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The Effect of Unrewarded Exploration Upon Maze Learning in Rats

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THE EFFECT OF UNREWARDED EXPLORATION UPON
MAZE LEARNING IN RATS

A Thesis
Presented to
the Graduate Faculty
Central Washington State College

In Partial Fulfillment
of the Requirements for the Degree
Master of Education

by
James W. Croake
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TABLE OF CONTENTS

CHAPTER	PAGE
I. THE PROBLEM AND DEFINITIONS OF TERMS USED	1
The Problem in General	1
Definition of Latent Learning	1
Importance of the Study	1
II. REVIEW OF THE LITERATURE	6
Classification of the Various Latent	
Learning Experiments	6
Type I	7
Type II	8
Type III	16
Type IV	20
Summary of Limitations of Previous Studies . .	28
Hypothesis	32
III. METHOD AND PROCEDURE USED	33
Sample.	33
Materials	33
Procedure	33
Approach Experiment	34
Avoidance Experiment	37
Technique for Analysis of Data	37
IV. RESULTS OF EXPERIMENT	38
V. DISCUSSION.	42
BIBLIOGRAPHY	48
APPENDIX	52

CHAPTER I

THE PROBLEM AND DEFINITIONS OF TERMS USED

This experiment deals with the phenomenon of latent learning. It was specifically designed to measure the effect of prior unrewarded maze exploration upon subsequent performance under condition of both positive and negative reinforcement. In general, latent learning refers to the acquisition or alteration in a disposition to perform without the presence of any apparent reinforcement. The concept refers to a learning which has not manifested itself in performance but which may be revealed overtly under certain conditions. The present experiment uses two operational definitions of latent learning: 1) If after previous exploration of a T maze with differing goal boxes, a rat now goes to the one most similar to the replica in which he has just been pre-fed and 2) if after previous exploration of a T maze with differing goal boxes, a rat now goes to the goal box opposite to the replica in which it has just been shocked, latent learning is said to have occurred.

From 1929 to 1953 there were a great many experiments in latent learning. These experiments were primarily concerned with demonstrating the existence of the phenomenon. Subsequent experiments have been more concerned with defining the various conditions under which such learning occurs (19:54). Different theoretical interpretations of this learning

are of considerable significance because it presents an important focus in the controversy between the S-R theories of Hull, Guthrie, Thorndike and Skinner and the cognitive theories of learning as formulated mainly by Tolman and as restated by MacCorquodale and Meehl.

The theories of Thorndike, Hull and Skinner are similar in that all require a response and a subsequent class of event termed a reinforcer in order for any learning to occur. In contrast, cognitive theories of learning suggest that learning can occur both in the absence of any overt response and in the absence of a reinforcer.

Thorndike held that learning involves a strengthening of an S-R bond. The "R" refers to a response. Thus Thorndike required that a response occur as a prerequisite to learning. In addition, Thorndike asserted that not all S-R connections would be learned. The ones that were learned were "accompanied by or followed by a satisfying state of affairs" (12:20). A satisfying state of affairs was then defined as one in which the subject does nothing to avoid this state and often does things which maintain or renew it (12:20). Thorndike called such states satisfiers. Typically he used such satisfiers as saying "that's right" to a human subject, presenting food to a hungry animal, release from a small cage to an imprisoned animal. Such satisfiers are equivalent to the ordinary use of the term "reward". In

fact, Thorndike and his followers made frequent use of the term "reward". This position asserted that learning will not occur without such a reward.

Hull adopted Thorndike's law of effect but modified it substantially. Like Thorndike, Hull required that an S-R connection must occur and must occur in association with a reinforcing event. This reinforcing event may be either a reduction in a drive or a reduction in drive stimuli. Drives are conceived of as a neural condition brought about by some deficit or imbalance. Thus to effect learning, Hull requires that a response occur and that it be accompanied by or followed by an event reducing a drive.

In general the type of behavior used to demonstrate latent learning falls within Skinner's classification of type "R" or operant conditioning. In order for learning to occur there must be an occurrence of the operant, that is the response in question, followed by a reinforcing stimulus. A reinforcing event for Skinner is anything which increases the probability of a response. It may increase this probability by its occurrence in which case it is said to be a positive reinforcer or by its removal in which case it is classed by a negative reinforcer. Reinforcers are a particular class of stimuli. Presumably they are transituational. That is, an event which increases the strength of a given operant will under similar conditions

increase the strength of another operant. Skinner implies that reinforcers are some observable stimulus event which we may manipulate. Operationally, Skinner and his followers have used such classes of events as the following as reinforcers: food to a hungry animal, water to a thirsty animal, "right", "that's good", to adult humans, toys and candy to children, and removal of loud noises and electric shock for various classes of subjects.

A theory that is in direct contrast to the above positions which require a response and a reinforcing event, is that of Tolman's. Tolman asserts that stimulus combinations are sufficient for learning. He speaks of a kind of perceptual learning whereby an organism connects one stimulus, a "sign" with another which is an antecedent or a consequence of the first stimulus. The latter is called a significate and Tolman refers to this perceptual process as learning a sign-significate relationship. Tolman emphasizes the distinction between learning and performance. Reinforcement is not necessary for learning, but it is an easy way to manipulate a motivated organism so that it performs overtly. Tolman would maintain that learning could build up a large repertoire of sign-significate relationships without the occurrence of any reinforcing event. Then if the learner was in a motivated condition, a reinforcer could be used to reveal some part of the previous learning.

