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LEARNING THROUGH STIMULUS SATIATION:  
ONE TRIAL A DAY

Thesis for the Degree of Ph. D.  
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This is to certify that the  
thesis entitled  
LEARNING THROUGH STIMULUS SATIATION:  
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## ABSTRACT

Recently learning theorists have been attempting to determine the effects of the numerous factors which are involved in alternation behavior. The present thesis was concerned with several of these factors. The primary interest was in an attempt to determine whether or not the stimulus satiation developed in a specific situation decreases to zero in less than 24 hours. This was tested. The effects of maze cues during the early trials of the learning period, before the formation of a habit, were compared to the effects of the same cues after a turning-response habit had been acquired. Lastly, a comparison was made of the reversal tendency of satiated subjects with that of food-deprived animals.

The apparatus was a standard T-maze; black cardboard inserts were used to line one alley when differential maze cues were required.

Forty-seven experimentally naive male rats were used in the study. Group 1, ten animals, received the following training; (1) 52 days, one trial a day, 2L:1R ratio, (2) 6 days, 3 trials a day with a fifteen-minute inter-trial interval, 2L:1R ratio, (3) 26 days, free trials, followed by a three-day delay period, (4) 1 day, free trial, with three subjects satiated and two subjects food-deprived, (5) 3 days, free trials, maze rotated 180°. During the entire experiment, the left alley was black and the right alley was natural wood finish. Group 2, eleven animals, received the following training; (1) 24 days, 2R:1L ratio, left alley - black, and right alley - natural wood finish, (2) 3 days, free trials, (3) 33 days, 2L:1R ratio, (4) 12 days, 2L:1R ratio, left alley - natural wood finish and right alley - black, (5) 12 days, free trials, followed by a three-day delay period, (6) 1 day, free trial, with four animals satiated

and three animals food-deprived, (7) 3 days, free trials, maze rotated 180°. Group 3, five animals, received the following training; (1) 19 days, 2L:1R ratio, left and right alleys - black, (2) 14 days, left alley - natural wood finish and right alley - black, (3) 16 days, Forced L, Forced L, Free-choice sequence, (4) 8 days, maze rotated 180°. Group 4, five animals, received the following training; (1) 19 days, 2R:1L ratio, left and right alleys - black, (2) 14 days, left alley - natural wood finish and right alley - black, (3) 16 days, Forced L, Free-choice, Free-choice sequence, (4) 8 days, maze rotated 180°. All trials for Groups 2, 3, and 4 were on a one-trial-a-day basis. Group 5, seven animals, received the following training; (1) 31 days, 2L:1R ratio, left alley - black and right alley - natural wood finish, (2) 10 days, free trials, one a day, (3) 3 days, free trials, five a day with twenty-minute, inter-trial intervals. Group 6, nine animals, received the following training; (1) 31 days, 2R:1L ratio, left alley - black and right alley - natural wood finish, (2) 10 days, free trials, one a day, (3) 3 days, free trials, five a day with twenty-minute, inter-trial intervals.

The following results were obtained. The acquisition of a habit did occur with all six groups even though the inter-trial interval was 24 hours. Groups 1, 2, 5 and 6, with which differential intra-maze cues were used, showed a tendency to respond to the less frequently experienced stimulus complex. Groups 3 and 4, with which non-discriminable maze cues were used, learned to go to the left alley, presumably on the basis of extra-maze cues. The running response which was learned was extremely resistant both to reversal when the maze stimuli were changed and to extinction when the trials were all free-choice. The tendency for satiated animals to show more reversals than food-deprived animals was discussed. There was an indication that extra-maze cues have some eliciting value

after a running habit has been developed as shown by the effects of maze rotation after 88 days of running trials.

The limitations of various theoretical approaches to the problem of alternation phenomena were discussed.

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ONE TRIAL A DAY

By

RUTH HOLM WELLS

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## INTRODUCTION

Tolman (26), in 1925, discussed a specific phenomenon of rat behavior in the following manner:

"A simple T-maze was used, and it was arranged so that the animal could get back to the food box in identical fashion whether he chose the left or the right angle of the T. Either route met with success . . . . (There was) a very pronounced tendency toward continuous and regular alternation - left, right, left, right, or right, left, right, left . . . . It appeared, in short, that even where either side was equally "satisfactory" there was in our rats a positive tendency left over toward variation of response . . . a positive tendency in and of itself."

This positive tendency, now referred to as spontaneous alternation, has been investigated extensively in recent years, inasmuch as the behavioral phenomena related to it present a difficult set of data for any existing theory of behavior to explain.

Attempts to explain alternating behavior within a Hullian framework have been based on the concept of inhibition. Hull's (12) Postulate 8 includes three ideas relevant to spontaneous alternation patterns: (1) A primary negative drive,  $I_r$ , results from the occurrence of a response and lessens the probability of the repetition of the response, (2) The amount of  $I_r$  which develops is an increasing function of the amount of work or effort involved in making the response, and (3)  $I_r$  dissipates according to a decay function of time. Heathers (11) has reported experimental evidence relating the amount of alternation in a T-maze situation to the length of the inter-trial interval which seemed to support the Hullian postulate. Using 15, 30, 60, and 120-second intervals between five massed trials, he found the percentage

of alternation on a free trial ranged from 85.6 with the 15-second interval down to 65.6 with the 120-second interval. A test trial fifteen minutes after the massed trials yielded 50.3% alternation and on the first trial on the following day, (24-hour delay) 50.4% alternation. Thus, his data showed no evidence for any reaction decrement after a fifteen-minute period.

Zeaman and House (32) made three deductions from Hull's postulate which were specifically related to the spontaneous alternation problem and then attempted to test these ideas directly. They stated, "Alternation tendency will be (1) a negatively accelerated decreasing function of the time between responses; (2) a positively accelerated increasing function of the work involved in the execution of the response; and (3) a simple linear increasing function of the number of evocations." Thus, if the amount of reactive inhibition were to be built up by increasing the number of responses in a short period of time, the percentage of alternation responses should increase proportionately. In the case of a T-maze experiment then, the greater the number of times a response to one side of the maze is forced in massed trials, the greater should be the tendency for the alternate response to occur on a test trial. Supposedly, this rise in the number of alternating responses demonstrates the growth of inhibition. Zeaman and House also intended to demonstrate the decay of inhibition by showing a fall in the curve relating the percentage of alternation to the time interval between the massed, forced trials and the subsequent test trial. Using varying numbers of forced trials and varying delay periods between the massed trials and the test trial, Zeaman and House obtained the following results. The percentage of rats alternating increased linearly with increasing numbers of forced trials. The alternation

percentage decreased as a negatively accelerated function of the length of delay period between the massed trials and the test trial. The percentage of alternation decreased gradually from 100% after no delay between the massed trials and the test trial to 71% at 12 hours delay and to 51% at 24 hours. This contrasts markedly with the conclusion drawn by Heathers to the effect that the tendency to alternate drops to 50% after a fifteen-minute period.

Berlyne (1), in a similar approach to the problem, has developed two postulates and three corollaries based primarily on Hull's Postulate 8. Berlyne's Postulate I states, "When a novel stimulus affects an organism's receptors, there will occur a drive-stimulus-producing response." This response Berlyne called curiosity. Postulate II states, "As a curiosity-arousing stimulus continues to affect an organism's receptors, curiosity will diminish." The corollaries include the following ideas; (1) "An organism will learn to respond to a curiosity-arousing stimulus with activity which will increase stimulation by it", (2) after a time, the activity, labeled exploration by Berlyne, will cease, and (3) "After a further lapse of time, if the curiosity-arousing stimulus is again affecting the organism's receptors, there will be a second spell of exploration, but this time there will be less exploration than during the first spell; such spells of exploration will recur at intervals, until exploration of the stimulus in question ceases altogether." Berlyne's experimental results were in line with the predictions following from his corollaries; the rats spent more time exploring a novel stimulus than they did exploring stimuli which had been explored previously and they spent less time exploring stimuli the second time the stimuli were encountered. This type of explanation can be used in dealing with an alternation problem;

the stimuli of the most recently visited T-maze arm will have less effect in arousing the drive-stimulus-producing response, curiosity, than the other arm and hence, the animal alternates.

Solomon (25) reasoned that if the concept of reactive inhibition is a valid explanation of the occurrence of alternation behavior, the tendency to alternate should be greater when more work is involved in the reactions. He tested this hypothesis experimentally by inclining the goal arms of a T-maze at a 16° angle from the horizontal level so that greater effort would be expended by the animals in getting to the goal boxes. The alternation percentage increased from 74 to 90, a significant change. However, another attempt to increase the amount of effort in attaining the goal which involved strapping weights to the backs of the rats did not lead to increased alternation.

