Spring 1945

A study on the relation of motivation and rewards to learning in the white rat

Jorge G. Millas
University of Iowa

A STUDY ON THE RELATION OF MOTIVATION AND REWARDS TO LEARNING IN THE WHITE RAT

by

Jorge Millas

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Arts, in the Department of Psychology, in the Graduate College of the State University of Iowa

~~January~~ April, 1945

ACKNOWLEDGMENTS

The candidate feels deeply grateful to Dr. Kenneth W. Spence, Head of the Department of Psychology of the State University of Iowa, for the help in the planning and conduction of the experiment and in the preparation of this manuscript.

CONTENTS

FIGURES

Chapter I

THEORETICAL AND HISTORICAL BACKGROUND

Since Thorndike's first formulation of the Law of Effect in 1913, a great amount of experimentation and theoretical discussion has been carried on about the dependence of learning upon motivation. The problem is not merely incidental, but rather a fundamental one whose solution affects the basic conception of the learning process.

The original statement of the Law of Effect read: "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." (23) This formulation involved three principles: a) that learning is a process of "connecting" situations and responses; b) that the strength of these assumed connections depends, other things being constant, upon the after effects of the response; c) that these after effects act differently, according to their nature: if "annoyers", they weaken the corresponding connections; if "satisfiers", they strengthen them.

It is to be noticed that such concepts as "connection", "annoyers" and "satisfiers" are definitely neurological, and therefore they have to be understood in

the light of a particular physiological conception of learning. Thus, discussing the physiology of learning, Thorndike said in 1913 (23): "The connections formed between situation and response are represented by connections formed between neurones and neurones whereby the disturbance, or neural current, arising in the former is conducted to the latter across their synapses. The strength or weakness of a connection means the greater or less likelihood that the same current will be conducted from the former to the latter rather than to some other place."

Many of the original implications and assumptions of the Law of Effect were maintained in Thorndike's latter formulation in 1932. But he realized that "its suggestion that the action of annoyers is the opposite of that of satisfiers in all respects is misleading" (24). Accordingly in the new formulation specific distinction is made as to the way in which learning is affected by satisfying or annoying after effects. A satisfying state of affairs can be relied on to strengthen the stimulus response connection. But an annoying after effect under the same conditions does not consistently weaken the connection in any way equivalent to the strengthening effect of a satisfying after effect. Its action is rather indirect, and depends upon what it leads the organism to do in response to the annoying situation.

The most recent and elaborated formulation of the Law of Effect is Hull's principle of reinforcement, which

reads: "Whenever an effector activity occurs in temporal continuity with the afferent impulse, or the perseverative trace of such an impulse, resulting from the impact of a stimulus energy upon a receptor, and this conjuction is closely associated in time with the diminuation in the receptor discharge characteristic of a need, there will result an increment to the tendency for that stimulus on subsequent occasions to evoke that reaction." (9)

This Principle is in essential agreement with Thorndike's recent formulation, even though they differ in many important aspects, which concern more the elaboration and scientific use of the principle than with the principle itself. Their common postulate is that learning is a process of strengthening of connections between stimulus and response (S-R connections), and that this strengthening is a function of the satisfying state of affairs or need reduction which follows the elicitation of a response.

The attacks against this Principle of Reinforcement or Law of Effect have involved both an experimental and a theoretical issue, which closely follow one another. The experimental aspect of the problem has been promoted by the experiments on latent learning, started by Szymanski, Simmons (18) and Lashley (12) in 1918 and 1919. But the first elaborated discussion and the coining of the problem came from Blodgett in 1929 (1).

Szymanski (6) ran three rats through a maze whose correct path led to the home cage in which food was provided. No reduction in time or blind alley entrances was shown in a preliminary period covering 61 trials, during which the animals were not hungry. When in a second period the rats were run under hunger motivation, they learned so soon that they could run the maze without error in one or two trials. (6)

Blodgett (1) conducted a similar experiment, designed to study the efficiency of practice when unaccompanied by reward. Two experimental groups of hungry rats run through a six choice point maze without food reward for periods of 3 and 7 days respectively; a control group was also run, but was fed in the box at the end of each run. On the third and the seventh day respectively, food was given in the maze to the two experimental groups. Significant drops appeared in the learning curves on the day following this first reward, and on the second day after reward the curves had dropped almost to the level of the curve for the control group. Blodgett concludes that the marked improvement in performance following the introduction of reward is a fact which indicates that "during the non-reward periods, the rats were developing a <u>latent</u> learning of the maze which they were able to utilize as soon as reward was introduced".

The theoretical issue, which closely follows the

interpretation of these and other latent learning experiments, is the distinction made for the first time by Lashley (11) and Elliot (5) between learning and performance, or learning and knowledge, or acquisition and utilization of habits. Thus Elliot suggests that efficient maze performance is determined at least by three primary variables, "knowledge", "reward", and "drive", and that knowledge may be acquired independently of the reward conditions.

