or problem box experiment. The successful act was as likely to occur in the middle of the trial as at the end. And it should be noted, too, that in the learning attempts of practical life, the "trials" are not sharply defined.

In another type of explanation, the successful reaction is supposed to stand out in some way from the mass of unsuccessful attempts, other than by its temporal position. It is distinguished because of its feeling tone, or because of the accompanying increase in metabolism. According to a variation of this, it is marked by increased glandular or general organic activities in such a way as to insure its ultimate selection. Or, it is merely assumed to attract the attention of the learner, and in this way to take on a quality of vividness which will mark it as an object for conscious selection. In this group of theories, consciousness may or may not play a rôle.

In each of our tests, the learner was in a position, so far as objective test conditions are concerned, to note each success and each failure, and the second type of theory, therefore, merits consideration. One might conceivably admit the principle of non-anticipated discoveries, and yet claim that, once made, they were observed and consciously incorporated as habits. Against this solution, however, stands the fact that both the processes of acquisition and of fixation were at times unconscious; and the fact that, in the second type of learning problem, the learner was in a position to note results, not learning processes. The experimenter's observation, as well as the subject's reports, in the balancing tests, testify to the surprise of the subject, sometimes at his successes, sometimes at his failures. He was scarcely able to associate either with its antecedent causes. In the steadiness test, he was warned of each failure by the electric buzzer, but here again he was unable to describe his reactions immediately preceding the failure signal, in such a way as to differentiate it from his general reactions to the test. Even in the aiming test, in which he was apprised visually each time of his degree of success, it was obvious that no corresponding differences in kinaesthetic experience were observable. The same statement applies to the coördination test. In this, he was kept fully informed as to his progress, by visual, auditory, and kinaesthetic cues, but he was not made aware of causes. It is rather significant that, in a number of instances, subjects developed a decidedly fatalistic attitude towards their achievements: failures and triumphs were equally inexplicable. And in all cases, their explanations of specific results were either vague or general. It is clear, then, that if this theory implies a conscious association between a success and the movements directly responsible for the success, it does not explain the learning process; and if it does not presuppose conscious connections, it is all the more unsatisfactory.

No direct evidence is available which bears upon any glandular or organic theories. The difficulty here is plainly one of conception. To imagine that glandular changes parallel each attempt in the Bogardus problem, in which there were 43 per

minute, is out of the question. And to introduce this theory as an explanation of gross results begs the question. More justifiable is the assumption that endocrinal activities may be useful in accounting for drive, perseverance, or motive.

In a third type of explanation, it is assumed that the adequate reaction is the one most frequently made. This certainly has the merit of simplicity. It is in harmony with current neurological beliefs, and with the more obvious facts of behavior. Furthermore, it dispenses with the somewhat artificial distinction made between acquisition and fixation. The question is whether or not either the objective conditions of the experiment or the nature of the reactions made favor the more frequent repetitions of the successful act. Watson has tried to demonstrate that the laws of chance so favor the animal in the maze, since it is forced, in any given trial, to follow the true path, but it is not under physical obligations to follow any other one sequence of paths (5). It is not our purpose to pass judgment upon this particular argument; but we may point out that emphasis must be placed upon the learning reaction itself, rather than upon the objective conditions of the task, if we are to employ this principle as a universal explanation. Clearly, the human learner is not physically coerced into placing the blocks correctly in the Bogardus test, in any possible sense.

That the nature of the learning process does distinctly favor the greater frequency of the successful act is made plausible when we introduce the principle of habit hierarchies. Possibly the maze furnishes only an ambiguous example of this principle, but if the theory possesses any merit at all, it must stand the test of examination in connection with a variety of learning situations. It has been rather distinctly assumed that maze habits are grouped in a coördinate series, with the path segment and its turn as the unit of this series. But an earlier investigation by the writer disclosed the fact that the human subject, at least, builds up first a general reaction and only subsequently a series of specific reactions. Incidentally, this fact was expressed in terms of ideas, but it can be stated just as fairly in terms of habit. The point was, however this may be, that the human

adult finds himself equipped with an idea of the general direction of the true path, as the result of his first trial in the maze. Armed with this general idea, he is enabled to work out the details in ensuing trials—developing, of course, a successive series of ideas which become less general and more specific (6). If this does characterize the human learning process in the maze, we should expect something analagous to it to operate in the case of the animal, unless we are willing to assume a hiatus between human and animal forms of learning.

