EXPLORATORY BEHAVIOR IN A COMPLEX MAZE, UNDER CONDITIONS OF SATIATION AND DEPRIVATION

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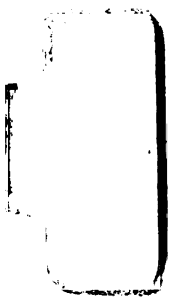

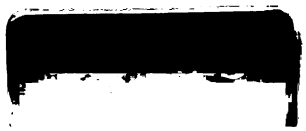

EXPLORATORY BEHAVIOR IN A COMPLEX MAZE, UNDER CONDITIONS OF SATIATION AND DEPRIVATION

BY

JAMES NORMAN ALLEN

AN ABSTRACT

Submitted to the College of Science and Arts
Michigan State University of Agriculture and
Applied Science in partial fulfillment of
the requirements for the degree of

MASTER OF ARTS

Department of Psychology

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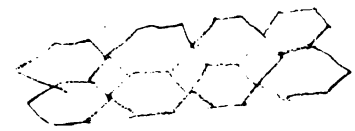
Approved by: M. Ray Denny

ABSTRACT



The present problem arose from the empirical disagreements present in the literature, among Montgomery, Alderstein and Fehrer, Thompson, and earlier Dashiell, as to whether satiated or deprived animals explore at a faster rate. In contrast to the disagreement present in exploration studies, general activity studies regularly report that deprived animals are more active. One other consideration underlying the planning of this study was a prediction flowing from two postulates in an unpublished theoretical paper by Denny. On the basis of these postulates it was predicted that animals would learn to explore a comples maze merely for the reward of approaching novel stimuli and that later these stimuli would lose their novelty and the animals would extinguish their maze exploring habit.

The Ss were run one trial daily in a large, complex maze for short periods of time, (50 to 100 seconds) and exploration scores were recorded.

The maze consisted of nine hexagons joined together in two rows of four and one row of one. The method of joining the hexagons yielded 39 short segments or units. The maze was constructed of one-inch white pine lumber, had a three-quarter inch fir plywood floor and was left in natural finish. The tops of the maze

alleys were covered with one-half inch hardware cloth. Ss were blocked from further exploration of the maze by inserting heavy cardboard rectangles downward through the hardware cloth covers of the maze alleys through suitably placed holes in the screening.

A total of 43 Ss were run in six groups containing 11, 10, 6, 6, 5, and 5 animals respectively, but the statistical analysis was confined to the two largest groups.

It was found that hungry animals explored more than satiated ones except on Day 1, when, with exploration held to a constant one-third of the maze, the satiated animals took half as long to explore this amount as did the deprived animals.

Due to the exploratory nature of this study no formal hypotheses were tested or advanced.

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I would also like to express appreciation for the help given me by the other committee members, Dr. Charles Hanley, and Dr. S. Howard Bartley.

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CHAPTER I

INTRODUCTION AND STATEMENT OF THE PROBLEM

In recent years, there has been a good deal of literature dealing with the problem of exploratory behavior. This is often called free exploration, because no restrictions are placed on the animal's movement through the maze. A recent article by Welker (15), however, was aimed at discovering any differences that might obtain between "free" and "forced" exploration of the same box, by the same rats, on alternate days. "Forced", for Welker, meant that the animals were placed in the box and allowed to explore for a five minute period. "Free" exploration periods, on the other hand, meant that the rat had access to the box for a five minute period, and could enter or not as it chose. Welker found that on days the animals were placed directly in the box they generally explored more than on days they were allowed free exploration. On forced days, the amount of exploration declined from day to day, whereas, if anything, the opposite was the case during free periods. Without exception, in other studies of exploratory behavior the rats were "forced to explore", according to Welker's terminology.