Similarly Lashley states that the drive is one of the associated elements in the maze habit rather than the agent responsible for the association, and that the different forms of the Law of Effect confuse learning and performance. This distinction has also been made by Leeper who has clearly emphasized that "motivation can exercise a directive function in relation to habit utilization and that, for acquisition of learning proper, motivational satisfaction is not as important as is commonly believed". (13)

Closely related to the findings of latent learning experiments and to the distinction between the acquisition of habits and their use, is Tolman's conception of the learning process, which opposes Hull's and Thorndike's views in many aspects, particularly in the interpretation of the role of motivation and reward. Learning, according to his conception, is the acquisition on the part of the animal, of sets of "expectations" that in the presence of definite stimulus patterns, such and such a behavior will lead to such and such a

subsequent environmental event. These "expectations" are cognitive determinants aroused by actually presented stimuli (20) and refer to a "sign", a "significate" and a "behavior-route" leading from sign to significate (22). Learning, therefore, is not a direct association between stimulus and response, but rather the making or remaking of imminent, intervening cognitive structures between stimulus and response, which set the animal to "expect" that when he behaves, a particular and actually present field-feature (sign) will lead by means of a definite behavior ("behavior-route" or "means-end-relations") to a demanded field-feature ("significate"). These elements make up a complex whole, that is, they do not exist independent of each other; rather, they are reciprocal functions. A "sign" is a <u>sign</u> when and only when it is related to a <u>significate</u> by means of a <u>behavior-route</u>. This is one of the theoretical aspects which put Tolman's doctrine in the line of Gestalt conceptions, and which also led him to state that an "expectation probably always actually occurs as the expectation of a total sign-Gestalt" (20), and that learning is "the new formation or the reformation of "sign-Gestalts" within the larger psychobiological fields" (22). Thus, conditioning is an acquired expectation-set on the part of the animal that the feature of the field corresponding to the conditioned stimulus (sign) will lead, if the animal but waits (behavior-route), to the feature of the field corresponding to the unconditioned stim-

ulus (significate). Similarly, trial and error learning consists in the acquisition of expectations with respect to "what" each of the initially alternative responses "leads to".

Tolman has not yet however, formulated any clear-cut relationships with respect to the experimental variables determining the actual acquisition of sign-Gestalt-expectations. In many elaborate discussions he does point to some of the factors, such as exercise, belongingness, symbolic capacities, and the like which would determine such acquisitions, but his statements are, as yet, primarily on a programatic level.

In the light of the latent learning experiments and the Lashley-Elliot distinction between acquisition and utilization of learning, Tolman has been led to reject the law of effect as a fundamental principle governing the formation of sign-Gestalt expectations. His criticism involves not only the influence of positive (and negative) after effects in the learning process, but also the complementary conceptions of learning as a process of association between stimulus and response. (21) He writes, for instance: "Stimuli do not, as such, call out responses willy nilly. Correct stimulus response connections do not get "stamped in", and incorrect ones do not get "stamped out". Rather learning consists in the organisms' "discovering" or "refining" what all the respective alternative responses lead to. And then, if, under

the appetite-aversion conditions of the moment, the consequences of one of these alternatives is more demanded than the others - or if it be "demanded for" and the others "demanded against" - then the organism will tend, after such learning, to select and to perform the response leading to the more "demanded for" consequences. But, if there be no such difference in demands there will be no such selection and performance of the one response, even though there has been learning". (20 - P. 344)

However, Tolman has not always been so emphatic in his views regarding motivation and need reduction as conditions of learning and he has sometimes admitted that the Law of Effect may be valid to a slight degree (20 - P. 344 and P. 364; 22 - P. 399). It is interesting to note that Tolman recognizes a particular function of motivation, which is not duly emphasized in many discussions of his theories. The reorganization of the sign-Gestalt-expectation set, of which learning consists, comes, according to one of his writings (22 - P. 389) "from the impetus of a need or needs, together with some obstruction to any immediate, already-acquired, easy route to the satisfaction of such need or needs". In other words, the animal has to be under stress, has to be motivated, even though a primary or secondary satisfaction is not required for the actual learning. (See Appendix I, 1) Since Blodgett's study a number of experiments dealing with the latent learning problem have been conducted. We will

briefly review some of them before we summarize the main criticisms which have been made by the reinforcement theorists.

Elliot (4) investigated the effect of changing to a new reward after rats had been trained to run a maze for another quality of reward. Using a fourteen choice point maze, he found that a significant difference in performance resulted from the change of reward. Although his experiment is not directly related to the latent learning type of investigation, it is relevant here, since, in Elliot's opinion, his results, as Blodgett's, "indicate that performance in the maze may not exactly mirror the course of actual learning" and that "a poor performance may be due to the strangeness or undesirability of the reward as well as to lack of learning" (4 - P. 29).

Tolman and Honzik (19) in an experiment designed to study the relative effects of reward and drive on maze performance in rats, found results similar to those of Blodgett. Two groups of rats were compared as to their learning curves; one control group of hungry rats was consistently rewarded at the end of each run throughout the experiment, and an experimental group of equally hungry rats was not rewarded in the end boxes (they received their food three hours later in their living cages) from the first to the tenth day inclusive. This latter group, when reward was introduced in the eleventh day, showed a quick drop in the error curve and what seemed to the experimenters even more suggestive, by the thirteenth

day the curve had been brought considerably below the rewarded group curve.

Haney (6) tested the effect that familiarity (and, as a matter of fact most of latent learning experimental techniques involve directly or indirectly this problem of familiarity), defined in terms of previous living in and running about a maze in a random fashion, would have on maze performance of rats after the introduction of reward. He found, as did Lashley, in a similar investigation (12), clear cut differences between the error curves of the two experimental groups, and the corresponding curves of two control groups which were not familiar with the maze prior to learning it. The critical ratio of these error differences for the combined experimental and control groups was found to be 8.8.

Daub (3) in a study designed to test the effect of allowing the free retracing of the correct paths in the rewarded running of the maze, repeated Haney's experiment, with similar results, even though no statistical significance of the difference is reported.