This may be regarded as a generalized habit, rather than an idea, as an illustration will show. It was ascertained in the same investigation that the human subjects, familiar with the location of the maze exit at the periphery of the maze, were thoroughly confused when they encountered a maze with its exit located in the center. Their reaction certainly was not one of weighing the possibilities, and then ruling against the central exit idea; rather, it was one of proceeding without ideational inhibitions towards the outside of the maze, after the manner of one who unthinkingly lights a loaded cigar. It was essentially a transfer of training phenomenon and it is probable that a rat so trained would make a similar error, as the result of similar interferences.

Something analogous to this successive and narrowing series of habit formations is to be found in each of the learning processes studied in our investigation, and this common principle is referred to in this paper as a habit hierarchy, suggested by the Bryan and Harter studies. In no instance was a complete learning achievement found to consist of a sequence of coördinate habit acquisitions. The first duty of the beginner at the Bogardus test was to acquire the gross arm movements; this mastered, his second task was to perfect the finer habits involved in picking up the cubes, placing them on the platform, catching them in his left hand. In the coördination test, he first learned to hold the tracers, to move them in their appropriate directions, and to do so with the metronome. He next discovered the trick of moving them simultaneously in the proper direction. The avoidance of contacts with the sides came early with some,

later with others. This seemed to constitute a separate problem.¹ Probably the best example of this principle is to be observed in learning to dance—an accomplishment unfortunately not included in our experimental program. It is quite obvious in this learning problem that gross movements are practiced first, and that the finer ones, leading to ease, smoothness, and grace, are incorporated later. Balancing, too, affords an excellent example of this same phenomenon. The principle, as a descriptive fact, is not new: one at least similar to it has received considerable emphasis, for instance, from Judd (7).

There is no doubt of the tendency for the learner to proceed in temporal order from the coarser adjustments to the finer. That the habit zones were not sharply differentiated and that they over-lapped with wide margins scarcely need be mentioned. And it is quite possible that a learner might be forced under controlled conditions to acquire the minute habits first and the more general later. He might, for instance, practice at picking up cubes before reacting to the Bogardus apparatus in motion. In the case of the subjects already adepts at dealing cards, the essential finer coördination called for in card sorting was perfected before they were introduced to that test. But as a learning problem is ordinarily faced, in the laboratory and in life itself, the gross adjustments necessarily come first.

It will be noticed that the transition from the gross to the fine may show two different aspects. In some situations, different sets of muscles are brought into function. Arm movements, as opposed to hand and finger movements, would be a case in point. In other situations, the same muscles are seemingly called into play, but with an increased premium upon such kinaesthetic discriminations as are manifested in greater accuracy, rapidity, and steadiness. If the Bogardus test illustrates the first aspect, the balancing tests furnish an example of the second. In the first, the gross movements are frequently retained as

¹ An investigation of the motor learning processes of children is now under way in the laboratory. While the results have not been studied to date, it has been demonstrated that young children succeed with this test only by mastering each step at a time, beginning with the gross habits and gradually acquiring the finer ones.

permanent and necessary acquisitions; in the second, they are eliminated. In spite of the apparent contrast, these aspects possess a common feature, to be referred to subsequently.

The similarity between habit hierarchies as just defined and the generalized maze path habit is possibly not to be accepted without question. We can scarcely say that the rat shows gross movements for the outlines of the complete true path, and more refined movements for its individual segments or for *cul-de-sacs*. The animal evidently reacts in one essential way only, by running or walking. The similarity is more clear in the case of the human, occupied with the pencil maze. In that situation, direct introspective evidence justifies the distinction between the more extensive arm movements, and the movements restricted by maze unit segments. Since no discernible difference existed between the reactions of the human in the pencil maze and maze through which he walked, we may infer similarity as regards habit functions in the two. The point in common between the habit systems of the maze and those of the motor tests is to be found in the fact that the smaller habits are associated with the larger, and organized into the general reaction program. One may develop the habit of pacing back and forth across a room, as well as the habit of walking; and one may acquire habits of extending the arms over a piano key-board, in addition to the habits of key manipulation with the fingers. Of course, the act of crossing the room presupposes walking, but this difference is incidental.