A big controversy arises from these studies. Some Es reported that deprived animals explored more (1,3), while

others (10,11,16) reported that sated animals explored much more. Montgomery (10), in a study published in 1953, reported that in a single unit "Y" maze with 2 ft. arms, the curves of exploratory behavior for the sated and deprived groups were similar in character. Montgomery also stated that multiplication of the points on the curve for deprived animals, by the constant 1.32, would superimpose the two curves. Montgomery, along with all other investigators, used a fairly long exploration period (ten minutes per day). Montgomery said in explaining these data: "These results are interpreted as providing evidence that the exploratory drive is a primary drive, aroused by external stimuli, which undergoes a decrement in strength when another primary drive is present." This explanation seems, to the writer, to be nothing more than a reiteration of the findings, with that somewhat mystical word 'drive' thrown in.

In a somewhat more recently reported study, Alderstein and Fehrer (1), using a complex maze for the exploration ground, instead of a box or a "Y" maze, found that deprived animals explored much more than sated animals. They used two groups of rats and divided the experiment into three parts of three days each. Four days of ad lib feeding were interpolated between parts A and B, and five days between parts B and C. Group I was hungry for part A and satiated

for parts B and C. Group II was satiated for parts A and B and hungry for part C. The findings show Group I to be clearly superior to Group II in units explored, measured during part A, when the first group is deprived and the second is satiated (75% more units explored). For part B, with both groups satiated, there were no differences, and for part C, with Group I satiated and Group II hungry, Group II explored 53% more units. The differences between the two groups in both parts A and C were significant at the .01 level of confidence. On the basis of design differences among Montgomery's study, a study by Thompson (14) described below, the classroom demonstration of Dashiell (3) in the twenties, and their own experiment, Alderstein and Fehrer assumed that hunger operated selectively on the exploratory level as a function of the environment encountered. In their words, "(in) a maze offering a profusion of spatially separated new stimuli, the hungry and therefore more sensitive animal should be readily diverted from the stimulus it is now exploring, to a new one. ....in a very simple homogeneous maze allowing for much stimulus generalization, ... the hungry rat might not be more easily diverted than the sated rats."[1]

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1. Underlined words the author's.

In explaining their findings, Alderstein and Fehrer stated that they seemed consistent with their initial assumption that hunger lowers the reaction threshold to novel stimuli. They also said that the greater frequency of washing, the presence of napping, and the spurts of activity by the satiated group in the maze, could be accounted for by assuming that satiated animals may be relatively more influenced by moment to moment internal conditions.

Thompson (14), in a study of exploration by "maze-bright" and "maze-dull" rats, found no differences in amount of exploration between satiated and deprived rats.

One can thus find in the literature a study to support any of three view points:

(1) Satiated rats explore more than hungry rats.

(2) Hungry rats explore more than satiated rats.

(3) There is no difference in the amount of exploration by satiated and hungry rats.

There is yet another body of recent research measuring general activity under conditions of satiation and deprivation. In these studies the results are in agreement: satiated rats regularly engage in less general activity than do hungry ones. For example, in a study by Reid and Finger (12), a comparison was made between satiated and hungry rats with respect to total daily activity, and activity in the hour

preceding feeding time. Reid and Finger found that the total daily activity of rats had risen about 1350 per cent after 35 days of food deprivation and had not yet stablized.[1] The activity in the hour preceding feeding had risen even more.[2] In contrast, the satiated animals' daily activity dropped from 521 revolutions of the activity wheel to 370, and there was no change in the activity level during the hour before feeding. Reid and Finger stated that the activity rise had not yet approached an asymptote, even after 35 days of a deprivation schedule, although after 15 days, water and food intake were stabilized and the animals showed no further weight loss.[3]

Campbell and Sheffield (2) reported a study in which activity was measured in relation to food deprivation. Rats were housed in an enclosed activity cage, representing a very homogeneous environment. They found that Ss totally

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1. The rise in activity was from 493 revolutions of an activity wheel per day, per animal, to 6664 revolutions per day, per animal.