In a recent report, Herb (7) has communicated a slight variation in the technique of latent learning experiments. He tested the assumption that "if it be true that during the non-reward period the animals are learning a whole array of sets as to "what-leads-to-what", then the animals should, during this period, be acquiring sets not only as to

the true path segments but also as to the blinds". Using a 14 unit T maze, he ran a control and an experimental group under the following conditions. The control group found food at the end of each blind from the first day on. The experimental group for the first 10 days received no food in the maze, but on the eleventh day and thereafter they found food in the end of each blind. His results showed that the experimental group soon began to eliminate the blind entrances, whereas the control group averaged more and more errors. When, however, food was introduced into the blinds, for the experimental group, their blind entrances on the first days increased in significant amounts, until on the third day they reached the level of the control group.

Finally, we must refer here to a much more elaborate discussion and careful experimental treatment of the problem, which has been recently undertaken by Buxton (2) in a study of the relationships between latent learning phenomena and the speed of locomotion gradient together with the backward order of difficulty of blinds. Repeating Haney's experiment, with the introduction of some specific corrections and experimental controls, he duplicated his results, finding not only reliable evidence of latent learning, but also a speed of locomotion gradient and a backward order of difficulty of blinds when there has been no differential reinforcement. (See Appendix I, 2)

Difficulties in the interpretation of the results

of these studies have been raised by the reinforcement psychologists (16,17). They point out that the type of learning involved in these experiments is an extremely complex affair and they insist that the studies require careful scrutiny before conclusions such as have been drawn from them regarding "latent learning" are accepted.

With regard to studies such as Blodgett's and Tolman's and Honzik's, in which a preliminary series of standard trials is given daily in the maze except that no food is present, Spence (17) has pointed out the possibility that another entirely different factor from that which Tolman assumes, may be responsible for the drop in the performance curves. He has called attention to the fact that in Blodgett's experiment four of the six true paths pointed in the direction of the goal box, while none of the incorrect paths pointed toward the goal box. Similarly in the maze used by Tolman and Honzik nine of 14 true paths pointed in the direction of the goal. These structural details are important in view of the fact that it is entirely conceivable that some tendency toward goal orientation could be set up as the result of the single reinforcement. In this event the reduction in errors that occurs is exactly what should be expected. Spence points out further, that the assumption of the establishment of goal orientation with a single reinforcement is just as plausible as Tolman's assumption that the animal learned in a single trial to associate the end-box with food and was able, further, to combine this

new sign-Gestalt-expectation with others in such a manner as to lead to the appropriate performance.

Still another factor that operates to exaggerate the drop in the curve of learning in these studies is the cessation, after once finding food in the end box, of repetitive errors, i. e., going into the blind a second time. In the case of the Tolman and Honzik study, the drop in the performance curve with the introduction of food is very sharply reduced if repetitive errors are not included. The dropping out of such errors would probably represent a difference in the motivational set of the subjects in running the maze prior to and after discovery of food.

The chief criticism offered of the type of latent learning study which compares the learning of subjects which have had a previous period of exploration in the maze with subjects that are unfamiliar with it, is that one has little knowledge and hence no control over the motivations operating in the preliminary experiences in the maze.

Spence writes (17), "Presumably, all manner of needs and their satisfactions occur during this period. The animals explore, exercise, lose their fears, etc.; and, as the result of these activities they show a quite different distribution of errors when run through the maze later than do animals that have had no such previous experiences with it. They do, indeed, learn something in this period, and it would be presumptious to say that motivation and reinforcement were

not factors in this learning." (See Appendix I, 3)

Spence (17) goes on to point out the fact that the experimental group starts the learning emotionally adjusted to the maze, giving it a great advantage. Likewise satisfactions of the needs for exercise and exploration during the preliminary period in the maze could result in a lessening of the response tendencies to enter the blind alleys. In support of this latter interpretation he calls attention to the fact that Buxton's control group that had previous experience in the maze performed much better on the test trial than one which had no such experience and almost as well as the experimental group which had previous experience in the maze and had also received food in the goal box just prior to the first test trial. Additional evidence that some such learning occurs prior to the introduction of food is shown by the steady, consistent drops in the learning curves of Tolman and Honzik's non-rewarded group prior to the day on which it was introduced. The curve of errors for Blodgett's seven-day group likewise shows a slight but consistent drop during this period. Haney and Buxton have called attention to still another possible rewarding factor in these studies; namely, the removal of the animal at the end of each run to the home cage.

More recently a series of experiments concerned with this problem of the roles of motivation and reward has been carried on in the University of Iowa laboratory. Because of

the difficulties of interpreting the results of the studies employing the complex type of maze, and also, because the studies were designed to test Tolman's theory of simple trial and error learning, a much simpler, single-choice point maze involving the selection of two alternative paths was employed.

In the first experiment, all subjects were thirsty, but satiated for food. The right alley of the maze always led to water; the left, for half of the subjects, led to an empty box (zero group) and to food for the other half (food group). A training period of 12 days was given with five runs per day, two of which were free and three of which were forced. One of the forced runs was to water and two to food or empty boxes. On the thirteenth day, after the rats had learned the location of the water, the motivation was changed from thirst to hunger, all 20 animals continued to choose the water alley, against what might have been expected by the Tolman-Leeper "what-leads-to-what" principle. When a comparison was made in subsequent days of the error curves of the food group and the zero group in the learning of the location of food while running under the hunger drive, the result came out once more against the latent learning assumption. For, in the light of that assumption quicker learning might have been expected on the part of the food group, which had opportunity to experience the location of the food in the first part of the experiment. Actually the zero group made slightly fewer errors than the food group.