"The S-R reinforcement theory holds that learning is the establishment of a definite connection between the stimulus and the response, and that these connections are formed only in conjunction with motivational satisfactions" (27:284). The cognitive theorists oppose such an S-R bond that is directed by motivational satisfaction.

Although many of the differences between the two schools may be reduced to a matter of terminology, this issue remains. The issue of whether learning requires a reinforcing event remains a focal point of controversy. The various latent learning experiments are asserted by cognitive theorists, at least, to demonstrate a learning without the presence of a reinforcing event.

CHAPTER II

REVIEW OF THE LITERATURE

The first important experiment in latent learning was reported in 1929. In this experiment Blodgett (6:25) allowed a group of hungry rats to explore a maze which contained a goal box but not food. Another group of rats explored the maze, but their goal box contained food. The rats which were rewarded with food seemed to learn the maze on schedule. The group which had received no food reward was making almost as many cul entries (blind alleys) on the seventh day as they had on the first day. Then food was placed in the goal box. Their performance suddenly improved, so that almost immediately they made as few errors as the previously reinforced rats.

Thistlethwaite (33:99) has classified the various latent learning experiments into four main groups:

1. Type I, or the Blodgett variety of latent learning experiment, consists in giving the rats a series of unrewarded, or slightly rewarded, trials in a maze. A relevant goal is then introduced and additional trials are given.
2. Type II is characterized by the procedure of permitting the animals to explore and live in the empty maze for brief periods of time. Subsequently a relevant goal is introduced into the maze, and a single test trial or a series of test trials is given in the maze.
3. Type III consists in giving rats which are satiated for food and water a series of trials in a maze, the pathways of which contain the goal objects for which the animals are satiated.

After this series of trials the rats are made hungry or thirsty and given additional free trials in the maze.

4. Type IV involves giving thirsty or hungry rats a series of trials in a maze containing relevant and/or irrelevant goal objects. The animals are then satiated for the formerly desired goal object. One or more trials are then given in the practiced maze.

I. TYPE I

In all four types of latent learning experiment, one may vary the motivational state of the animals or manipulate the incentives present in the maze in order to alter the relationship between the drives and the incentives. In the Blodgett variety of latent learning experiment, it is the incentives in the maze which have been manipulated. The reward in the actual Blodgett experiment was a mash saturated with water and the animals were run under a condition of both thirst and hunger as a motivator (33:100).

In repetitions of this experiment, Reynolds (23) and Meehl and MacCorquodale (21) failed to find results similar to that of Blodgett. This may be attributed to the fact that they used dry food pellets instead of a wet mash. Reynolds may also be criticized because he used maze wise rats. That is, rats that had been used in another maze experiment were again utilized (33:102-3). Using procedures similar to that of Blodgett's, the following

studies reported positive results: Blodgett, Elliott, Herb, Simmons, Tolman and Honzik, Wallace, Blackwell, and Jenkins and Williams (12:211).

II. TYPE II

In the type II variety of latent learning experiment the animal is given a period of free exploration followed by a relevant reward. In one of the earlier experiments of this type, Haney allowed an experimental group of rats 72 hours of free exploration. The exploratory time occurred over a period of four nights. During the daytime, the rats were fed in their home cages. The control group spent its nights in a rectangular runway which was free from blind alleys. For both groups, food was placed in the goal box after the preliminary training. Both groups were then given one trial a day for 18 days. The experimental group entered only half as many blind alleys in the beginning as the control group, and they maintained this lead consistently (36:636-46).

Buxton doing a similar experiment to that of Haney's made a special effort to prevent the goal box from acquiring any reward value during the period of free exploration. He did this by placing the rats in the maze and taking them out at various points. The animals spent three nights in a 12-unit T maze. They were fed in the

home cage during the day. After the rats had spent three nights in the maze, each one was deprived of food and placed in the goal box where for the first time he found food. He was allowed to eat a few bites, and then he was placed at the entrance to the maze. Here the question was whether he could find his way back to the food. Positive results were found which favored the experimental group (2:636-46).

Karn and Porter (13) conducted a study which utilized much shorter exploratory and handling periods than in the Haney experiment, although the actual days were more in the Karn and Porter study. They felt that the more complete the pre-training experience, the greater the result upon subsequent performance in the maze. They attempted to demonstrate this by handling one group of rats for six days. Another group had both handling and confinement in an enclosure. Here the rats were placed in a box similar to that of the starting box of the actual maze for five consecutive days for the same length of time as the third group spent exploring the maze. The third group had handling and exploration in the maze. The maze exploration time was equal to that of the time spent by another group which had explored the maze for five days and then were given rewarded trials until they made two consecutive correct runs. Although the results pointed in the expected

direction, they were not significant. However, they did suggest that unrewarded exploratory experience in the maze has greater effect on maze performance than pre-training which does not include exploration.

Leeper (17) employed a method of feeding and watering his rats in distinctive goal boxes. This was done after a preliminary period of exploration on an elevated maze which contained no food or water. He removed the food box and the water box to a different portion of the room before the feeding and drinking stage. The rats were carried to the goal boxes individually and in a fashion which did not allow them to see the exterior of the boxes. This procedure made it unlikely that any association occurred between the location of the boxes and the eating or drinking. On the first day, the rats were hungry and were first fed in the food box for 30 or 40 minutes. They were then placed in the endbox where they were to receive water, and they remained here for 20 minutes. They were next placed in the third empty endbox where they were allowed to explore for 30 or 40 minutes before being returned to their home cage. On the second day, the animals were made thirsty and were placed first into the water endbox and next into the food endbox. On the third day the procedure was the same as the first day. The critical run occurred on the fourth day. The endboxes were markedly different. One floor was constructed

of corrugated wood. The second endbox was smaller and had a hardware cloth floor below this. The third endbox had a linoleum floor which was partitioned off into eight divisions which were cut through by arched doors. Although the endboxes in this experiment had distinctive interior textures, the rats were seemingly unable to make the proper associations. That is, when they were required to rely just upon intra-end box cues apart from the maze during the feeding or drinking experiences, they were then unable to locate the proper goal box on the critical run in the maze even though the goal boxes were not interchanged.