2. The actual percentage of the rise is incalculable, since activity during the base period was measured at zero revolutions of the activity wheel during that hour, and it rose to 1671 revolutions per day, per animal, by day 35.

3. Reid and Finger used unlimited food and/or water in the cage of the animals for a limited amount of time as a restrictive diet, rather than a limited amount of food or water in the cage to be entirely eaten.

deprived of food showed a slight but significant rise in general activity level. However, when certain auditory and visual manipulations were made in the environment, the resulting rise in general activity level was relatively large. Campbell and Sheffield, like Alderstein and Fehrer, concluded that the hunger drive seems to involve lowered thresholds of response rather than an internal stimulation to activity.

Hall (8), with a somewhat different design than Campbell and Sheffield, studied ostensibly the same problem, but concluded that while an environment provides for increased activity, the addition of a condition of food deprivation increases it still more. Hall used activity measures one-half hour in length in his comparisons.

Finger (6), studied the activity levels of rats under 24 and 72 hour food deprivation, and under subsequent conditions of satiation, in attempting to get at yet another aspect of motivation. He found a drastic decrease in general activity level takes place when the rats are reinstated on an ad lib feeding schedule. The group previously deprived for 24 hours showed only 57% as much activity as normal rats fed ad lib throughout the experiment, and the 72 hour deprived rats only 17.6% of normal, during the first 24 hours after satiation. Finger termed this behavioral

pattern "satiation shock." He also said that the return to normal general activity level parallels the recovery of weight lost during the deprivation schedule.

It would seem then that some exploration could profitably be undertaken in this welter of empirical disagreement. Do hungry rats explore more than satiated ones, or vice versa? Is heterogeneity of environment more important in the elevation of general activity level of deprived rats, or is food deprivation the more important variable? Or, do these two variables act in concert?

This study is not designed to answer all these problems. It is in fact not a conclusive answer to any of them, but it does attempt to throw a little light on a few of them.

STATEMENT OF THE PROBLEM

Denny, in an as yet unpublished paper (4) delineating a contiguity type learning theory, enumerates two postulates which bear on the problem: the postulate of acquisition, and the postulate of sensory adaptation or satiation.

> Post. 1. Acquisition
> (a) The stimulus complex (S) which closely precedes in time any response elicited by any stimulus (Se) acquires the property to elicit this response (conditioning). (b) To increase the probability that S will elicit a specified response it is necessary that the response be consistently elicited in close temporal association with this stimulus. (c) With each elicitation there results an increment to the tendency for this stimulus to elicit this response.
> Post. 2. Sensory Adaptation or Satiation
> With continued or repeated presentation all stimuli lose or partially lose the property to elicit a response as a decay function of the duration or frequency of presentation. The slope of this decay function varies with the nature and intensity of the stimulus, i.e., some stimuli (food for a hungry animal, shock, etc.) are much more resistant to adaptation than are other classes of stimuli. With the passage of time stimuli recover their capacity to elicit a response.

It would seem then, from these two postulates, and from the findings about activity level in relation to food deprivation, that an animal activated by hunger would first acquire and then lose all, or some of, a maze running habit when running solely to approach novel stimuli. It was precisely this point, along with the controversy about whether satiated or hungry rats explore at a greater rate, which suggested the present study to the writer.

One of the mechanical problems of the study was this: If possible improvement in performance is to be the same for all Ss, the amount of exploration by all individuals in all groups should be equated on Day 1. Otherwise, any initial differences between groups will permit greater absolute and relative improvement by one over the other. E chose one-third of the maze as the amount to be explored on Day 1 for two reasons. First, there should be a large portion of the maze still unexplored to make possible the quantification of any learning which might take place in the situation, and to encompass the limits of the learning if it is present at all. Secondly, if an S did show satiation to intra-maze cues, this satiation should not begin for the entire maze until after Day 1. It was felt that leaving two-thirds of the maze unexplored on Day 1 would be enough to meet these conditions.