The generalized habit, with its associated specific habits, finds additional illustration in daily experience. The first impulse of an individual familiar with a Dodge car, when he is called upon to drive a car with the standard gear shift, is to carry over the old habit into the new situation. The readjustment once made, he finds time to acquire the minor habits involved in grasping the new lever with the proper amount of force, etc. Or, we may say that the motor responses to a book are fairly uniform and general, but that the habits elicited by a prayer book and a dictionary differ. This, of course, is not to be taken in too literal a fashion: it is not implied that book, prayer book, and dictionary reactions comprise three distinct

habits, or that the first is composed of the other two functioning conjointly. Habit hierarchies correspond to instinct groups; and psychologists no longer regard instincts as rigid entities, capable of formal classification.

If the learner responds to his problem by a narrowing series of habit adjustments, the conclusion is suggested that each step in the process not only prepares the way for, but actually arouses, the succeeding step. If we may express it in stronger terms, the learner is invited, at any stage of the process, to do the correct thing. At the risk of seemingly stressing the obvious, it may be pointed out that when he is seated before the Bogardus apparatus for the first time, he reacts to it in a manner generally correct. It does not elicit, for instance, swimming reactions. His initial movements are restricted by verbal directions and possibly by a demonstration, but they are also controlled by the visual stimuli, furnished by the apparatus itself. He is not literally led through the first movements in the way that the novice at dancing is lead through the steps, but he certainly is not required to choose a reaction from a series of suggested ones. As the result, then, of these combined stimuli, he learns to extend his arm to the supply box, where his fingers come in contact with the cubes. Here again, the most probable reaction is the one desired. The cubes are more likely to stimulate the grasping reaction than typewriting or piano reactions. The same statement may be made regarding his method of placing the cube, of catching it with his left hand, and of executing the other reactions called for. The consciousness involved is primarily perceptual, not in any sense unique or particularized.

In emphasizing this principle of the probably correct reaction, full allowance should be made for the fact that the first manner of meeting a situation calling for motor control, however spontaneous it may be, is frequently relatively inefficient, and at times apparently futile. The same, of course, holds for the first response at any stage of the learning. No one would claim that the efforts of one attempting to swim for the first time resemble the maneuvers of the expert swimmer. These efforts are indeed likely to result in drowning. Yet, within the scope of his repertoire of habits, the beginner at this problem comes more nearly

doing the correct than the incorrect thing; and if mal-adjustments were not so immediately serious, he would in time acquire the correct coördinations. The heroic method observed a generation back, by which a boy was thrown into the water and was forced to work out his own salvation, may be criticized as inefficient, but it cannot be condemned as essentially and psychologically false.

According to this interpretation it is not necessary to assume that reactions are discovered by a trial-and-error process, and that consciousness then selects the one most fitting. Rather, the habit 'discovered' is the one brought by the stimuli, and the one most likely to be needed. If this is true, the chances are favorable for its re-arousal and permanent selection. But it is evident that on many occasions one of a number of coördinate habits may be stimulated, as when an option is presented in the maze. In this case, it may stand an even chance of being the incorrect habit. But we should remember that "incorrect" is a relative term. The raccoon who learned to master the problem box by standing on his head merely failed to discover the most efficient method. Many of our subjects developed inefficient reactions in card sorting, such as standing too far away from the boxes or holding the deck too high. So the false habit, unless specifically inhibited, becomes part of the final system.

The process of actual elimination, therefore, is shown only when an adjustment clearly proves itself to be a detriment to learning. It is possible that consciousness, while it neither necessarily discovers nor selects, may yet function by censoring habits which have crept into the reaction system. But again we find no logical necessity for this supposition. The phenomenon of elimination is clearly one of inhibition when it is not (as in Watson's example of the maze) a matter of unfavorable chances. Here we may distinguish between special inhibitions for specific reactions and a general inhibition due to failure of the gross reactions. For the first, we have the buzzer warnings of contacts in the coördination test, visual promptings of failures in the Bogardus and card sorting tests, pain stimuli where the animal receives an electric shock in the event of a false maze