In a second experiment of the same study, results somewhat more favorable to the latent learning interpretation were found. In order to rule out the possibility of associating "need satisfaction" with one of the alleys, as could have happened in the first experiment, all subjects were satiated for both food and water during the training. They received four trials (two free and two forced) daily for seven days. Two tests were then given, one per day on two successive days; on the second test the motivation was the reverse of that on the first. A marked shift in the curve of percentage of choices to the side which contained the needed goal object was found on the first test day. This side was chosen 35.9% of the time on the last day of training and 61.5% on the first test day. The difference of 25.6% was 2.38 times its standard error. When the motivation was shifted on the second test day the curve of right choices also shifted. This time the needed goal object was chosen 69.2% of the time, thus responding only 30.8% of the time to the side they had chosen 61.5% on the previous day.

In the light of their experimental findings, Spence and Lippitt conclude that while "there was some evidence of latent learning in a situation which did not involve during the training motivation for either of the differentially located significates, the results suggest that motivational factors, drive and goal attainment, play a much more important role in the process of learning or acquisition than the sign-

Gestalt theory . . . has tended to ascribe to them." (16)

In a further series of studies conducted at the University of Iowa, Kendler (10) confirmed and extended the findings of the Spence-Lippitt experiments. His first two experiments more or less duplicated the two earlier ones except that an attempt was made to increase the differentiation of the stimulus cues provided by the two alternative paths by painting one of them black and leaving the other unpainted. The results of the first experiment were identical with the results of the first Spence-Lippitt experiment. All subjects, whether motivated for food or water, chose the same alley in the test trials that they had taken in the original training and did not shift to the opposite alley with the shift in motivation.

The results of the second study, in which the subjects were satiated for both food and water during the original training, were also similar to those for the comparable Spence-Lippitt experiment. Thus the subjects of this study chose the path which led to the goal object for which they were motivated on the first test trial 58.3% of the time, as compared with only 37.5% choice of this alley on the last day of original training. The increase (20.8%) in this instance, however, was only 1.62 times its standard error and thus gives somewhat less support to the Tolman-Leeper view than the earlier experiment in which the critical ratio was 2.38.

In a third experiment subjects that had been satiated in the original training and had seen food and a water bottle in one or other of the goal boxes, were compared with respect to their subsequent learning of the problem of responding appropriately in the maze to the food or water alleys when hungry or thirsty with a group of subjects which were trained originally under similar motivational conditions (satiation) but which had not seen either food or a water bottle in the end boxes of the maze.

In support of the Tolman-Leeper interpretation, the group of subjects which had seen the goal objects during the original training demonstrated quicker learning of the problem. The difference between their mean number of trials provided a t of 2.11, which is significant at the 5% level of confidence.

Finally, a fourth experiment demonstrated that subjects which were both hungry and thirsty and found food in one side of the maze and water in the other, were able to respond in a test series a significant number of times to the appropriate side when motivated for only one of the goal objects. While this result is interpretable in terms of Tolman's concepts, the difference in the test series between the data for this group and the group of subjects which were satiated during the original training (Experiment III) does not lend support to the notion that the change occurring in learning, whether conceived in terms of acquisition of sign-

Gestalt-expectations or stimulus-response associations, is independent of motivational satisfaction. Kendler found that the group motivated for the two goal objects during original training made a significantly smaller number of errors on the four test trials. The difference was significant beyond the two percent level of confidence.

Chapter II

STATEMENT OF PRESENT PROBLEMS

The present investigation represents a continuation of the series of studies carried on in the University of Iowa laboratory concerned with the motivational and reward conditions underlying learning in the simple T maze. It provides, furthermore, another test of the theory of learning proposed by Tolman that this process involves the acquisition of cognitions concerning sign-significate sequences of "what-leads-to-what".

The specific experimental question was as follows: Will thirst motivated white rats run in a simple T maze, one path of which leads to food and water and the other only to water, learn that one of the paths leads to food, and be able subsequently to make use of this cognition so as to respond appropriately when motivated for food? A positive finding would lend support to the Tolman conception of the development of sign-significate cognitions whereas negative results would signify the necessity for rejecting this interpretation or, at least, some modification of its present formulation.

Chapter III

EXPERIMENTAL PROCEDURE

A. Apparatus and Subjects

The floor plan and dimensions of the apparatus are shown in Figure I. It consisted of a single choice T maze, constructed of pine board, painted black and covered with a wire screen. Five vertically sliding doors, controlled by means of strings from behind a wire screen located at the starting end of the maze were provided, as shown in the floor plan. Each of the goal boxes contained panels into which the drinking tubes of water bottles could be inserted. In order to facilitate discrimination of the respective signs for each alley, small pieces of wire screen, six inches long and differing markedly in the size of their mesh were placed at the entrance of each alley.

Electric lights placed over the choice point and each of the goal boxes provided illumination. The experimenter watched the movements of the rats within the maze from his observation stand by means of three mirrors.

The subjects were 24 rats - albinos, and provided from the colony of the University of Iowa Psychology Department. All were males, and their ages ranged from four to five months at the beginning of the experiment.