On the other hand, equating exploration measures may cause serious differences in time measures for the groups. However, it was decided to equate performance rather than time, this permitted a wide differential in exploration time by satiated and deprived Ss.

Given this apparently unavoidable dilemma, the study proceeded along the following lines.

If a rat in a complex maze is allowed a period

initially short enough to forbid exploration of the entire maze, will the complex activity/approach/exploration response be elicited in following trials? Will the Ss later become satiated to the intra- and extra-maze cues? Lastly, will there be quantitative and/or qualitative differences in the exploration of hungry versus satiated rats?

These questions define the problem the study sets out to answer. Since it is purely exploratory, covering a rather wide area, no formal hypotheses were formulated. However, informal hypotheses, or hunches, are implied in the preceding paragraphs. They are:

(1) Hungry rats will explore more of the maze than satiated rats.

(2) A day-to-day plot of mean maze units explored by the groups will look much like classical acquisition and extinction curves.

CHAPTER II

DESIGN AND PROCEDURE

As will be seen in this section, the design of the experiment was not particularly rigorous or tight. This is not caprice, but rather indicates the relatively broad scope and exploratory nature of the investigation.

Subjects The Ss in the experiment were naive rats selected from the colony maintained by the Michigan State University Psychology department. All were albinos except for four male hooded rats equally divided between two groups. A total of 43 rats were used; 27 females and 16 males. Of the six groups in the experiment, three contained males and three females. The design was not, in any way, balanced for sex of Ss. The age range of the Ss was from 90 to 172 days at the time of selection.

Apparatus A diagram of the apparatus appears in Fig. 1. It originated from a multiple hexagonal maze built by Jensen (9) for use in research on latent learning. The original maze had two rows of hexagons joined together, with four in one row and three in the other. In the present study, the Jensen maze was modified by the addition of two more hexagons, one to the short row in Jensen's original maze, and a third row containing one hexagon. This manner of joining the hexagons together yielded 39 straight segments,

or units, eight inches long, three inches wide, and five inches high.

The maze was constructed of one inch pine boards, finished both sides, with a three-quarter inch fir plywood floor. The maze was left in a natural finish, and the tops of the alleys were covered with half-inch hardware cloth (a welded wire screening). The maze was placed on a large table to raise it off the floor.

In addition to the experimental maze, an habituation maze was built, identical in construction and size to one of the hexagons in the large maze cut through the mid-line. This produced a maze with three straight alleys joined at the angle encountered in the experimental maze.