Thistlethwaite sums this up as follows:

If differential cues to which the animals would normally respond during the course of training are removed so that the identifiability of the endboxes is lessened, or if the cues are altered during the course of training so that conflicting expectations arise, rats are unable to solve the problem (33:105).

Seward (25) conducted three of the Type II experiments. The second and third experiments were essentially checks on the first. In the first experiment, both the control group and the experimental group were given six days of preliminary adaptation in a straight alley that resembled the maze. The experimental group was then allowed to explore the maze for 30 minutes on each of three successive days. On the fourth day, the rat was given three minutes of solitary

exploration in the maze. He was then placed in a remote detention box for approximately 25 minutes. After the isolation in the detention box, he was placed into one of the endboxes. Here for the first time he found the door closed and food in the cup. The rat was allowed to eat a few bites of food, and then he was lifted out and placed in the starting box. The control group, which was treated exactly like the experimental group except that it was given no preliminary exploration, failed to take the correct path on the critical trial any more frequently than would be expected by chance, while almost all of the experimental group made successful runs.

In Seward's second experiment, he attempted to determine the cues to which his rats had relied upon in the first experiment. The animals may have relied upon both intra and extra maze cues since both were present. In this experiment, he left out cues from inside the endboxes for some rats and left out cues other than those inside the endboxes for other rats. This was carried out for the first group by interchanging two identical goal boxes in the maze during the exploratory period. The second group was given its prefeeding experiences in one of the endboxes which was part of the maze but now was placed just behind the starting box. He eliminated the extra maze cues by covering the entire maze with cheese cloth draped over

wires 18 inches above the maze and hanging down both sides of the alleys. This group also had exploratory experience. These two groups were unable to take the correct path on the critical trial any more often than chance. The conclusion drawn by Seward is that the animals in the first experiment must have used cues both inside and outside the endboxes.

In the third experiment, Seward attempted to determine whether the rats in his first experiment were merely reacting to a perseverating goal response. Did the rats go to that particular goal box just because they had a natural tendency to turn to that side of the maze? Here the rats were placed for two minutes in one endbox and then for two minutes in the other endbox. There was food in only one box and half of the animals were assigned to each box. The results were favorably significant. Therefore, Seward concluded that the rats performed, not in reaction to a perseverating goal response, but rather from knowledge of the maze (33:104-6).

Gilchrist performing an experiment similar to that of Seward's first experiment which employed a mash food, also found positive results (9).

An experiment of similar logic to that of Seward's, but one that utilized negative reinforcement, was conducted by Strain (31). He gave his rats a period of free

exploration as did Seward. The rats were placed in one of six compartments of an elongated wooden alley which was separated by swinging doors. Each compartment was 17 inches long, 5 inches wide and 5 inches high. The designs on the doors were $1\frac{1}{4}$ inches in size and were made of adhesive tape. There were 12 designs in all. These were the only directional cues. Each rat was always placed in the same compartment. After this training, the rats were put in a detached replica of one of the endboxes where they were shocked. They were then placed back into the same runway compartment as before. Fifty-three out of 80 rats went from this compartment in the direction away from the shock box. This was significant. The total amount of time the rats spent in each compartment increased with its distance from the shock compartment. Also, the closer the entry compartment was to the shock, the higher the frequency of departures the other way, and the rats that did go in the direction of the shock compartment tended to reverse direction before they got there (19:56).

An experiment which is similar to that of the Type II was conducted by Tolman and Gleitman. It differs in that the rats are given trials in a maze which has food in the goal box. The animals are not allowed to explore the maze freely. They are taken out after they have eaten in the goal box. The logic behind this experiment is similar to

discriminating response on the part of the rats. One box was a flat white and measured 13 by $9\frac{1}{4}$ inches. The other box was a flat black with measurements of $9\frac{1}{4}$ by 16 inches. Both boxes were 16 inches high. These were the only differences. Most of the Type II studies afforded tactile as well as visual cues (7).

III. TYPE III

The Type III experiment involves training animals which are satiated for food and water in a maze that contains the reward for which the animals are already satiated. The first experiment of this type was performed by Szymanski. He ran food-satiated rats through a maze to the home cage where the animals found food. During the critical trials the rats were made hungry, and they displayed efficient maze performance. However, during the training period there was no tendency for the animals to reduce time, errors, or distance traveled per trial (33:108).

Spence and Lippitt, using a single-unit Y maze with food in one end and water in the other, demonstrated that food and water satiated rats learned the location of the goal objects. Rats which showed a preference for the food side during training were made thirsty for the critical test trial. The animals that showed a preference for the water side during training were made hungry for the

critical test trial. The rats were able to take the correct path in a significant number of instances on the first test run. The next day their need was shifted, and they were unable to make a significant change to the correct side (33:108). The first part of the study did demonstrate latent learning, but these researchers were interested in demonstrating Type III latent learning. Here they failed to find positive results.