turn. As an example of the second type, of general inhibition, may be mentioned the individual who sinks at his first attempts at swimming, or the subject who steps off the board altogether in the balancing test. In the latter case, it is evident that the individual cannot react favorably at all to the problem situation. He is forced, therefore, to make a new attempt. If the new attempt is a reproduction of the old—and it frequently is—failure again results. The beginner must then either continue in his fruitless endeavors, or attack the problem with a different set of gross reactions. When special warnings of failures are given, the same readjusting process may be observed. The tendency, in this type of difficulty, is again for the learner to substitute a different higher-order adjustment. Thus, minor difficulties in the Bogardus test prompted the subject to change his position in the chair, and warnings of contacts in the coördination test led him to grasp his stylus in a different manner. The result of any inhibition, then, is apparently a change in the method of attack most closely associated with the difficulty. It is similar to the method of an individual who, unable to find an index card in a set, proceeds to go back a considerable distance and revise his general method of search.

With the human subject, the inhibition undoubtedly results in the "felt difficulty," and in an attempt, at times, to analyze this difficulty. This analysis is essentially an act of reasoning. But two important facts should be kept in mind. In the first place, the reasoning process may be unsuccessful, although the learner may finally make progress in spite of this fact. So far as the laboratory tests referred to in this article, including the maze test, are concerned, we are justified in saying that reasoning reactions were on the whole thoroughly unsuccessful. They did not offer a solution of maze difficulties, and they did not furnish effective ideational controls for balancing, aiming, and moving the arms correctly in the coördination test. The learners had no data upon which they could reason; they were merely aware of failures. It may be said, in this connection, that while reasoning is not necessarily exclusively a verbal process, it does function primarily in those situations which permit verbal description. If the interpretation of the observer may be

trusted, the subject who experiences difficulty in these tests characteristically reacts with a series of fairly random verbal responses which express emotional states, volitional resolutions, and to a limited extent only, analytical processes.

In the second place, since idea and act are so closely associated, the view is again suggested that the idea itself is essentially motor in nature. It is certain that the same situation, or the same stimulus, which elicits the idea may also elicit the act. According to this view, the idea is either (1) the incipient act, or (2) the act translated into articulatory processes. In either case it is an implicit motor reaction habit, functioning as a stimulus for a more overt act. Whether or not the idea contains imaginal factors other than motor is a question not answered by our evidence. But the motor element seems to predominate in the thinking processes of the individual engaged with motor tests.

A detailed application of the principles which have been emphasized to each of our learning processes could not be made without additional experimentation. The systematic recording of all observable movements made by a group of subjects would necessarily constitute part of the desired data. But so far as our laboratory observations go, the principles do seem to hold. For purposes of rough observation, a group of five subjects were given a set of mechanical puzzles and directed to solve them. The first reaction to a puzzle was to grasp it and to pick it up. This led to a number of separate manipulations which included pressing, twisting, pulling, and bending the movable parts. A majority of these habits of manipulation were clearly aroused by the specific tactual and kinaesthetic stimuli furnished by the position of the hand and of the puzzle, and by the immediate antecedent habits. The inhibitions observed were in the main physical—the subjects ceased in their attempts to move parts which would not move. The correct responses were inevitable, rather than accidental, since these inhibitions tended to narrow the groups of responses. Again, in learning to walk and to balance the body on the edge of a board—possibly the most difficult learning process for any theory to explain—it was evident that the first efforts at equilibrium, involving extensive

arm and body movements, were followed by more refined responses. A wild sweep of the arms would be replaced by a slight movement of the forearm, as inhibitions due to falling and to over-compensations developed. There was no evidence of a conscious plan to substitute finer movements for coarse, or to replace a long sweep of the arms by a more restricted one. The substitutions came "naturally." In these two examples, conscious directing, if present at all, was responsible for the gross movements involved, not the fine; but the gross movements were just the ones most easily performed, since they were the ones already established. Learning consciousness, in all cases, was correlated with drive, not mechanism.

The above considerations are offered, in part, because of the writer's conviction that an unfortunate contrast is too frequently made between habit acquisition and instinct. The one is regarded as something inexplicable, the other is disposed of in summary fashion as "innate." Yet in any concrete manifestation of either we may observe an organism bringing to bear upon its problem an organization of fairly crude reactions, out of which more refined adjustments are finally evolved. In either case, the most generally correct reaction is the one first aroused, and as the result of repetitions of the problem-stimuli, the final adjustment becomes elaborated. And in either case, intelligent and conscious analysis of the adjusting process is made possible by the development of the process itself.

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