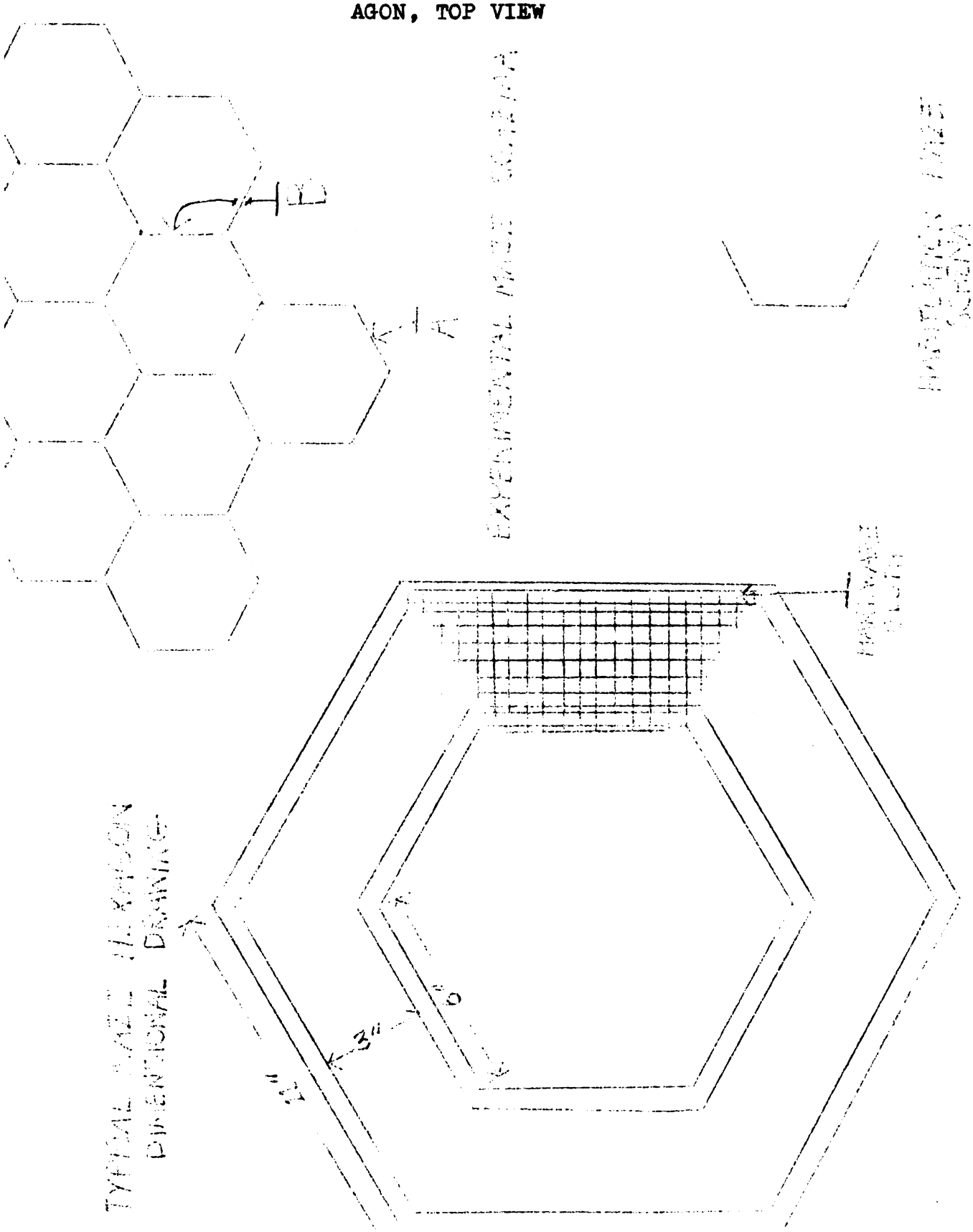
The experimental room was lighted by four shaded 100 watt incandescent bulbs suspended from the ceiling.

Incidental Equipment Three rectangles of heavy cardboard were used to block further exploration of the maze by Ss at the conclusion of the day's exploration period. The cardboards were inserted downward in the maze through suitably placed openings in the wire screening, and effectively halted Ss from progressing further through the maze. Experimental periods were timed with a stopwatch, and all observations were rounded to the nearest second.

Procedure The 43 animals were divided into six

FIGURE 1

SCHEMATIC DRAWING OF EXPERIMENTAL MAZE AND HABITUATION MAZE WITH A DIMENSIONAL DRAWING OF A TYPICAL MAZE HEXAGON, TOP VIEW



experimental groups with 10, 11, 6, 6, 5, and 5 animals respectively.

On the two days prior to the start of data collection, E handled the animals for one-half hour, and placed them in pairs in the habituation maze for ten minutes each day. This procedure was followed for all groups. Table 1, on page 15, contains information about the make-up of, and the experimental conditions for, all of the groups.

Group I consisted of 10 female albino rats which were fed ad lib throughout most of the experimental period. Their diet consisted of Purina Laboratory Chows and plain tap water. The floors of their cages were continually littered with Chows in excess of their daily requirements, two water bottles were attached to their cages, and both food and water were replenished daily to insure that the Ss were never deprived of either.