B. Experimental Method

The experiment covered an 18-day period, which was

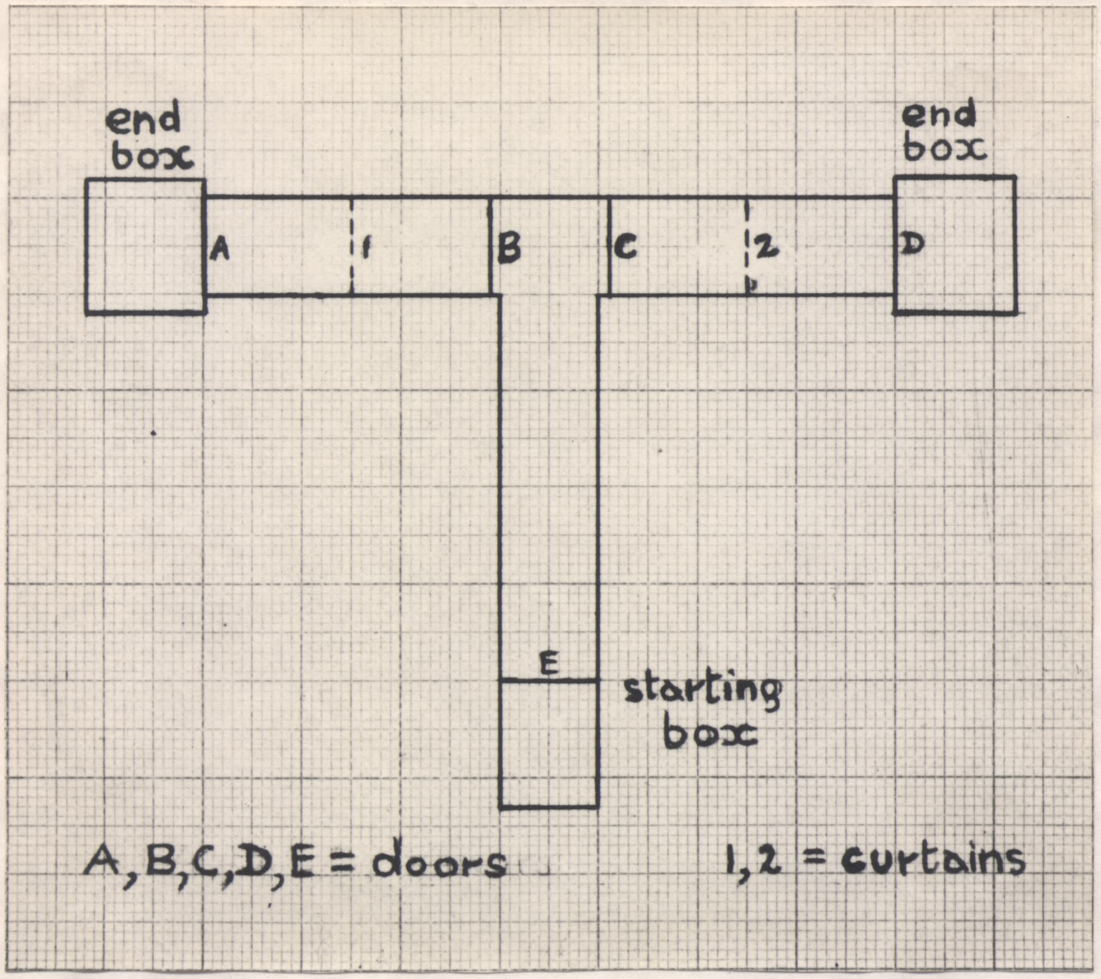

FIGURE I . Floor Plan of the Apparatus

divided into a preliminary training period of two days, a training series of twelve days, and a test period of four days.

a) Preliminary Training. All twenty-four subjects were handled about 3 to 5 minutes for several days prior to the beginning of the experiment. Adjustment to the apparatus and testing for position preferences were accomplished in the preliminary training period. During this period all doors in the maze were raised and the animal was given two runs each day. As a general rule, the subject was not removed from the maze until after it had made a complete exploration of both goal boxes. Only 4 out of 24 animals did not perform 4 complete explorations through the preliminary training period, but they were retained in the maze for half an hour.

b) Training Series. The training period lasted for 12 days during which four trials were given each day. All 24 subjects were thirsty, but satiated for food, during this period. The thirst drive was produced by placing water in the living cages after the daily runs and removing it about fifteen minutes later when the animals had stopped drinking. The animals were thus without water for a period of approximately 23 hours. Food was always available in the living cages.

A water bottle was present in both the left and right goal boxes. Food, on the other hand, was present in only one of the goal boxes, and its position, either left or

right, depended upon the behavior of the animal in the preliminary training. Those subjects which had run to the same side on three successive trials, were assumed to have a preference for that side, and thereafter, found food in the goal box opposite to this preferred side. Eight animals showed such a preference during the preliminary training. All remaining subjects (16) found food in the left goal box. Five of these latter subjects showed no preference for either side during the preliminary training period. Ten out of the remaining eleven exhibited an initial preference (3 out of 4) to the right alley.

The food consisted of dog biscuits which the subjects were accustomed to receive in their living cages. A number of biscuits were spread over the floor of the goal box. At the end of a run the animals were allowed to drink for about ten seconds in either goal box. They were then removed to the cage in which they were kept while in the experimental room, where they remained until their next trial.

After the last run of the training series water was introduced into the living cages and food was removed after a period of one hour. On the following four days all 24 subjects were given one test trial under this condition of hunger drive and thirst satiation. During these test trials the subjects, with the exception of three, found neither food nor water in the goal boxes. Through an error three of the subjects found food in the end box on the first of the test

trials. Although none of them ate the food, the possibility that the sight of food might have served as a secondary reinforcement led to their results being omitted from the data involving trials beyond the first test day.