Data from numerous other studies have not been adequately explained with Hull's concepts. Dennis (4) has found that in a multiple-unit maze, animals did not alternate on a right-left basis with individual maze units but rather they alternated their total pattern, for instance, from left, left, left, right turns to right, right, right, left turns. This is in direct contradiction to the results to be expected if the alternation tendency were a function of a response-produced decrement. Dennis also found that increasing the length of the final section of the maze from 0 to 38 feet resulted in no change in the amount of spontaneous alternation, in spite of the increase in inhibitory effects which one would hypothesize from Postulate 8. Wingfield (31) has shown that human subjects show more alternation in a situation which calls for a choice of lights when the lights are different in color than when the lights are the same.

Glanzer (8) has presented in a review article the major find-

ings in the area of spontaneous alternation up until early 1952. He has pointed out the above-mentioned inadequacies of the response-theory type of explanation and has formulated a postulate and corollaries in terms of the stimulus aspect of the situation. The first part of the postulate states, "Each moment an organism perceives a stimulus-object or stimulus-objects, A, there develops a quantity of stimulus satiation to A. Glanzer posits that the amount of stimulus satiation developed over a period of time is an increasing linear function of time, that satiation to A will be generalized to other stimulus-objects B, and that stimulus satiation reduces the organism's tendency to make any response to A. Glanzer has experimentally tested two deductions from his postulate and has contrasted the results obtained to those which would have been predicted from a response-type theory. The first hypothesis states that exchanging the stimulus-objects of a two-alternative maze between trials will result in a repetition rather than an alternation of turns. This was tested by using a cross-shaped maze with two starting boxes. On half of the eight experimental days, the 26 animals were started from one starting box for the first trial and were started from the opposite box for the second trial which followed immediately. The animals alternated alleys (stimuli) rather than responses, whereas any response-type theory would predict opposite results. The second hypothesis states that increasing the time interval between trials will have varying effects on spontaneous alternation depending on the place of the delay. Glanzer found that a delay of ten minutes in the alley which had been chosen on the first trial resulted in the greatest amount of spontaneous alternation as compared to an equal delay period in the starting box or at the choice-point. A response-type theory would regard the amount of alternation as a function of the time

interval and not as a function of the stimulus complex during the delay interval. The verification of these two hypotheses is accepted by Glanzer as evidence for the accuracy of explaining alternation phenomena in terms of the effects which exposure to stimuli has on the organism.

Montgomery (17, 18, 19, 20) has reported several studies and an original theoretical development on the problem of spontaneous alternation. In one study the relationships between increased work and increased inter-trial intervals and the tendency to alternate were investigated. Montgomery varied the work by placing weights on the arms of a bar-pressing apparatus and found that increasing the weights did not result in an increase in the alternation of turn-responses. However, inasmuch as Hull posits reactive inhibition as being highly specific to a response and in this situation the relevant response was a turning-response, not a bar-pressing response, the data cannot be considered a test of Hull's concept. The data did confirm earlier studies in showing that with increasing inter-trial intervals, there is a corresponding decrease in the tendency to alternate.

From research designed to study the relationship between exploratory behavior and the general activity level, several important findings have been reported by Montgomery (21, 22, 23). Animals deprived of food or water showed significantly fewer exploring responses than satiated animals showed. Animals deprived of their normal amount of activity by constant enclosure in a cage which was too small for any activity showed no more exploratory behavior in a test period in a maze than a control group which was allowed constant access to an activity wheel. From these data, Montgomery concludes that exploratory behavior is independent of the general activity level. With considerable evidence that neither Hull's concepts nor any other formulated theory





could explain the phenomena of exploratory behavior and spontaneous alternation, Montgomery has posited a unique drive, exploratory drive. He regards the drive as a primary drive which is relatively independent of the other primary drives, although it shows some tendency to decrease in strength when another primary drive is heightened, as in the case of food or water deprivation. His specific hypothesis states, "(a) that a novel stimulus evokes in an organism an exploratory drive which motivates exploratory behavior, and (b) that strength of exploratory drive, as measured by amount of exploratory behavior, decreases with time of continuous exposure to a given stimulus situation and recovers during a period of non-exposure." From this theoretical orientation, it was hypothesized that any decrement in exploratory behavior from the exposure to a stimulus situation would generalize to other situations and that the amount of the generalized decrement would decrease as the similarity of the stimulus situations decreased. These hypotheses were tested and confirmed and on the basis of these results, Montgomery has stressed the importance of external stimuli as a factor in exploratory behavior as contrasted to the importance of the response.

Walker and his coworkers (28, 29, 30) have studied the functional relationships among several of the variables operative in spontaneous alternation behavior. One study yielded results contradictory, in part, to the studies of Glanzer and Montgomery in regard to the influence of the stimulus and the response in determining alternation. Walker, like Glanzer, used a cross-shaped T-maze but found half of his animals alternating the response and the other half of the animals alternating the stimulus, although Glanzer's study showed significantly more animals alternating the alley (stimulus). When the maze arms were inclined, however, his data substantiated the other two studies; that

is, his animals alternated the stimulus complex. In a study using discriminable maze cues, white and black maze covers, Estes and Schoeffler (7) randomized the turning responses during the ten massed trials, and found alternation on the basis of the maze stimuli significant at the .01 level while alternation of the turning response, right or left, was 52% or chance.

In a study utilizing the cross-shaped maze and adding the feature of rotation of the maze in order to change the extra-maze stimuli, a comparison was made of the strength of place (extra-maze cues), stimulus (maze cues), and response as determiners of alternation. Walker (30) found that the stimulus had significantly more influence than place, place had significantly more influence than response, and that the response, in this case, was not operative in increasing or decreasing alternation. The general conclusion drawn from this study was that the tendency to alternate would be at a minimum when the stimuli in the two alternatives were the same and would increase as the stimuli became increasingly discriminable. Estes and Schoeffler (7) ran an alternation study with a maze designed in such a way that for an animal to alternate at the choice point, it would be necessary to make the same turning response that had been made moments before. Using ten massed trials and then a test trial, it was found that 100% alternation resulted; that is, all animals ran to the new stimulus complex even though this involved repeating the response. In a maze rotation experiment (90° rotation) in which the specific response could be alternated but the place, extra-maze stimuli, could not be alternated, Estes and Schoeffler found 50% alternation or chance behavior. In contrast, Rothkopf and Zeaman (24) rotated a maze 180° between the forced trials and the test trial and found 69% "response alternation".

In another study, Walker (27) has found that animals which were rewarded in the goal box of a standard T-maze showed significantly more alternation behavior than animals that were not rewarded. He states, on the basis of these data, "the effect of reward is to increase the tendency to alternate and by implication to increase the size of the reaction decrement".

In a study designed to determine whether or not exposure to a stimulus outside of the maze situation would influence the choice of that stimulus on a test trial, Walker (29) obtained negative results. Exposing the animals to both the stimulus color and the place by putting them in the goal box for a 45-second period did not result in any tendency to avoid the color on a test trial. At this point, Walker hypothesized that animals had to make a choice in the stimulus situation before any reaction decrement or stimulus satiation would take place. His next study (14) was designed to test this idea. On the first trial, animals were placed in a T-maze which had glass doors at the choice point so that the alleys could not be entered but they could be observed. Both alleys were the same color, either black or white. On the second trial, one of the alleys was changed in color, the glass doors were removed, and the animals were allowed to make a choice, run to either alley. The results indicated a tendency to run to the alley with the changed stimulus color, significant at the .01 level. Dember (3) hypothesized that these results did not indicate necessarily the effects of stimulus satiation as differentiated from a tendency to explore novel stimuli. In an experimental setup similar to that used by Kivy, Dember placed his animals in the straight alley of a T-maze with glass doors at the choice point but with one alley black and the other alley white. On Trial 2, both alleys were the same color, the glass doors were re-

moved, and the animals were allowed to respond. The subjects responded to the alley which had been changed in color, significant at the .001 level of significance. The stimulus satiation postulate does not seem to be adequate for explaining these data.

Two recent experiments dealing with the intensity of the afferent feedback from a response and with the discriminability of the afferent feedback of different responses as they affect alternation have been reported by Walker (28). The study in regard to intensity or the amount of effort involved in making a response yielded results similar to studies by Solomon and Montgomery; there was no increase in alternation. However, when the maze was built in such a way that the responses to be made were quite different, the tendency to alternate increased significantly. Walker states that these data cannot be explained in terms of any response-type theory.