On the first day of data collection the animals were introduced, one at a time, into the maze at the point marked A on Fig. 1. They were handled in such a way that their initial orientation was to the left end of the maze entry section, but orientation was not rigorously controlled, since the animals were all handled by their tails.[1]

1. The animals were handled by their tails because the maze alleys were too narrow to allow grasping the Ss around the body. For consistency, all lifting and transporting was done by their tails. With this system a rat would occasionally enter the maze facing right, but well over 90% of the entries were with the rat facing left.

MAKE-UP OF, AND THE EXPERIMENTAL CONDITIONS FOR, ALL EXPERIMENTAL GROUPS

GROUP	AGE	SEX and NO.	PRE-EXPERIMENTAL FEEDING CONDITIONS	FEEDING CONDITIONS DURING EXPERIMENT	AMOUNT OF MAZE EXPLORED ON DAY 1	NO. OF EXP. DAYS	Ss TIME IN MAZE PER TRIAL
1	5-6 mos.	10 ♀	AD LIB	AD LIB	1/3 OF MAZE	25	50 SEC.
2	3 mos.	11 ♀	8 GRAMS PURINA LAB. CHOWS PER DAY FOR 9 DAYS.	9 GRAMS P.L.C. PER DAY	1/3 OF MAZE	25	INDIV. TIMES $\bar{X}$=99 SEC.
3	3 mos.	6 ♀	AD LIB	AD LIB	1/3 OF MAZE	10	INDIV. TIMES $\bar{X}$=46.5 SEC.
4	3 mos.	6 ♂	8 GRAMS P.L.C. FOR 5 DAYS - 9 GRAMS P.L.C. FOR 10 DAYS	9 GRAMS P.L.C. PER DAY	50 SEC. PER S IN MAZE	9	50 SEC.
5	3 mos.	5 ♂	NO WATER FOR 1 DAY	45 MIN. WATERING PER DAY FOR 4 DAYS. THEN WATER AD LIB AND 8-9 GRAMS P.L.C. FOR REMAINDER OF EXPERIMENTAL PERIOD.	50 SEC. PER S IN MAZE — 100 SEC. PER S IN MAZE FROM DAY 5 ON.	15	50 SEC.
6	3 mos.	5 ♂	8 GRAMS P.L.C. PER DAY FOR 9 DAYS	9 GRAMS P.L.C PER DAY	50 SEC. PER S IN MAZE	15	50 SEC.

TABLE 1

On entry into the maze, S was timed while it explored one-third of the maze (13 units). The S was then blocked from further exploration, and initial exploratory time was recorded. The day's experimentation was concluded after all Ss in the group had had one experience in the maze. The animals were given one trial per day for the balance of the testing.

At the conclusion of Day 1, the group mean exploration time was computed, and on subsequent days animals were allowed an exploratory period closely approximating the group mean time.[1]

For Group I, the procedure of allowing 50 seconds exploration of the maze per day, per animal, was followed for 16 days, but on day 17 the exploration time per animal was raised to 100 seconds per day. This time closely corresponded to the group mean time for the Group II animals on Day 1.[2] The 100 second per day exploration time was continued through Day 25 of the experiment.

Two days following Day 25, Group I Ss were placed

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1. Group mean time, 51 seconds. Exploration time allowed, 50 seconds per day, per animal. Since the range of individually attained times was quite small, using the group mean time seemed to E to be a legitimate procedure.

2. The mean exploration time for Group II on Day 1 was 99 seconds.

on a food privation schedule of eight grams of Purina Laboratory Chows per day, per animal, for seven days with water available ad lib. After one week of a food privation schedule, the Ss were reintroduced into the maze for a 50 second exploration period; this time at the point marked B on Fig. 1. This particular manipulation was undertaken to determine whether Group I Ss would exhibit generalization from one starting place in the maze to another, and thus explore relatively small amounts of the maze. Another alternative was that the day-to-day exploration curve might show an increment due to a heightened level of general activity brought on by the food deprivation schedule. The Ss continued for five days during their second experimental period and were then terminated altogether.