Chapter IV

RESULTS AND DISCUSSION

The behavior of the subjects with respect to their choices of the two alleys in the training period are shown in Figure 2, which shows the percent of choices on the first free trials of the alley leading to food. Despite the fact that food was always placed on the side opposite to any position preference exhibited during the preliminary training the 24 subjects exhibited little preference in their choice of the two alleys on the first trial of the first two training days. Thus they chose the alley leading to the goal box containing food 46% and 50% of the time on these two days as compared with 29% and 37% choice of the same alley on the two preliminary training days. (See Table I in the Appendix) By the third day of training, however, a definite preference had begun to develop for the alley <u>opposite</u> to that leading to the goal box with food, and after the fourth day this preference was maintained at a fairly constant level. On the last day of training all but 2 (8.3%) of the 24 subjects took the non-food alley on the first free trial of the day.

From the point of view of the main purpose of the experiment, the development of this preference for the non-food alley was unfortunate, for the reason that it makes difficult the interpretation of a shift in the choice of the two alleys under the test condition. Thus, while a statistically

significant increase from a low percentage of choices of the food alley (e. g., 10% to 50%) could be taken as evidence in support of the Tolman notion that the subjects did learn during training that the food alley led to the significate, food, when not specifically motivated and rewarded by it, this same experimental result could be interpreted as indicating the breakdown of a differential preference built up during training while under thirst drive, which tended to break down when the drive condition was altered. In other words, only a definite preference on the test series for the food alleys could be interpreted as offering unequivocal support for the Tolman conception.

The results of the test trial run on the first test day did show an increase in the percentage of choices of the food alley. As may be seen from Figure 2, eight, or 33.3% of the subjects chose the food alley on this trial. This increase of 25% from 8.33% choice on the first trial of the last training day is, moreover, a significant one, the t ratio of 2.2 being at the two to five percent level of confidence.

The results for the four test days are presented in Figure 3. The curve represents the percentage of choices of the food alley made only by the 21 subjects that did not find food present on any of the test trials. That the shift towards chance behavior during this period was significant is shown by a t ratio of 4.54 (.01% level of confidence) obtained

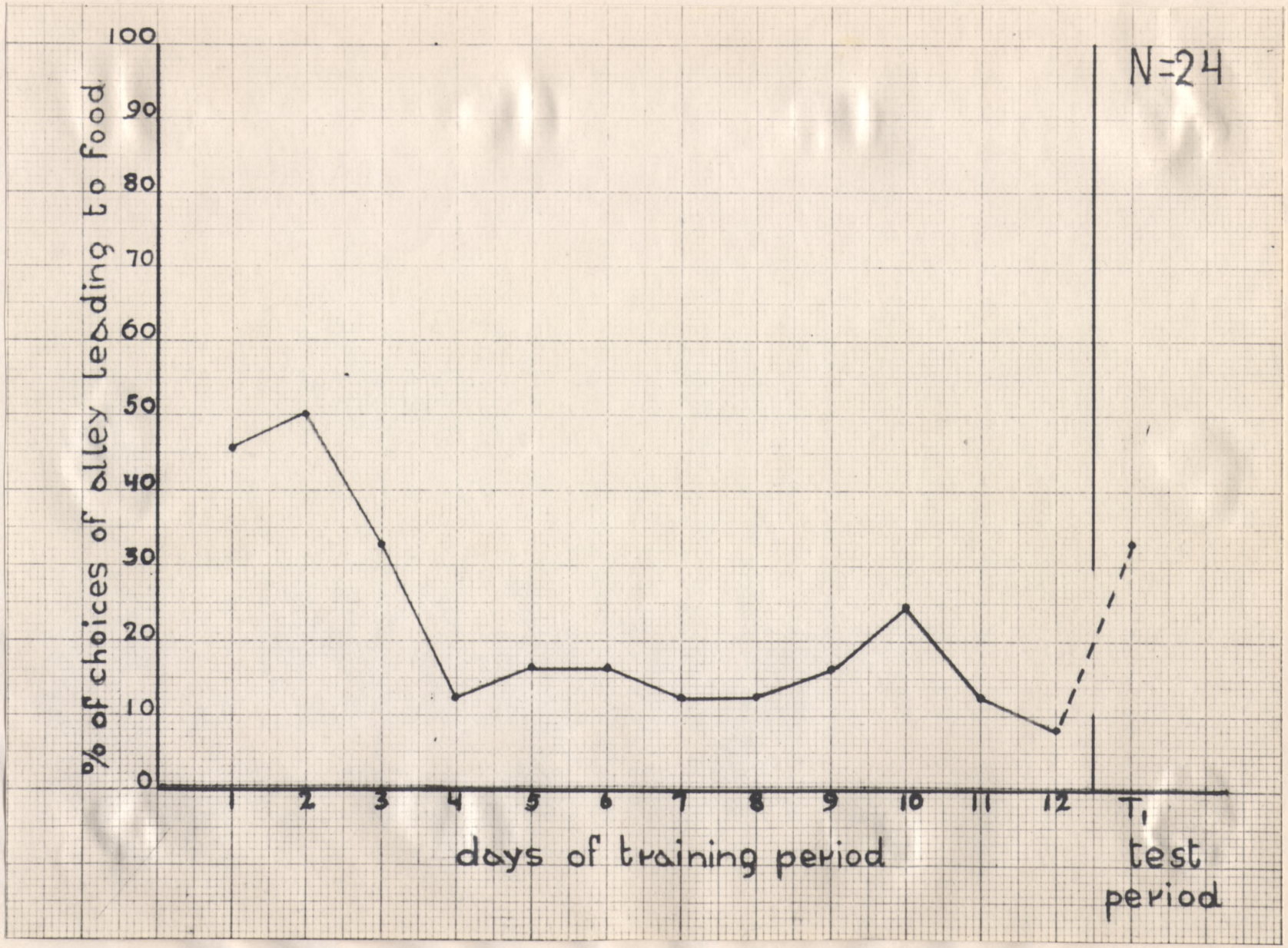

FIGURE II. Percent of choices on the first free training trials of the alley leading to food as compared to the choice of same alley on the first test day.