Spence and Lippitt's experiment was slightly modified by Meehl and MacCorquodale. In their repetition of the experiment, they used a single-unit T maze with terminal sections of the maze so located that the rat made a left turn at the end of the left alley and a right turn at the end of the right alley. Water was placed at one terminal section and food in the other terminal section during a training period of 40 trials under satiation. The rats responded correctly during the training trials, and when the drive was shifted the number of appropriate choices was still significant (33:108). Meehl and MacCorquodale's significant results where Spence and Lippitt did not find significant results might be due to the possibility of more cues being afforded in the two turn T maze than in the Y maze.

Maltzman (20) conducted an experiment similar to that of Meehl and MacCorquodale's, except that in Maltzman's

study there was a social cage located on the other side of each endbox. In each of these social cages was a mate for the rats used in the study. During the training trials, the animals would go to either arm of the T, push aside the food or walk through the water dish, depending upon which arm of the T that they selected, and they would then enter the social cage. Maltzman reported negative results: when made hungry or thirsty on the critical run, the animals failed to take the correct path a significant number of times. It is possible that the social cages interfered with the animals recognition of the food and water thereby producing negative results.

Employing a repetition of the Blodgett six-unit multiple T-maze, MacCorquodale and Meehl (18) allowed a group of 28-hour-food deprived rats to explore the maze which contained no food or water. After two days of this exploration, the rats were placed in the entrance box and allowed to move about freely until they entered the goal box. The results indicated a significant tendency to avoid culs and to take the correct path to the goal box. MacCorquodale and Meehl concluded that since there was none of the usual reinforcement present, that the performance was due to negative reinforcement of having to turn around in a confined cul entry.

Thistlethwaite (33) trained two groups of rats in a Y maze under conditions of satiation for food and water. A wet mash was located in one arm of the Y maze. The animals were given two free training trials a day for six days. One of these groups found food in the maze on only one of their trials, while the other group found food in the arm on every trial. On the critical test trial, both groups were under 22 hour food deprivation. The results were that each group made a significant number of correct turns. The rats which had found food in the maze on only one training trial performed as well as the group which had repeatedly experienced food in the maze.

Seward, Levy and Handlon allowed two groups of rats exploratory trials in a single unit T maze which contained water in one endbox of the T. One group was run under 22 hour water deprivation. The other group was satiated. On the critical run, the correct performance by the deprived rats was at the one per cent level. The correct performance by the satiated group was at the five per cent level (26).

A possible criticism of the positive results which Spence, Bergmann, and Lippitt (28) found with the Type III experiment was that the animals during the exploratory trials were always removed from the goal box at the end of each trial.

In Kendler's (14) experiment the satiated rats had a series of training trials in a T maze. One end of the T contained food, the other end contained water. On the critical test run the animals were made either hungry or thirsty and allowed to run the T. Although there was a tendency for the rats to choose the correct side, Kendler might not have found negative results, if he had used a mash instead of dry biscuits and a water bottle. Then too, the sample of 12 rats which he used is relatively small.

It seems that one of the problems of the Type III experiment is that of the rats actually noticing the food and water in the endboxes when they are satiated for these rewards. Other possible reasons for negative results have been mentioned. These are: more cues afforded in a slightly more complex maze, interference from the introduction of social cages, and the use of a mash instead of dry food. In summary, this type of experiment has yielded positive results for MacCorquodale and Meehl, Meehl and MacCorquodale, Seward, Levy, Handlon, Spence, Bergmann, Lippitt, Spence and Lippitt, Szymanski, and Thistlethwaite. Negative results on the Type III experiment have been found by Kendler and Maltzman (12:211-3).

IV. TYPE IV

In the Type IV experiment the animals are trained

under a strong drive in a maze which contains goal objects which may or may not be relevant to the drive. On the test trial the motives of the animal are manipulated, for example, he is now made hungry so that the goal object is relevant. If on the test trial the animal gives evidence of a significant increase in the number of choices of the alley of the maze which contains the goal object for which the animal is now motivated, then irrelevant-incentive learning is said to have occurred.

Most experiments of this type employ a T or Y maze. Such an experiment using a Y maze was conducted by Walker, Knotter and DeValois. Their experiment was designed mainly to see whether irrelevant-incentive learning might readily occur when forced trials are effected. Three groups of rats were run with both ends of the terminal boxes containing water. The rats were under 16 to 18 hours of water deprivation. The maze also contained intermediary boxes. One of the intermediary boxes contained food, the rest contained water. The intermediary boxes were located between the choice point and the endbox on each side of the maze. One group of rats was allowed to run freely for 40 training trials. Another group was given 50 per cent forced trials and 50 per cent freely chosen trials. A third group was given all forced trials. The group which had all free trials and the group which had 50 per cent

forced trials had a significant tendency to go to the food when made hungry (33:114). This experiment could suggest that forced trials interfere with further learning.

Kendler and Mencher (16) gave their rats a series of training trials in a simple T maze. One end of the T contained four glasses of food and one glass of water. The other end of the T contained one glass of water and no food. The rats were trained under water deprivation and they went to the appropriate side of the T which contained water; however, when the need was shifted to the food, the animals failed to go to the food side a significant number of times.

Grice (11) utilized a study which was similar to the Kendler and Mencher study, except that Grice had the food in a large quantity rather than in individual glasses. His results were also negative. In both studies, the animals were able to see the food but were unable to eat it. Woodworth (15) felt that the rats in both experiments had perceived the food while under thirst motivation but because they were unable to eat it, their perception of the food became extinguished.