De Valois (6) studied alternation behavior in a maze with several equally long routes to the goal. Groups of rats running under four different conditions, 6 hours of thirst, 22 hours of thirst, a light shock, and a strong shock, were divided so that half of the animals were shifted to the other condition of the same type half way through the experiment. His results indicate that the "low motivation" subjects were more variable than the "high motivation" subjects, increasing the strength of motivation leads to a decreased amount of variability, and that decreasing the strength of motivation leads to an increased amount of variability in the case of subjects originally run on moderately strong motivation (strong thirst) but not significantly in the case of subjects originally run on extremely high motivation (strong shock).

In an attempt to determine whether a massed series of forced trials increases the tendency to avoid a specific maze location or to

avoid recently visited locations, Estes and Schoeffler (7) ran another experiment. After ten massed forced trials to one side of a T-maze, animals were given ten massed test trials. The tendency to avoid the specific T-maze alley to which the animals had been forced to run dropped to a chance level on the third test trial while the tendency to alternate alleys increased to and remained at approximately the 65% level. This seems to indicate that the animals tend to avoid the specific maze location and that the general tendency to alternate alleys is not affected.

Several unpublished studies by Denny and his students (13, 15, 16) at Michigan State University have dealt primarily with two problems related to alternation behavior. One of these problems was to compare the eliciting value of two stimulus complexes when one complex has been experienced twice as frequently as the other. For instance, in a T-maze situation if some forced trials are used so that animals run to the left alley twice and to the right alley once in each block of three runs, all runs being rewarded, will the free trials indicate a tendency to turn left or right? The second main problem with which these studies have been concerned is the length of time during which the reaction decrement is operative. Matus and Lange's study (16) used two trials a day with a thirty-minute interval. Two groups of animals were used, one group on a L L R ratio and the other on a R R L ratio, to control for direction preference. By the twelfth day, 80% of the animals were running to the alley which had been experienced less frequently. In a similar study, Martindale (15) found that after animals had formed a running habit to the less frequently visited alley and the schedule of forced trials was reversed, the animals' running habit also was reversed and the animals again were running to the stimu-

lus complex less frequently experienced. Julian (13) used three trials a day with a two-hour inter-trial interval and obtained similar results. His animals also selected the less frequently experienced alley on free trials. After Julian's group was showing consistent behavior, 100% going left on free trials on days five through nine, the schedule was reversed from R R L to L L R and with nine more days, the percentage of left turns had fallen to 50. Since Julian's animals developed rapidly the tendency to turn to the less frequently experienced alley even with a two-hour interval, research for the present thesis was planned with a much longer interval in an attempt to determine the limit to the parameter.



## STATEMENT OF THE PROBLEM

The present research was designed primarily to determine whether or not the effects of stimulus satiation are present after a 24-hour period. If a 24-hour period does not allow for complete dissipation of the satiation effects from a single event, trials administered on a one-a-day schedule should result in a habit of running to the less frequently visited side of a T-maze with dissimilar arms.

The same T-maze, but with similar arms, also was used in order to determine the role of the differential intra-maze stimuli in the development of an alley preference.

Two other variables, food satiation and extra-maze stimuli, also were manipulated experimentally.



## APPARATUS

The apparatus used in this experiment was a standard T-maze as shown diagrammatically in Figure 1. It consisted of a starting box, a combination stem and choice-point section, 14" long, two alleys, 20" long, and two goal boxes. All of the sections were 6" deep and 4" wide. The entire maze was natural wood and was covered with hardware cloth. Black cardboard was used to line the stem and one of the two alleys when the experimental design called for differential stimuli. Guillotine-type doors were placed at the exit of the starting box, at the choice point, and at the entrance to the goal boxes, and were used to prevent retracing.

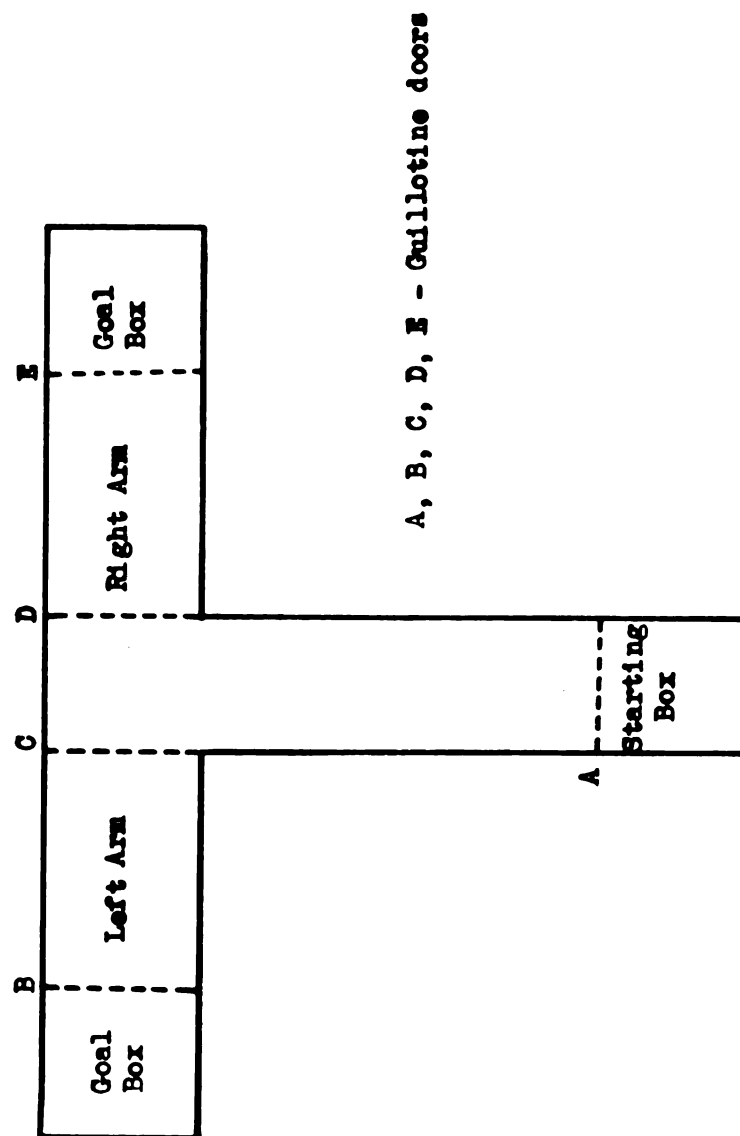


Figure 1. Diagrammatic drawing of T-maze.

## SUBJECTS

The subjects used in the present study were 54 experimentally naive male rats from the colony maintained by the department of psychology of Michigan State University. The animals, 27 albino rats and 27 hooded rats, ranged in age from 120 to 150 days at the beginning of the experiment.

## PROCEDURE

All animals were handled and then fed in individual feeding cages for ten days prior to the beginning of the experiment. During this period, they were fed 8 grams of Purina Dog Chow every 24 hours, water being available at all times. At the end of the ten-day period, the animals were randomly divided into four groups, except for the control of the proportion (50-50) of hooded and albino animals in each group and the total number for each group.

The basic design for all four groups involved specifying the proportion of runs to each maze alley. Two ratios were used, L L R and R R L. For animals on a L L R ratio, each three-day period included two trials of running to the left alley and one trial of running to the right alley and for animals on a R R L ratio the reverse was true. During each three-day period, the first day's trial was a free-choice trial; both maze alleys were unblocked and the animals could go left or right. The second day's trial was forced or free depending upon the direction of the first day's run. For an animal on a L L R ratio, if the first run were to the right alley, the second and third trials were forced left runs. However, if the first run were to the left alley, the second trial was again a free-choice trial, and only the third trial was forced. Sliding panels located at the entrance to each alley were used on forced trials; the animal could enter only one of the alleys. A pellet of food was in the goal box of each alley on each trial so that all runs were rewarded.

Group 1 (N-twelve animals) was given 52 days of training on a

L L R ratio, with the left alley of the maze lined with black cardboard and the right alley unlined, or natural wood finish. On Days 53 through 58, the subjects were given three trials a day at fifteen-minute intervals. Following the training period, 26 extinction trials were run, one free-choice trial a day. In an attempt to determine the influence of satiation and extra-maze cues on the learned response, the following procedure was utilized. A three-day delay period was introduced and three of the five remaining animals (with five animals the response had been extinguished) were placed on an ad libitum feeding schedule while the other two were continued on their regular feeding schedule of 8 grams a day. On Day 88, these animals (three-satiated, two-food-deprived) ran one trial. On Day 89, the maze was rotated 180°, reversing the extra-maze cues, and on Days 89, 90, and 91, the subjects were given one free-choice trial a day. Two animals were discarded from Group 1 on Day 2 when they failed to leave the starting box for the second consecutive day. A 10-minute criterion period was used.