for the difference between the average number of responses to the food alley on the first trial of the last four days of training and the same measure for the four test days. Motivated as these subjects were for food, the test trials may perhaps be regarded as involving failure of reinforcement. Looked at from this point of view the curve may be thought of as representing extinction of the preference which, for some reason, was established in the training series.

It is interesting to speculate as to the basis underlying the development of the systematic preference exhibited during the training series. A possible explanation is to be found in the different procedures followed in the two goal boxes after the subjects had drunk water for ten seconds. In the case of the box containing food the water bottle was withdrawn and the subjects were given another ten seconds in the box to insure perception of the food. In the non-food box, however, the subjects were lifted out of the box at the end of the ten-second period. If we assume that the removal of the water results in some frustration it will be seen that the box containing food would become associated with this frustration reaction, whereas the non-food box would not as the subject does not continue in it while frustrated.

The disappearance of the preference during the test trials lends some support to this interpretation for with the removal of the thirst drive and the cessation of the differential treatment and reward in the goal boxes the preference

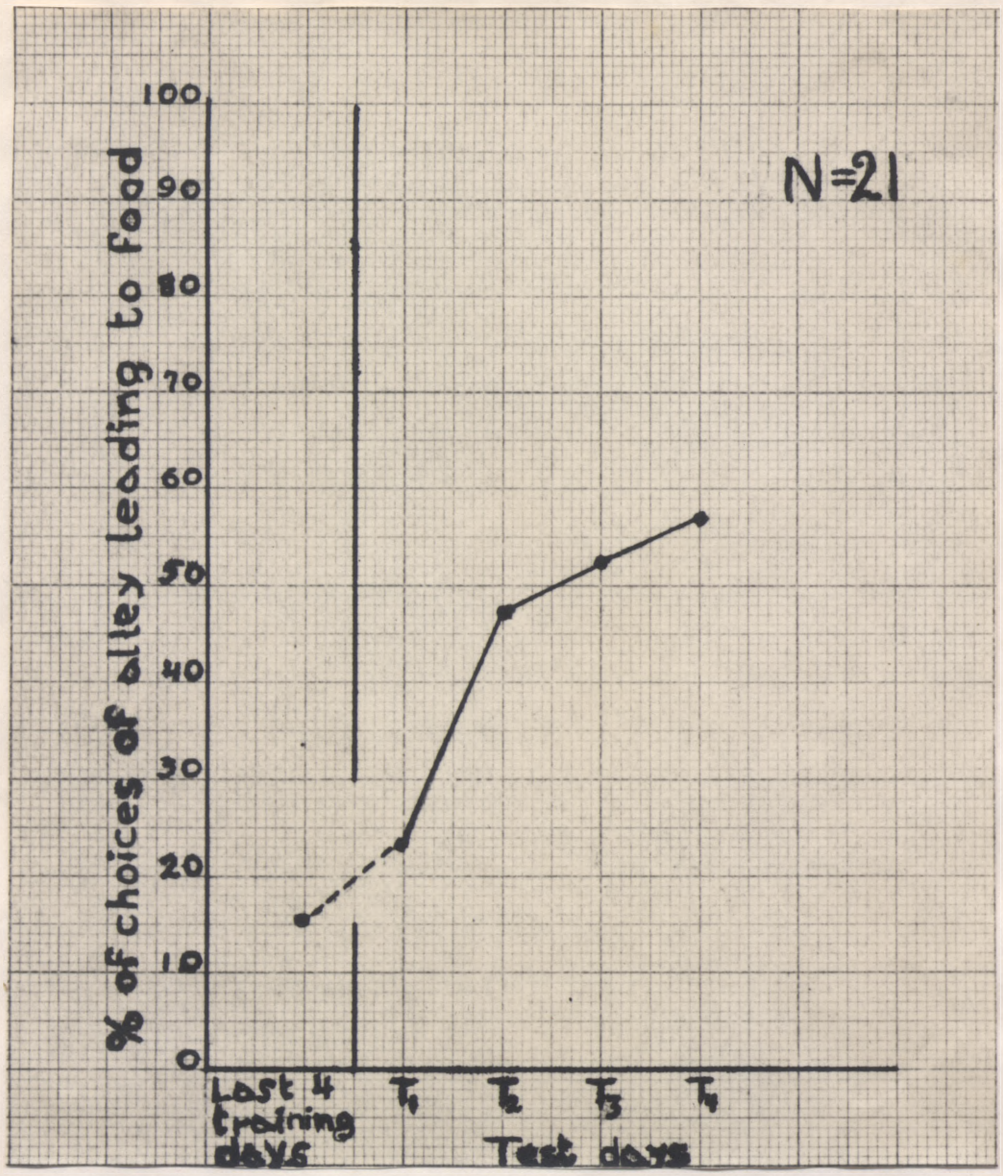

FIGURE III. Percent of choices on the four test days of the alley leading to food as compared to the average choice on the last four training days.

should tend to disappear and the choice of the two alleys should approach chance (50%). On the other hand, the fact that the curve was still rising at the end of the fourth trial is somewhat embarrassing to this interpretation. It is unfortunate that another day or two of testing was not given. A continuation of the upward trend of the curve in the face of no reinforcement would have had considerable significance.