Another study utilized essentially the same experimental procedures as these used by Kendler and Mencher except that on the last two days of the seven day trial period, food was introduced into one of the endboxes. Kendler and Kanner (15) found that when the drive of thirst

was shifted to hunger, the animals failed to take the path to the food a significant number of times. The researchers mentioned that the rats received a two day preliminary training period, but they did not give reference as to how much or what type of training was initiated.

Christie (4) trained a group of rats for 30 days to discriminate between hunger and thirst drives (early deprivation). These animals were then subjected to an experiment very similar to that of Kendler's. However, Christie found negative results. His results might have been due to the fact that the animals were trained under a thirst drive. When the drive was shifted to hunger, they continued to choose the water side. Since it is generally recognized that thirst is a stronger drive than hunger (5), the behavior of the rats in not responding to the other side of the T could be explained by a cathexis toward the water bottle. This hypothesis was later borne out in a second experiment by Christie.

In the second experiment, he used a procedure similar to that of the first. He found that rats which were subjected to early deprivation and given hunger motivated trials in a T were able to respond to a previously irrelevant water bottle when made thirsty. However, when the rats had these drives shifted from thirst to hunger, they were unable to respond appropriately. Neither of

these groups had had pre-maze exploration.

In another experiment (5) using a procedure again similar to that used in his first experiment, Christie demonstrated the value of pre-maze or pre-experimental adaptation. The pre-experimental adaptation was an elevated path leading to a table. The rats were given 20 exploratory trials leading to the table top. They were also subjected to periods of water and food deprivation as in his second experiment. These animals which had the benefit of pre-maze exploration on the table top were able to go to the appropriate side of the T when their drive state was shifted. This was true for the hunger drive as well as the thirst drive.

Gleitman (10) attempted to find out why rats were unable to change to the food side when made hungry after they had been trained under thirst deprivation. Most researchers believe that the presence of the water while the animals were trained under a thirst drive had interfered with the animals going to the food. Gleitman ran a group of rats in a simple Y maze. Food was located in one arm and neither food nor water was present in the other arm. The animals were given trial runs in the maze under 22 hours of water deprivation. When the animal's drive was shifted to hunger there was a tendency for the rats to go to the food side, although this difference was not significant.

Gleitman can be criticized in this experiment for not giving his rats any preliminary adaptation before they were put into the actual maze.

Walker (35) found positive results with the Type IV experiment. He gave his rats 10 trial days in a diamond maze in which one arm contained water and the other arm contained food. During these ten days the rats were placed under 16 to 18 hours of water deprivation. At the end of these ten days, 95 per cent of the animals were taking the path toward the water. It was about this point in the experiments of Spence and Lippitt and Walker in which they changed the motivation to hunger. That is approximately the same percentage of them were taking the path toward the water in the experiments of Spence and Lippitt and Walker as well as in the Walker study. The rats continued to choose the water side which could be the reason why they found negative results. In other words the stimuli that are selected during both conditions of hunger and thirst could be similar. Therefore, the animal has difficulty in discriminating between which is a hunger drive and which is a thirst drive.

During the next seven days of the Walker experiment, the animals continued to be under water deprivation and were given trials in the maze; however, the maze was now without water. By the end of this seven day extinction period, 50 per cent of the turns now made by the rats were to

the food side and 50 per cent were to the side which had previously contained water. All rats were now given one test trial under 23 hours of food deprivation. The results were that the animals chose the correct food side a significant number of times. This similar procedure could also account for the positive results which Walker, Knotter, and DeValois (503) and Thistlethwaite (504) obtained, since these experiments like the Walker experiment also allowed for a period of extinction before the drive was shifted. The latter two experiments besides using food, also placed water within the maze during the training trial.

Bendig (1) took a different approach to the Type IV experiment and found very significant positive results. He gave a group of 23 rats five days of preliminary adaptation in a straight alley which was filled with water. This was followed by four days of maze trials in a water filled T. The rats were satiated for food and one arm of the T always contained food which was placed on a water free platform. The platform at the other end of the T contained no food.

Fehrer (8) utilized the Type IV experiment to test the hypothesis that "cognition formation may be a function of previous experience with the to-be-cognized object". She took a group of rats which had been deprived of food prior to this experiment and gave them trials in a T maze

under 22 hours of water deprivation. One arm of the T contained water, the other contained food. When the drive was switched to hunger, there was a tendency for the rats to go to the food side although this was not significant.

Shaw and Waters (27) failed to find positive results for the Type IV experiment. They may be criticized in that they changed position of their goal boxes during the trials so that the rat was required to discriminate only by the color of the box without benefit of a constant location.

Most of the experiments of this last type utilize the closing of doors behind the animal to prevent retracing and to insure equal exploration of all parts of the maze during the training trials. Tolman (27) has criticized this procedure. He felt that the doors being closed behind the rat causes disrupting conflict and frustration which hampers learning.

Positive results with the Type IV experiment appear to be more likely under the following conditions: when there is a period of extinction after the training trials as in the walker study, hunger rather than thirst as an irrelevant drive, free rather than forced trials, and contact with the undesired goal object (18:120).