Group 2 (N-twelve animals) was given 24 days of training on a R R L sequence, with the left alley of the maze lined with black cardboard and the right alley unlined. The animals then were given three free-choice trials, after which, the training sequence was reversed from R R L to L L R and was continued for 33 days. Then, the black cardboard was moved so that the left alley was natural wood and the right alley was lined with black and training trials were continued for 12 additional days. An extinction period of 12 days followed. Finally, a three-day delay period was used, during which four subjects were placed on an ad libitum feeding schedule while three animals continued on the deprivation feeding schedule. One free-choice trial was run on Day 88. The maze was rotated 180° and free-choice trials

were run on Days 89, 90, and 91. One animal was discarded from Group 2 on Day 2 when it failed to leave the starting box for the second consecutive day. A 10-minute criterion period was used.

Groups 3 (N-five animals) and 4 (N-five animals) were given 19 training trials with both maze alleys lined with black cardboard, Group 3 on a 2L:1R ratio and Group 4 on a 2R:1L ratio. At the end of the 19 days, the cardboard was removed from the left alley, leaving the left alley a natural wood finish and the right alley black. Acquisition trials were continued for 14 days. The procedure was changed at this point so that Group 3 was forced to run to the left alley on the first two trials of each block of three trials and Group 4 was forced to run to the left on the first trial only. After the subjects had run 16 trials on this schedule, the maze was rotated 180° and eight final trials were run with the extra-maze cues reversed.

A partial replication was done with Groups 5 (N-ten animals) and 6 (N-ten animals) in an attempt to eliminate the influence of the unknown extra-maze stimulus operative with Groups 1 and 2. Groups 5 and 6 were given 31 training trials with the left alley lined with black cardboard and the right alley a natural wood finish, Group 5 on a 2L:1R sequence and Group 6 on a 2R:1L ratio. The extinction period consisted of ten days of one-a-day free-choice trials followed by three days of five massed trials, with an inter-trial interval of approximately twenty minutes. Three animals from Group 5 and one animal from Group 6 were discarded on Day 2 when they failed to leave the starting box for the second consecutive day. A 10-minute criterion period was used.

TABLE I

## DESIGN

|                       |         |                                                        |
|-----------------------|---------|--------------------------------------------------------|
| <u>Group 1</u> N - 10 |         |                                                        |
| Acquisition:          | 52 days | 1 trial a day, L L R, L - black, R - natural           |
|                       | 6       | 3 trials a day, 15-minute interval                     |
| Extinction:           | 26      | 1 trial a day, free-choice trials                      |
|                       | 3       | delay period - no trials                               |
|                       | 1       | free-choice trial, 3 animals satiated                  |
|                       |         | 2 animals food-deprived                                |
|                       | 3       | free-choice trials, maze rotated 180°                  |
| <u>Group 2</u> N - 11 |         |                                                        |
| Acquisition:          | 24      | 1 trial a day, R R L, L - black, R - natural           |
|                       | 3       | free-choice trials                                     |
|                       | 33      | L L R schedule                                         |
|                       | 12      | L L R, L - natural, R - black                          |
| Extinction:           | 12      | free-choice trials                                     |
|                       | 3       | delay period - no trials                               |
|                       | 1       | free-choice trial, 4 animals satiated                  |
|                       |         | 3 animals food-deprived                                |
|                       | 3       | free-choice trials, maze rotated 180°                  |
| <u>Group 3</u> N - 5  |         |                                                        |
| Acquisition:          | 19      | 1 trial a day, L L R, L and R - black                  |
|                       | 14      | R - black, L - natural                                 |
|                       | 16      | force L, force L, free-choice                          |
|                       | 8       | force L, force L, free-choice<br>maze rotated 180°     |
| <u>Group 4</u> N - 5  |         |                                                        |
| Acquisition:          | 19      | 1 trial a day, R R L, L and R - black                  |
|                       | 14      | R - black, L - natural                                 |
|                       | 16      | force L, free-choice, free-choice                      |
|                       | 8       | force L, free-choice, free-choice<br>maze rotated 180° |

Group 5 N - 7

Acquisition: 31 days 1 trial a day, L L R, L - black, R - natural

Extinction: 10 1 trial a day, free-choice trials

3 5 trials a day, 20-minute inter-trial interval,  
free-choice trials

Group 6 N - 9

Acquisition: 31 1 trial a day, R R L, L - black, R - natural

Extinction: 10 1 trial a day, free-choice trials

3 5 trials a day, 20-minute inter-trial interval,  
free-choice trials



## RESULTS

The experimental results have been analyzed in terms of the responses made on the test trials, the first trial of each block of three days. The number of left-turning responses made by each group was used as the basis for statistically comparing performance trends during acquisition and extinction.

### Acquisition Data

Figure 2 shows the percentage of animals in Group 1 running to the right alley of the T-maze on free trials. This group was trained on a 2L:1R ratio and after 52 days showed a consistent pattern with five animals going to the right alley on each free trial and five animals going to the left. During the six days, Days 53-58, when the subjects were given three trials a day at fifteen-minute intervals, there were no reversals in choice of alley. Each of the ten subjects ran all six free trials in the same direction that it was running at the end of the 52 days of training with one trial a day.

On the 2R:1L ratio, 100% of the animals in Group 2 ran left on five of the eight free trials during training, as can be seen in Figure 3. Free trials on three consecutive days, Days 25-27, yielded 100, 91, and 82% of the subjects turning left. The training sequence was reversed from 2R:1L to 2L:1R for 33 days and the percentage of animals making left turns on any specific trial varied from 75 to 100. In other words, the group showed no significant tendency to reverse; alternating responses did not occur at this stage of learning. On the thirteenth day of this reversal period, a sudden drop in temperature resulted in the

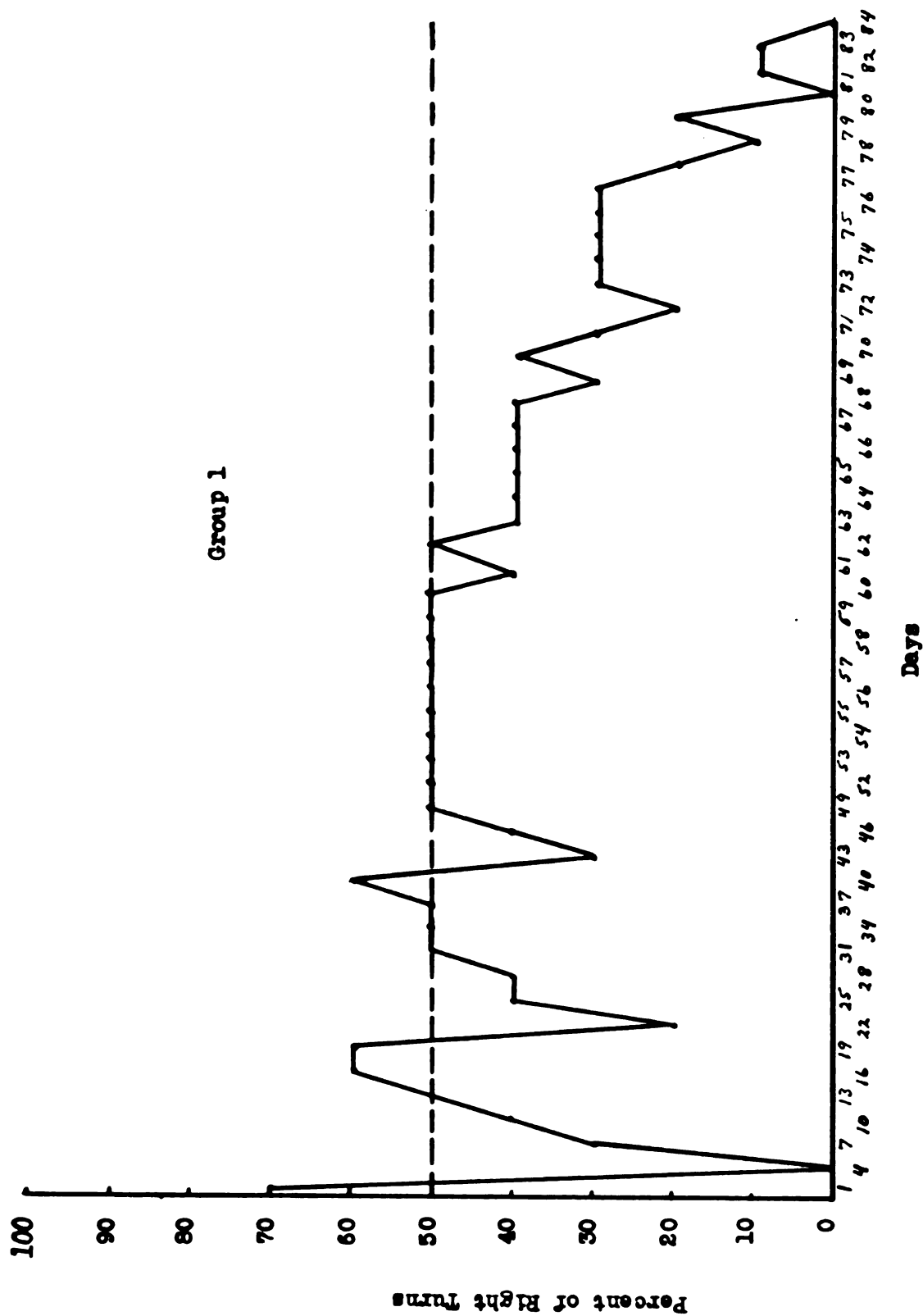


Figure 2. Percent of right-turning responses on each test trial during learning, Days 1-58, and extinction, Days 59-84.