From the viewpoint of the Tolman theory the results are not very encouraging. They carry, at least, the implication that if sign-Gestalt expectations with respect to significates for which the organism is not at the moment motivated are established, they are acquired much more slowly than in the case the significate is relevant to the immediate needs. Another possibility is that these particular types of sign-Gestalt expectations are not very effective when the motivational conditions are altered.

Chapter V

SUMMARY AND CONCLUSIONS

In an attempt to provide further experimental data on the relation of motivation and rewards to learning, 24 thirst-motivated white rats were given two free and two forced trials per day in a simple T maze, one path of which led to food and water and the other to water only for twelve days. In a subsequent test series involving one free trial per day for four days the subjects were motivated for food. The main experimental concern was whether the subjects would respond in the test series by choosing the alley leading to food. Tolman's theoretical conception of the interrelation of learning and motivation led to the implication that this experimental result would occur.

The data of the learning period and test period, expressed in terms of the percentage of first trial choices of the food-alley, showed that the subjects developed a strong systematic preference for the non-food alley during the training period. With the changed motivational condition of the first test day the subjects chose the food alley a significantly (2% to 5% level of confidence) greater number of times than on the last training day but still considerably short of 50%. During the four test trials the choice of the food alley rose steadily to a value slightly above chance (57%).

The results (particularly the shift in choice of food alley in the test trials) are shown to be interpretable in terms of experimental extinction of a systematic preference set up during the training period. They suggest that if Tolman's theory is to be employed it will have to be modified (or developed) considerably in respect to the rate with which various types of sign-Gestalt-expectation are acquired.

BIBLIOGRAPHY

1. Blodgett, H. C. - "The effect of introduction of reward on the maze performance of rats" (University of California Publications in Psychology, 1932, 6, pp. 75-82).

2. Buxton, C. E. - "Latent learning and the goal gradient hypothesis" (Contribution to Psychological Theory, 11, N 2, Serial N 6, Duke University Press).

3. Daub, C. T. - "The effects of doors in latent learning" (Journal of Comparative Psychology, 1933, 15, 49-58).

4. Elliot, M. H. - "The effect of the change in reward upon maze performance in rats" (University of California Publications in Psychology, 1928, 4).

5. Elliot, M. H. - "Some determining factors in maze performance" (American Journal of Psychology, 1930, 42, 315-317).

6. Haney, G. W. - "The effect of familiarity on maze performances of albino rats" (University of California Publications in Psychology, 4, N 20, 319-333).

7. Herb, F. H. - "Latent learning: non-reward followed by food in blinds" (Journal of Comparative Psychology, 1940, 29, 247-256).

8. Hull, C. L. - "Differential habituation to internal stimuli in the albino rat" (Journal of Comparative Psychology, 1933, 16, 255-273).

9. Hull, C. L. - "Principles of Behavior" (D. Appleton Century Company, New York, 1944).

10. Kendler, H. H. - "A Study of learning under different motivational conditions" (M. A. Thesis, 1941, State University of Iowa).

11. Lashley, K. S. - "Learning: I. Nervous mechanisms in learning". In Murchison, C. (ed.): "Foundations of Experimental Psychology", Worcester, Mass. - Clark University Press, 1929, ch. 14.

12. Lashley, K. S. - "A simple maze: with data on the relation of the distribution of practice to rate of learning" (Psychobiology, 1918, 1, 353-367).

13. Leeper, R. - "The role of motivation in learning, a study of the phenomenon of differential motivational control of the utilization of habits" (Journal of General Psychology, 1935, 46, 3-40).

14. Leeper, R. - "A study of a neglected portion of the field of learning - the development of sensory organization" (Journal of Genetic Psychology, 1935, 46, 41-75).

15. Leeper, R. - "Dr. Hull's Principles of Behavior" (Journal of Genetic Psychology, 1944, 65, 3-52).

16. Spence, K. W. and Lippitt, B. - "Latent" learning of a simple maze problem with relevant needs satiated" (Psychological Bulletin, 1940, 37,429).

17. Spence, K. W. - Paper read at "Symposium on Motivation", meeting of the Mid-Western Psychological Association, 1941.

18. Simmons, R. - "The relative effectiveness of certain incentives in animal learning" (Psychological Monographs, 1924, 2, N 7).

19. Tolman, E. C. and Honzik, C. H. - "Introduction and removal of reward and maze performance in rats" (University of California Publications in Psychology, 1930, 4, 257-275).

20. Tolman, E. C. - "Purposive Behavior in Animals and Man" (New York Century, 1932).

21. Tolman, E. C. - "The law of effect: (Journal of Experimental Psychology, 1933, 16).

22. Tolman, E. C. - "Theories of learning". In Moss, F. A. (ed.) "Comparative Psychology" (Prentice-Hall, Inc., New York, 1934, ch. 12).

23. Thorndike, E. L. - "Educational Psychology" (Teachers College, Columbia University, New York, 1913).

24. Thorndike, E. L. - "The fundamentals of learning" (Teachers College, Columbia University, New York, 1932).