With the Type IV experiment there is the possibility that a relevant drive which is too strong may interfere with the animal's ability to recognize the presence of an

irrelevant reward (35). Also, both Hull and Tolman (34) have implied that training may be necessary in order for the rat to be able to distinguish between thirst and hunger drives. The following researchers have found positive results for this type of experiment: Bendig, Christie, Diesenroth and Spence, Strand, Thistlethwaite and Walker, Walker, Knotter, and DeValois. Negative results with this type of experiment have been found by Christie, Fehrer, Gleitman, Grice, Kendler, Kendler and Mencher, Kendler and Kanner, Littman, Shaw and Waters, Spence and Lippitt, and Walker (12:211-3).

The type of experiment with which the present researcher will primarily be concerned is that of the second type. This type of experiment was chosen rather than one of the other three types for the following reasons: because the Type I experiment employs trials, there is more opportunity for the presence of a reinforcement. As was mentioned before, it seems that with the Type III experiment there is the problem of the rats actually noticing the food and water in the endboxes when they are satiated for these rewards. The Type IV experiment appears to invite a multitude of confounding factors as were indicated above. Seward (25) has been the leader in the development of the Type II experiment. Seward's experiments were concerned with positive reinforcement, but both of the present

experiments followed a design similar to that of Seward's. His design is concise, clearcut, and appears to lend itself more readily to testing latent learning than do most other designs. His is also one of the few experiments in which there is no apparent reinforcement present during training. Perhaps second only in importance to Seward's experiment are the studies of Tolman (36) and Strain (31). The present experiment was designed, in part, to encompass all three of these important experiments and to check their findings. Furthermore, the present design attempts to avoid the following weaknesses of the prior studies:

In Seward's (25) first experiment the control group failed to receive an equal amount of exploration. It may be that exploration is not important per se, but valuable as part of a general handling and change of environment which reduces anxiety. Secondly, the experimental subjects were placed directly into one of the actual goal boxes which were located at each end of the T maze. Here they were fed prior to the critical run. According to reinforcement theories this allows many positional cues to operate, such as stimulus discrimination and secondary reinforcers.

Tolman's (36) study is confounded by the use of two reinforcers during training. These are: the presence of food in the goal box during the training trials and the

fact that the animals were picked up directly from the goal box. Thus, all reinforcement positions assert that learning could occur during training.

The Strain (31) experiment did produce significant results, but the 53 out of a possible 80 correct responses is not striking.

By closely following the procedure of a well-known experiment, by keeping the design in a simple form, and by eliminating confounding factors which were present in many previous experiments this researcher feels that he has added to rather than complicated the issue presented by previous researchers.

Probably the main question centering around latent learning experiments is whether there is learning without reinforcement. The cognitive theorists point to latent learning experiments as evidence for their theory. They claim that reinforcement is not essential to learning, only to performance. The reinforcement theorists claim that there is no learning without reinforcement. Even though there is an attempt to control reinforcement in latent learning experiments, the possibility may inadvertently exist that reinforcement occurs. Blodgett's experiment is used as a case in point, and may be criticized since the rats in the Blodgett experiment were removed from the maze and placed directly into their home cage. The home cage

may have offered a type of social reward. These criticisms will not be applicable to the present experiment, as the rats were removed from the maze at the end of the exploratory time no matter where they were, and the rats were placed in a remote detention box immediately after they were removed from the maze. If there is any reinforcing property connected with lifting the rats from the maze, then this researcher has given a reinforcement. However, the animals were not reinforced for their presence in any particular location in the maze as they were always removed from wherever they happened to be at the end of the exploratory time.

The present experiment was actually two experiments. The procedure was the same for both experiments except that one utilized food and the other employed shock just prior to the critical run. All rats received preliminary adaptation in a straight alley. They were then given exploratory time in the actual maze. Subsequent to the critical test run to determine whether they had learned the maze without reinforcement, they were either fed or shocked in a replica of one of the endboxes. Learning was said to have occurred if the rats went to the box which was similar to the one that they were fed in and if they avoided the box which was similar to the one that they were shocked in.

In the present experiment it was expected that the animals would avoid the negative reinforcement and approach the positive reinforcement as a result of knowledge which they acquired during the exploration period. The hypothesis tested is as follows: Unrewarded maze exploration does effect learning.

The next chapter will describe the sources, method, and the treatment of data which was utilized. Chapter III is a report of the obtained results and Chapter IV will present a discussion of the findings and related considerations.

CHAPTER III

METHOD AND PROCEDURE USED

The method of procedure, as was previously mentioned, closely followed that of Seward's experiment, but it differed in some aspects. The most prominent difference being the employment of shock in addition to the food which Seward utilized in his experiment.

I. SAMPLE

The present experiment included two parts, an approach experiment and an avoidance experiment. The sample used consisted of 16 naive female rats which were six to seven months old and 16 naive male rats which were eight to ten months old on the day of the critical test run. There were three albinos, seven hooded, four brown, and two black of the females. The males consisted of six albino, eight hooded, and two black. All animals were divided as nearly as possible into the two experimental groups according to sex, age and pigment.

II. MATERIALS

The apparatus used was a $4\frac{1}{4}$ inch alley maze built in the form of a T, painted a flat grey, with endboxes. The entire maze and endboxes were covered with a removable wire mesh. The measurements were as follows: 32 inch cross bar,

64 inches over-all, 32 inches on each side, and the endboxes were 14 inches square. One endbox was painted black, and it had a welding rod and sawdust floor. The other endbox was painted white, and it had a grid floor constructed of zinc mesh. Both endboxes contained a fixed aluminum food dish.