Days

death of three animals in this group. All three of the animals had been running consistently to the left alley.

In a comparison of the mean number of left-turning responses during learning made by the animals in Group 1 ( $M = 5.3$ ,  $S.D. = 2.53$ ) and Group 2 ( $M = 7.91$ ,  $S.D. = .668$ ) a  $t$  value of 3.01 was obtained, significant at the .02 level of confidence.

Figure 4 shows the percentage of animals in Group 3 trained on the 2L:1R ratio making right turns and Figure 5 shows the percentage of animals in Group 4 trained on the 2R:1L ratio making left turns. Both groups were trained for 21 days with the entire maze lined with black cardboard. On the test trial at the end of the period, 80% of Group 4 and 100% of Group 3 ran to the left alley of the maze. With identical maze stimuli, these animals acquired the same response habit, namely, running to the left alley. With the cardboard removed from the left alley so that the maze stimuli were discriminable (natural wood finish in the left alley and black cardboard in the right), twelve additional trials showed no significant change in the number of animals running left on free trials.

Figure 6 shows the percentage of animals in Groups 5 and 6 making running responses to the less frequently visited alley of the maze, right-turning responses for Group 5, left-turning responses for Group 6. Both groups were trained for 31 days with the left alley lined with black cardboard and the right alley a natural wood finish. At the end of acquisition trials, Group 5 showed a tendency to make right-turning responses on free trials, 71% on Days 28 and 31, and Group 6 showed the opposite tendency, 70% left turns on Day 28 and 89% on Day 31.

In a comparison of the mean number of left-turning responses

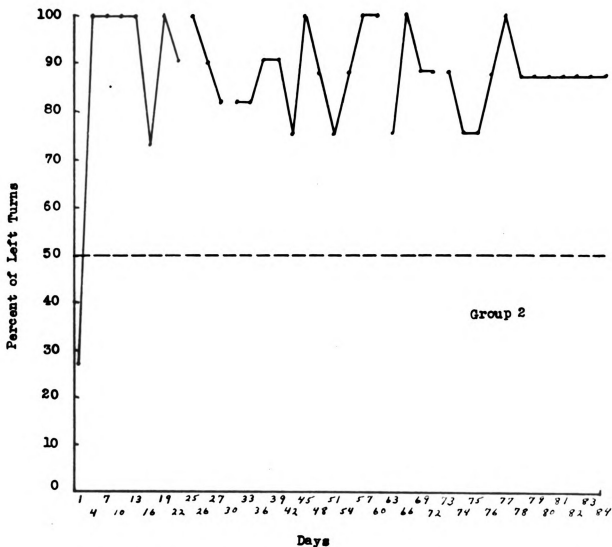


Figure 3. Percent of left-turning responses on each test trial during learning, Days 1-72, and extinction, Days 73-84.



made during the total acquisition period by the animals in Group 5 ( $M = 4.3$ ,  $S.D. = 2.81$ ) and Group 6 ( $M = 7.0$ ,  $S.D. = 1.82$ ) a  $t$  value of 2.05 was obtained which approaches the 5% level (2.145).

#### Extinction Data

In this study, extinction does not refer to the omission of food but to the omission of the forcing procedure. During the extinction period for Group 1, an extinction criterion of two reversals during a period of three days was used. During the first 26 extinction trials, the five animals which were turning left consistently at the end of acquisition trials showed no reversals, each animal turned left on 26 consecutive days. Of the five animals which had been turning right at the end of learning trials, four extinguished, i.e., ran twice to the left alley within a three-day period and the fifth animal showed two reversals but not on successive trials. After each animal extinguished, no trials were given for a period of seven days. This was followed by one free-choice trial; all four animals turned left on this test trial.

During the ten one-a-day extinction trials for Groups 5 and 6, only one animal, a right-turning animal in Group 5, varied its running pattern; it turned left on Days 9 and 10. Day 31, the last day of acquisition trials was a free trial and was followed by ten days of extinction or free trials. Massed extinction trials began on Day 42. Including the trial on Day 31, the trials on Days 32 through 41 and the first free trial of Day 42, there were twelve consecutive one-a-day extinction trials. The total number of left-turning responses made by each group during this twelve-day period was used to compare the performance of the groups as it existed at the end of acquisition and during spaced extinction. A  $t$  value of 2.624 was obtained, significant at the 2% level (Group 5,  $M = 3.7$  left turns,  $S.D. = 5.29$ ; Group 6,

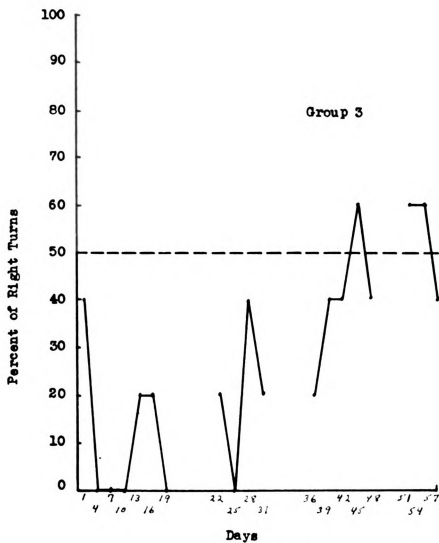


Figure 4. Percent of right-turning responses on each test trial.

$M = 10.7$  left turns,  $S.D. = 3.77$ ).

It seems clear from these data that the subjects in the differential alley maze did show learning on a one-trial-a-day schedule. The response which was learned was running to the less frequently experienced alley, the R of the 2L:1R ratio (Groups 1 and 5) or the L of the 2R:1L ratio (Groups 2 and 6) even when the left-turning tendency due to an unknown extra-maze stimulus had been eliminated (Group 6). All animals were exposed to both alleys throughout the learning trials since they were forced on the third trial of each block to one alley or the other, depending on which alley was entered on the test trial. At least four possible response patterns could have developed on a one-trial-a-day schedule in a T-maze with discriminable cues. The animals could have shown no learning or random alley selection, they could have alternated turning responses, they could have learned to turn in the direction that had been most rewarding or, as they actually did, they could have learned to run to the less frequently visited maze arm. When the intra-maze cues were reduced by lining both alleys with black cardboard, Groups 3 and 4, there was no significant difference between the response patterns of the two groups and thus no evidence of a developed preference for the less frequently visited side.

#### Subsidiary Findings

Several subsidiary findings have been noted from the data. The first question is that of whether or not original position preferences account for the turning habit acquired later in the experiment. That is, did these animals "learn" to go to the alley to which they responded on the first trial? On Day 1, three of the ten animals in Group 1, three of the eleven in Group 2, three out of five in Group 3, three out of five in Group 4, four out of seven in Group 5, and two out of nine





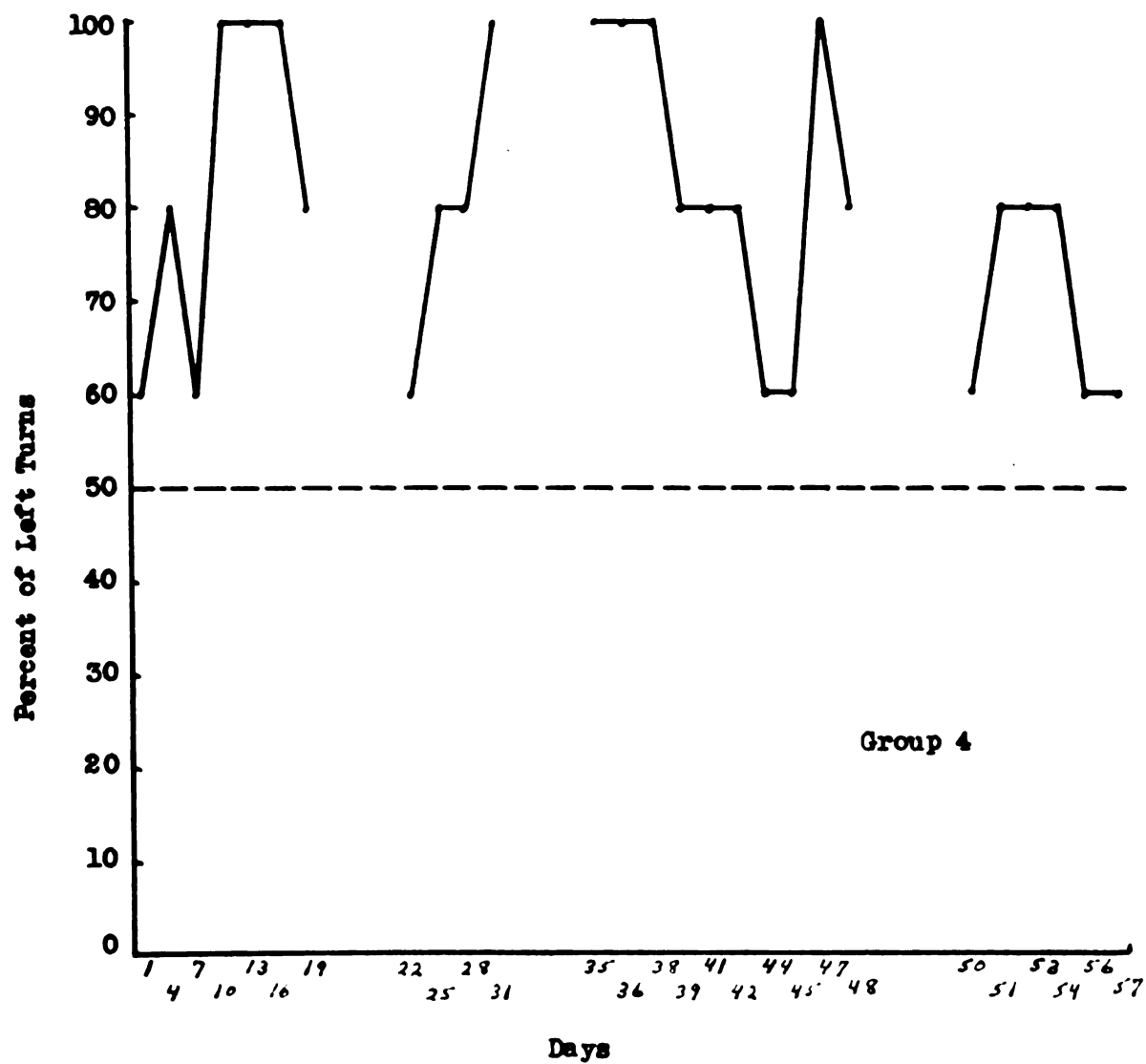


Figure 5. Percent of left-turning responses on each test trial.

in Group 6 made left-turning responses. There is no indication from these totals that the habit acquired was the same response as that made on Day 1, inasmuch as Groups 2, 3, 4, and 6 later acquired a left-turning response habit while Group 5 acquired a right-turning response habit.

Another factor apparent in the data of all six groups is the strength of the habit once it has been acquired. The extinction trials can be regarded as a demonstration of fixation, considering how seldom the animals responded to the non-habitual alley. With Group 2, for instance, after the initial acquisition period of 24 days (2R:1L), during which the group learned to make left-turning responses, there was no change in response pattern during the following 33 days on the opposite schedule (2L:1R). During a subsequent twelve days of training when the right alley was lined with black cardboard and the left alley was natural wood finish, the percentage of animals turning left varied from 75 to 100, the same as during earlier acquisition trials, Days 4-60. On the first free trial after the colors of the alleys were reversed, the median running time went from the usual 3 seconds to 7.5 seconds. However, the animals still ran to the left alley; possibly, the habit was maintained due to the effects of the extra-maze stimuli. At the start of extinction trials, seven animals in Group 2 were running consistently to the left alley of the maze and one animal was running consistently to the right alley. From Day 73 to Day 77, extinction trials, the percentage of left-turning responses varied from 75 to 100. Then, from Day 78 to Day 84, extinction trials, the seven animals which had been turning left consistently at the end of the learning period made only left-turning responses and the one animal which had been running to the right alley during learning trials made only right-turning responses.

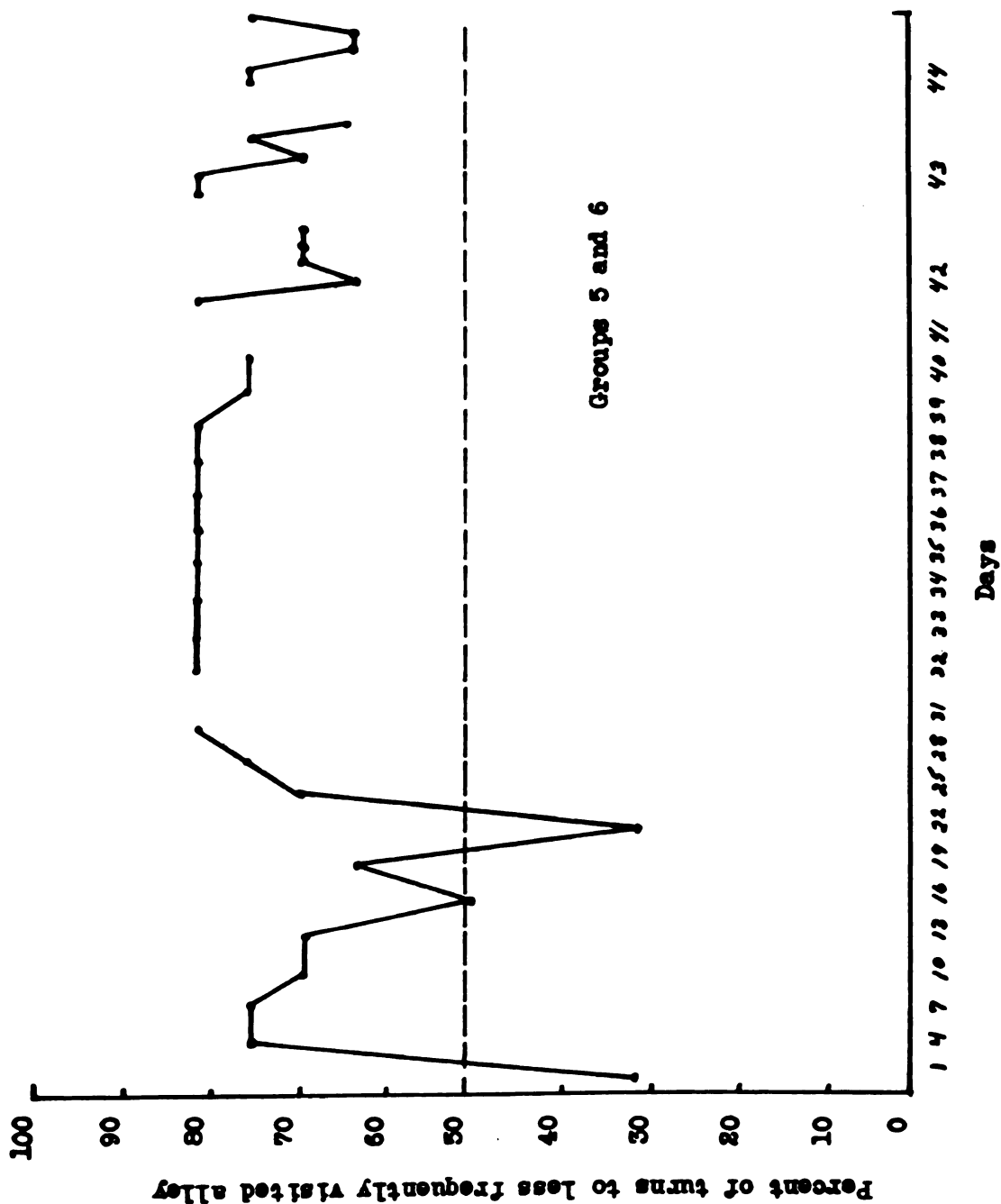


Figure 6. Percent of responses to the less frequently visited alley on each test trial during learning, Days 1-31, and extinction, Days 32-44.