III. APPROACH EXPERIMENT

All rats were handled nearly every day for two months previous to the employment of a food schedule. All of the rats were fed for one hour a day at approximately 24 hour intervals. The longest deviation from this 24 hour feeding schedule which occurred at any one time was two hours, and this was held constant for all rats. Water was available in the home cages at all times except for the 24 hour period previous to the critical test trial. At this time the animals were also deprived of water in addition to the usual food deprivation. Their diet consisted of Purina Rabbit Chow in the form of a wet mash, which they ate in a feeding cage similar to their home cage at the end of each day's experimenting. After three days on a 24 hour food schedule, they were given six days of preliminary adaptation in a straight alley 62 inches long that resembled the maze in every other respect. On the first three days they were randomly placed in the alley in groups of four and allowed

to explore it for a period of ten minutes at which time they were removed from wherever they happened to be in the alley to a remote detention box. Here they remained for 15 minutes before they were moved to the feeding cage and fed for one hour. They were then placed back in their home cage. On the last three days the rats were placed individually in the alley and allowed to explore it for a period of ten minutes. Other than the individual exploration, the procedure from the time that the rat was removed from the home cage until he was returned was the same as that of the first three days.

All rats were then placed in the maze, which was actually used in the experiment, in groups of four and allowed to explore it for 30 minutes a day for two days. After the exploration period, they were placed in a remote detention box for 30 minutes. The rest of the daily procedure was the same as the first three days. On the next two days the rats were placed in the maze individually and allowed to explore it for 20 minutes. The rest of the daily procedure was the same as the previous two days, including the detention period.

On all ten exploratory days, the rats were always randomly placed in the alley or maze and removed at whatever point they happened to be at the end of the exploration time. One day they were all placed in the start of the T.

The next day they were all placed in the left arm of the T. The next day they were all placed in the right arm of the T, etc. They were never placed in the endbox, but they were removed from the endbox if this is where they happened to be at the end of the exploration time. Although no record was kept, the rats were removed from endboxes about 12 times during all the exploration time.

The critical test day followed the second day of individual exploration in the actual maze. On this day, the rat was placed individually in the maze at the start of the T and allowed to explore for three minutes at which time it was removed from wherever it happened to be in the alley to a remote detention box. Here the rat remained for approximately 25 minutes. After the detention period, it was immediately placed in a replica of one of the endboxes where for the first time it found food in the food dish. The replica boxes were brought into the testing room just prior to each critical run. Both of the replicas were exactly like the two in the maze except that the black goal box was one inch narrower than the black goal box in the maze. The rat remained here for one minute or until it had settled down to eat. The rat was now lifted from the replica goal box, which was located just behind the starting point of the T, into the beginning of the T. Half of the males and half of the females of this group were fed in the black

box. The other eight rats of this group were fed in the white box.

IV. AVOIDANCE EXPERIMENT

The procedure for the avoidance experiment was the same as that of the approach experiment, except that in the avoidance experiment instead of receiving food in the replica goal box the other 16 naive animals received 110 volts of electricity from the grid in the bottom of the box for three seconds before they were lifted out and into the start of the T for the critical run. The handling, feeding, exploration and detention box time and all other procedures were the same for both experiments.

The data was analyzed by a Chi-square technique: applied separately to both the approach and the avoidance experiment, and applied to the data of the two combined experiments.

CHAPTER IV

RESULTS OF EXPERIMENT

In the approach experiment, 14 out of a possible 16 rats took the correct path to the appropriate goal box on the critical test run. Using Chi-square as the statistical measure, these results were significant at the 1 per cent level. In the avoidance experiment 13 out of a possible 16 rats took the correct path away from the replica shock box. This was significant at the five per cent level. A Chi-square value of 6.64 is needed for the one per cent level of significance. A value of 6.24 was obtained which was very close to the one per cent level and is significant at the two per cent level. The results of the two combined experiments were 27 of a possible 32 rats taking the correct path. This score was significant at the one per cent level.¹

An error was counted if the rat put his head past a set line in the alley which was 16 inches from the end of the alley. In only one case, did a rat go past this line and then turn around before it got to the goal box. This rat errored at the cut off line and then went to the correct goal box. It was, therefore, an incorrect run. One other rat hesitated and turned around at the choice point, and then he went directly to one of the endboxes.

¹Refer to Table I page 41

Three errors occurred in the black box in the avoidance experiment. These were rats that were shocked in the black box. When they were placed in the T, they went to the black endbox instead of avoiding it. During the approach experiment, one error occurred in the white box and one error occurred in the black box. The rats erred because they did not go to the endbox which was similar to the replical box.

A comparison between the number of subjects going to the white box and the number of subjects going to the black box yielded a Chi-square of 2. (probability $\sqrt{.20}$) which does not permit rejection of the null hypothesis. Therefore, the tendency for the rats to go to one box in preference of the other, was not significant. Four of the errors were committed by males and one error was made by a female.² The albino rats accounted for two errors, and the pigmented rats made the other three errors. All of the afore mentioned results are reported in Table I.

Because of the difficulty of removing the shocked rats from the shock box, three of the rats got onto the floor before they were put into the maze. One of these rats erred. The other two rats made correct runs. The first rat which received shock bit the researcher. Therefore,

²Refer to Table I page 41.

the other 15 rats in the avoidance experiment were handled with gloves. This was the first time that these animals had been handled with gloves: however, this did not seem to disturb the rats. Gloves were not used on any of the rats in the approach experiment. Glass was placed over the box when the animals were shocked, and a wire mesh was placed over the box when the animals were fed just prior to the critical run.