Massed trials were used with Groups 5 and 6 after the ten one-a-day extinction trials to determine whether or not massing would have any more effect on the fixated habit of these animals than did the one-a-day trials. During the massed extinction trials, five a day with 20-minute inter-trial intervals, the animals in Group 5 made 13 reversal responses out of a total of 105 responses or 12% while Group 6 made 11 such responses out of a total of 135, or 8%. Even this massing of trials resulted in very little extinction; the fixation of the learned response is apparent.

Some evidence regarding the effect of satiation on the running habit has been tabulated. On Day 88, after three animals from Group 1 and four animals from Group 2 had been satiated, one free-choice trial was given. Two of the seven satiated animals ran to the alley opposite to their learned response, one animal with a left-turning habit ran to the right alley and one animal with a right-turning habit ran to the left alley. None of the five control animals, food-deprived, reversed directions.

On Days 89, 90, and 91, after the maze had been rotated 180° so that the extra-maze cues were reversed, six out of twenty-one responses or 28.6% by the satiated animals were reversals while four of fifteen responses or 26.6% by the control animals were reversals. The following table summarizes these data.

|        | Group 1                     |         | Group 2  |         |
|--------|-----------------------------|---------|----------|---------|
|        | Reversals - Total responses |         |          |         |
|        | Satiated                    | Control | Satiated | Control |
| Day 88 | 1-3                         | 0-2     | 1-4      | 0-3     |
|        | Maze Rotated                |         |          |         |
| Day 89 | 1-3                         | 1-2     | 3-4      | 2-3     |
| Day 90 | 1-3                         | 0-2     | 1-4      | 0-3     |
| Day 91 | 0-3                         | 1-2     | 0-4      | 0-3     |

The number of subjects included in this part of the study is too small for the data to be anything more than suggestive.

## DISCUSSION

These data seem to indicate that learning does occur with a time interval of 24 hours between trials when there are discriminable intra-maze cues. In approximately 30 days the animals in all six experimental groups acquired strong habits either of running to the left alley or of running to the right alley on each free-choice trial. Previous theorizing in this area (11,27) would have led to no such prediction, on the basis of stimulus satiation or response factors, since a 12-hour interval was considered to be the longest interval over which a response was influenced by a preceding stimulus or response event. Hullian theorizing would have led to the prediction that in the event any learning took place in a situation involving a 24-hour delay, the response which would be learned would be that of running to the alley where the reward had been obtained the more frequently, the L of the 2L:1R ratio or the R of the 2R:1L ratio. The animals in this experiment did not learn to go to the more frequently rewarded alley nor did they simply alternate their responses. An alternating habit would have shown up during extinction, daily free-choice trials, in the form of alternate right and left turns. As has been pointed out earlier, the running habit, once acquired, was resistant to extinction in most cases.

Walker's study (30) in which he analyzed the influence of the three variables, indicated that intra-maze cues were the most important, extra-maze cues were of next importance, and the previous response was of little, if any, importance in determining alternation behavior. Using a cross-shaped maze, Walker found more animals making a response

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which involved different maze stimuli than making a response which involved different extra-maze stimuli or a different turning response, as such. In the present study, Groups 1 and 2 which had discriminable maze cues, learned different responses than Groups 3 and 4 which had non-discriminable maze cues. Most of the animals, 8 out of 10, in Groups 3 and 4 developed a habit of running to the left alley on free-choice trials. Inasmuch as the lighting was constant and an auditory masking stimulus, a fan, was used, the discriminable extra-maze cues to which these animals were responding are not known. However, the point is, the extra-maze stimulus pattern was identical for all four groups and Groups 1 and 2 with discriminable maze cues present learned on the basis of the intra-maze cues rather than on the basis of the extra-maze cues. In the absence of obvious intra-maze cues, as was the case with Groups 3 and 4, the extra-maze cues apparently became the eliciting agent in the situation. Another fact which seems to indicate the importance of extra-maze stimuli in the present study is present in the extinction data. The only animals which showed a tendency to extinguish were those in Group 1 which had acquired a habit of running to the right alley. The eliciting strength of the extra-maze cues, apparently located to the left of the maze, was sufficient to change the response pattern of the right-turning subjects. It also seems to have been the case that cues, intra-maze or extra-maze, play a more important role early in the learning sequence than they do later. When Group 2 was switched from a stimulus situation involving a black left alley and a natural wood right alley to the opposite pattern on the 63rd day of learning, no significant change in running habits occurred. Likewise, with Groups 3 and 4 which were changed from a stimulus situation involving a black left and a black right alley to a black left alley and



a natural wood right alley on the 22nd day, no significant change in response took place. Although Martindale (15) and Julian (13) found that their animals reversed their running responses when the stimulus pattern was reversed, the present study did not find this. Martindale used an inter-trial interval of fifteen minutes and Julian used an inter-trial interval of two hours contrasted to the interval of 24 hours used in the present study. It may be that after a response becomes established on a schedule using a long inter-trial interval, drastic changes in the stimulus complex are necessary to elicit a new response. The maze rotation on Day 89 resulted in 28.6% reversal responses by the satiated subjects and 26.6% reversal responses by the food-deprived subjects on the following three days' trials. Maze rotation, i.e., change in extra-maze cues, on Day 89 resulted in more reversals than changing the intra-maze cues on Day 63 with Groups 1 and 2.

The data of De Valois (6) indicate that low motivation, 6 hours of water deprivation or a light shock, leads to more variability of response in a multiple maze than does high motivation, 22 hours of water deprivation or a strong shock. The results on Day 88 in the present study would seem to lend some support to this idea although the number of animals was too small at that stage for being more than suggestive. However, two of the seven satiated subjects did reverse their turning response while none of the five control animals did. Inasmuch as these animals had developed a habit of approximately three months' duration, it is interesting that any of them reversed their response, and that the two which reversed were the satiated animals, low motivation.

No theoretical analysis of the various research results related to alternation phenomena has been sufficiently comprehensive. The attempts by various investigators to account for the research find-

ings invariably have left some contradictory evidence unexplained. Hull's concept of a response-produced inhibitory or negative drive state,  $I_r$ , includes the ideas that alternation of responses should increase as a function of the increasing effort of the response and that  $I_r$  and the tendency to alternate should dissipate within a short time. Experiments designed to test the first of these ideas, namely, that alternation of response should increase as a function of increasing effort of response, have yielded contradictory results. Solomon's (25) animals increased alternation responses when inclined planes were used as the method of increasing the effort of the response but they did not increase alternation responses when weights tied to their backs were used. Dennis (4) and Walker (28) have used increased effort as the experimental variable and have found no increase in the tendency to alternate responses. The work of Glanzer (8), Estes (7), and Walker (30) which found animals alternating intra-maze stimuli rather than the specific response would not be predicted from the  $I_r$  postulate.

Glanzer noted the theoretical weaknesses of Hull's concept,  $I_r$ , and formed a new postulate regarding stimulus satiation, a state which supposedly increases as an organism perceives a stimulus or stimulus complex. Glanzer's concept can account for his own research data, the results from which indicated that animals tend to alternate stimuli rather than responses. However, the concept does not explain Dember's data (3) which showed animals responding to a change in the stimulus situation even though the stimulus involved was that to which the subjects had been exposed, satiated. Neither does it explain Walker's experiment (29) in which the passive perception of a stimulus outside the maze or in the goal box of the maze if the animal is placed there instead of running there did not lead to an increase in

alternating responses. Glanzer's postulate and its corollaries do not lead to the prediction of differential amounts of alternation resulting from inactive perception or active responding, running.

Montgomery (22) has attempted to clarify the situation by naming the tendency of an organism to respond to new stimulus complexes, a primary drive, the exploratory drive. Those drives with which psychologists have been working in the past, e.g., hunger, thirst, etc., have been shown to be lacking any precise definition or any explanatory value (2). Therefore, adding one more specific drive seems to be something less than beneficial to theory development.

Estes (7) states that alternation behavior may represent transfer of training which has taken place during pretraining or in an incidental manner in the laboratory environment, the home cages of the animals. For instance, if there were a negative correlation between the probability of receiving reinforcement in a given location and the recency of visiting that location, alternation or responding to new stimuli would be predicted. In one study, Grossberg and Sprinzen (10) reinforced some rats when they repeated an approach response to a specific stimulus complex and reinforced other rats only when they varied their responses. When tested in a Y-maze situation, the latter group of animals alternated maze arms significantly more than the former group.

The learning theory currently being developed by Denny and Adelman (5) states in the Stimulus Satiation Postulate, "Thus, for all practical purposes, learning occurs if and only if a response is elicited in a consistent manner." In the present experiment, when discriminable maze cues were used, it would seem to be the case that the stimulus complex of the less frequently visited alley had higher eliciting value

than did the other alley and hence elicited a response in a consistent manner. Apparently, this holds true only during the first few days, approximately 30, while the turning habit is being acquired since after that time few alternating responses occurred with changes of stimuli or with extinction trials. One factor which undoubtedly contributed to the relative absence of alternating responses late in the course of the experiment was the long period of food deprivation of the animals. Montgomery found less exploratory behavior by food-deprived subjects than by satiated subjects and De Valois found fewer alternations in the case of highly motivated animals than in the case of rats with low motivation. Hence, an increase in the number of hours of food-deprivation would seem to lead to less alternation or to a greater tendency to fixate. The animals in the present study were kept on short rations for approximately two-three months and this may have increased the tendency to form fairly rigid response patterns.

## SUMMARY

The present thesis was concerned with several of the factors related to alternation behavior. The primary interest was in an attempt to determine whether or not the stimulus satiation developed in a specific situation decreases to zero in less than 24 hours. This was tested. A study also was made of the eliciting values of maze and extra-maze cues by the use of differential maze stimuli. The effects of maze cues during the early trials of the learning period, before the formation of a habit, were compared to the effects of the same cues after a turning-response habit had been acquired. Lastly, a comparison was made of the reversal tendency of satiated subjects with that of food-deprived animals.

Forty-seven experimentally naive male rats were used in the study. Group 1, ten animals, received the following training; (1) 52 days, one trial a day, 2L:1R ratio, (2) 6 days, 3 trials a day with a fifteen-minute inter-trial interval, 2L:1R ratio, (3) 26 days, free trials, followed by a three-day delay period, (4) 1 day, free trial, with three subjects satiated and two subjects food-deprived, (5) 3 days, free trials, maze rotated 180°. During the entire experiment, the left alley was black and the right alley was natural wood finish. Group 2, eleven animals, received the following training; (1) 24 days, 2R:1L ratio, left alley - black and right alley - natural wood finish, (2) 3 days, free trials, (3) 33 days, 2L:1R ratio, (4) 12 days, 2L:1R ratio, left alley - natural wood finish and right alley - black, (5) 12 days, free trials, followed by a three-day delay period, (6) 1 day, free trial, with four animals satiated and three animals food-deprived,

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(7) 3 days, free trials, maze rotated 180°. Group 3, five animals, received the following training; (1) 19 days, 2L:1R ratio, left and right alleys - black, (2) 14 days, left alley - natural wood finish and right alley - black, (3) 16 days, Forced L, Forced L, Free-choice sequence, (4) 8 days, maze rotated 180°. Group 4, five animals, received the following training; (1) 19 days, 2R:1L ratio, left and right alleys - black, (2) 14 days, left alley - natural wood finish and right alley - black, (3) 16 days, Forced L, Free-choice, Free-choice sequence, (4) 8 days, maze rotated 180°. All trials for Groups 2, 3, and 4 were on a one-trial-a-day basis. Group 5, seven animals, received the following training; (1) 31 days, 2L:1R ratio, left alley - black and right alley - natural wood finish, (2) 10 days, free trials, one a day, (3) 3 days, free trials, five a day with twenty-minute, inter-trial intervals. Group 6, nine animals, received the following training; (1) 31 days, 2R:1L sequence, left alley - black and right alley - natural wood finish, (2) 10 days, free trials, one a day, (3) 3 days, free trials, five a day with twenty-minute, inter-trial intervals.

The following results were obtained. The acquisition of a habit did occur with all six groups even though the inter-trial interval was 24 hours. Groups 1, 2, 5 and 6, with which differential intra-maze cues were used, showed a tendency to respond to the less frequently experienced stimulus complex. Groups 3 and 4, with which non-discriminable maze cues were used, learned to go to the left alley, presumably on the basis of extra-maze cues. The running response which was learned was extremely resistant both to reversal when the maze stimuli were changed and to extinction when the trials were all free-choice. The tendency for satiated animals to show more reversals than food-deprived animals was discussed. There was an indication that

extra-maze cues have some eliciting value after a running habit has been developed as shown by the effects of maze rotation after 88 days of running trials.

The limitations of various theoretical approaches to the problem of alternation phenomena were discussed.



## BIBLIOGRAPHY

1. Berlyne, D. E. Novelty and curiosity as determinants of exploratory behavior. Brit. J. Psychol., 1950, 41, 68-80.
2. Behan, R. A. The Quantification of Drive: III. Privation of food and water. Unpublished Ph.D. Dissertation, Michigan State University, 1954.
3. Dember, W. N. Response by the rat to environmental change. J. comp. physiol. Psychol., 1956, 49, 93-95.
4. Dennis, W. Spontaneous alternation in rats as an indicator of the persistence of stimulus effects. J. comp. Psychol., 1939, 28, 305-312.
5. Denny, M. R., and Adelman, H. M. Elicitation Theory: I. An analysis of two typical learning situations. Psychol. Rev., 1955, 62, 290-296.
6. De Valois, R. L. The relation of different levels and kinds of motivation to variability of behavior. J. exp. Psychol., 1954, 47, 392-398.
7. Estes, W. K., and Schoeffler, W. S. Analysis of variables influencing alternation after forced trials. J. comp. physiol. Psychol., 1955, 48, 357-362.
8. Glanzer, M. Stimulus satiation: An explanation of spontaneous alternation and related phenomena. Psych. Rev., 1953, 60, 257-268.
9. Glanzer, M. The role of stimulus satiation in spontaneous alternation. J. exp. Psychol., 1953, 45, 387-393.
10. Grossberg, J., and Sprinzen, H. Unpublished research, University of Indiana, 1954.
11. Heathers, G. L. The avoidance of repetition of a maze reaction in the rat as a function of the time interval between trials. J. Psychol., 1940, 10, 359-380.
12. Hull, C. L. Principles of Behavior. New York: Appleton-Century-Crofts, 1943.
13. Julian, J. Unpublished research, Michigan State University, 1955.

14. Kivy, P. N., Earl, R. W., and Walker, E. L. Stimulus context and satiation. J. comp. physiol. Psychol., 1956, 49, 90-92.
15. Martindale, R. Unpublished research, Michigan State University, 1954.
16. Matus, E., and Lange, E. Unpublished research, Michigan State University, 1955.
17. Montgomery, K. C. Exploratory behavior as a function of similarity of stimulus situations. J. comp. physiol. Psychol., 1953, 46, 129-133.
18. Montgomery, K. C. Spontaneous alternation as a function of time between trials and amount of work. J. exp. Psychol., 1951, 42, 82-93.
19. Montgomery, K. C. Exploratory behavior and its relation to spontaneous alternation in a series of maze exposures. J. comp. physiol. Psychol., 1952, 45, 50-57.
20. Montgomery, K. C. The relation between exploratory behavior and spontaneous alternation in the white rat. J. comp. physiol. Psychol., 1951, 44, 582-289.
21. Montgomery, K. C. The effect of the hunger and thirst drives upon exploratory behavior. J. comp. physiol. Psychol., 1953, 44, 315-319.
22. Montgomery, K. C. A test of two explanations of spontaneous alternation. J. comp. physiol. Psychol., 1952, 45, 287-294.
23. Montgomery, K. C. The effect of activity deprivation upon exploratory behavior. J. comp. physiol. Psychol., 1953, 44, 438-441.
24. Rothkopf, E. Z., and Zeaman, D. Some stimulus controls of alternation behavior. J. Psychol., 1952, 34, 235-255.
25. Solomon, R. L. The influence of work on behavior. Psychol. Bull., 1948, 45, 1-40.
26. Tolman, E. C. Purpose and cognition: The determiners of animal learning. Psychol. Rev., 1925, 32, 285-297.
27. Walker, E. L. Reward, Time, and Variability. Mimeographed paper, 1955.
28. Walker, E. L., Dember, W. N., Earl, R. W., Fawl, C. L., and Karoly, A. J. Choice alternation: III. Response intensity vs. response discriminability. J. comp. physiol. Psychol., 1955, 48, 80-85.
29. Walker, E. L., Dember, W. N., Earl, R. W., Fliege, S. E., and Karoly, A. J. Choice alternation: II. Exposure to stimulus or stimulus and place without choice. J. comp. physiol. Psychol., 1955, 48, 24-29.

30. Walker, E. L., Dember, W. N., Earl, R. W., and Karoly, A. J.  
Choice alternation: I. Stimulus vs. place vs. response. J. comp. physiol. Psychol., 1955, 48, 19-24.
31. Wingfield, R. C. Some factors influencing spontaneous alternation in human subjects. J. comp. Psychol., 1943, 35, 237-244.
32. Zeaman, D., and House, B. J. The growth and decay of reactive inhibition as measured by alternation behavior. J. exp. Psychol., 1951, 41, 177-186.

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