Positive results were obtained which favor support for the theory of latent learning. Therefore, this researcher does not reject his hypothesis which stated that unrewarded maze exploration does effect learning.

TABLE I
RESULTS OF EXPERIMENT

CATEGORIES	CORRECT CHOICES	ERRORS	TOTAL POSSIBLE	χ^2	PROBABILITY
Approach Experiment	14	2	16	9.00	$\leq .01$
Avoidance Experiment	13	3	16	6.24	$\leq .02$
Combined Experiments	27	5	32	7.56	$\leq .01$
Male Performance	12	4	16	4.00	$\leq .05$
Female Performance	15	1	16	12.26	$\leq .001$

CHAPTER V

DISCUSSION

The present paper has presented a problem which dealt with the theory of latent learning. This was facilitated by testing rats in a maze. A resume of the history and present status of the problem have been presented. Also set forth were the procedures and results of the experiment. There has been an attempt to eliminate any confounding factors which have been present in previous experiments of this type. These were mainly procedures which afforded the possibility of some reinforcement being present during the training period.

A Hullian might sight a drive of anxiety and escape from the maze as a reinforcing event. But the rats in the present experiment were not removed from the endboxes during training unless this was where they happened to be at the end of the exploratory period. A consistent Hullian position would lead one to suspect that the rats would tend to go to the point where they were last lifted from the maze. Since the location of removing the rats was randomized during training, then random learning pattern should have resulted.

Furthermore the rats were given six days of preliminary adaptation in a straight alley. The period of time in the straight alley had a two-fold purpose. One,

it gave the rats an opportunity to find that after they explored this environment outside of the home cage they would not be returned to their familiar home cage, but rather they were retained in another unfamiliar environment, i.e. the remote detention box. This experience would probably tend to lessen any reward which might be associated with escape from the maze.

Besides the possibility of a negative reinforcement, the reinforcement theorist might say that there was a positive reinforcement present. If there is an exploratory drive, an organism learns simply by being exposed to new combination of stimuli so that this drive is lessened. The term reinforcement used in this manner becomes so encompassing and ubiquitous that it is meaningless. In reference to Skinner, during the training there was no response reinforcement contingency using an event known in other studies to operate as a stimulant for response rate. No particular event marked the rats entrance or return to the cages as opposed to any experience in the maze. This experiment does not in any way contradict Guthrie's theory of learning. It would be possible to modify this experiment to limit motor responses. Such results, if favorable, would cast some doubts on Guthrie's position.

The results of the present research do not prove that learning occurs according to the cognitive theory as

formulated mainly by Tolman and given postulating support by MacCorquodale and Meehl. However, the results do tend to lend support to this theory, and they give no support to the S-R theories. The animals in the present experiment not only learned, but they learned very well. The strength of this learning was as efficient as could be expected from any other proposed method of learning which utilizes any combination of reinforcers.

This type of experiment which demonstrated learning in the present study is just one of a possible four types, but the underlying concept is the same. That is, all of the four types attempt to demonstrate the phenomenon of latent learning.

As an outcome of the present experiment, several secondary results are noteworthy. Positive and negative reinforcement as a means of eliciting performance were both effective since results for both the approach and the avoidance experiment were similar. The females took the correct path to the appropriate goal box a greater number of times than did the males; although, this difference was not large. There did not seem to be any particular advantage or disadvantage connected with either goal box, as the number of errors committed in the direction of one box did not differ significantly from the number of errors committed in the direction of the other box.

With the positive results of this experiment favoring a cognitive theory, the current fad of teaching machines might be questioned. The principle behind the teaching machine is that of reinforcement as being the best method of teaching. There is the possibility that reinforcement is not necessary in order for learning to occur, and it may not be the best method of teaching.

In teaching, it might be advantageous to merely expose the learner to a variety of ideas in a particular field. Then on occasion ask him to perform so as to determine whether he can organize these ideas into a meaningful context.

Also as a result of the present experiment there is further evidence for the belief that there is a difference between learning and performance. The reinforcement in this experiment made manifest the learning which was already present.

This researcher will not deny that subjects can be trained under reinforcement conditions to perform appropriately in a given situation. However, it is quite probable that more is learned without the presence of a reinforcement. The animals in the present experiment had to know the location of both of the two differing endboxes since they were assigned randomly to either goal box on the

critical run. A reinforced rat would have learned the location of only one of the endboxes. This learning would be confined to the endbox in which he had received reinforcement. Therefore, a reinforcement may be a hinderance to learning because it limits the scope of what is learned. These who learn under latent learning conditions may be much more flexible.

Muenzinger and Conrad demonstrated that nonreinforced rats which were given exploratory time in one maze and then placed in a mirror image of the first maze demonstrated negative transfer if a reward was introduced early into the first maze. Whereas those without reward demonstrated positive transfer (12:214). There are other questions which this researcher would like to know about latent learning. Could there be any other conditions, besides those mentioned in this paper, under which the phenomenon of latent learning might occur? Or in a more complex environment, would the rats still learn, and would they learn as well as reinforced rats? For example, in a complex 14 unit multiple T maze, would animals who were allowed to explore the maze without reinforcement learn the location of various places in that maze as well as rats who were rewarded at these various places? It would be this researcher's prediction that the nonreinforced animals would display a better knowledge of this maze than the reinforced

animals because latent learning is more flexible than reinforced learning which is more fixated.

It would seem most desirable to experiment with human subjects in this area, but many limitations are immediately obvious. The immense number of stimuli, reinforcements and other factors which constantly influence the human being would be difficult to control.

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