The procedure for Group II differed in several respects from that used with Group I. First, the rats were placed on a food deprivation schedule of eight grams of Purina Chows per day, per animal, with water ad lib. This schedule was continued for nine days prior to the experimental sessions. During the body of the experiment, Group II Ss were maintained on a diet of nine grams of Chows daily. The Ss daily ration was always fed in their home cages, 20 to 30 minutes after the conclusion of the day's testing.

Since the attained times of Group II animals for

exploration of one-third of the maze varied so widely, E thought it advisable to allow the Ss to explore the maze each day for their individually attained times on Day 1. This procedure is, of course, quite different from the one followed for the Ss in Group I, and indicates the dilemma E found himself in. Except for these differences, the Ss in Group II were run in a manner similar to the way the Group I Ss were run through Day 21. On Day 21, one-half hour after the experimental data had been gathered, the animals were placed on ad lib feeding, and for four more days were run in a satiated condition.

Because of the differences in age between Group I and Group II, (cf Table 1) Group III was run as a control. The Ss in Group III were the same age as Group II Ss, and they were run under the same conditions as Group I, except for being run on individual times. This was done for the reason given for Group II: a very wide range of Day 1 times. The mean for Group III is similar to that for Group I.[1] Differences due to age were not at all apparent for the first ten days of the experiment, and experimentation with Group III was terminated after Day 10.

Group IV, run at a somewhat later date, was composed of six male albino rats. In addition to the sex difference,

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1. Group I mean 51 sec., Group III mean 46.5 sec.

there was a difference in the pre-experimental food deprivation period. Group IV rats were placed on a schedule of eight grams Purina Laboratory Chows per day, per animal, for five days and nine grams per day for ten more days before being placed in the maze. The group was kept on the nine gram schedule throughout the nine day experimental period. Also in Group IV, the animals were not limited to exploring one-third of the maze on Day 1, as was the case with the previous groups, but were allowed to explore the maze for 50 seconds per day. In addition, Group IV was run by a different experimenter.[1]

Groups V and VI contained a total of ten male animals; three albino and two hooded rats in each group. These groups of Ss were run jointly by two different experimenters.[2] Group V animals were handled and habituated like the first four groups, but during the first part of the experiment they were deprived of water with food available ad lib. The animals were watered by placing them in individual cages, to which a water bottle was attached, for

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1. The author is grateful to Mr. Richard Lincoln for his assistance in gathering the data for the experiment. In talking over the experimental procedure used with Mr. Lincoln, E was unable to discover any differences between Groups II and IV other than those already noted.

2. Dr. M. Ray Denny and the author.

45 minutes per day. Ss were watered 20 minutes after the day's experimentation was completed. The Ss were 24 hours thirsty on Day 1 of the experiment.

After Day 4, Group V Ss were given water ad lib and placed on a food deprivation schedule of eight grams of Purina Laboratory Chows per day, per animal. This was raised to nine grams per day, per animal, after Day 9 of the experiment.[1]

For the thirst portion of the experiment, the animals were allowed 50 seconds exploration time in the maze per day, but during the food deprivation portion they were allowed 100 seconds of exploration. During this second part, a record was kept of the total amount of exploration and also of the amount of exploration during the first 50 seconds in the maze.

Group VI rats were on the same food privation schedule as Groups II and IV, and the habituation period was the same as for all previous groups. Group VI rats were allowed to explore the maze for 50 seconds per day, and were run daily through Day 11. At this point the Ss were placed on a schedule of 48 hours food deprivation, with a nine gram

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1. One animal in the group did not seem to be losing weight. He was taken from the group cage after Day 9, placed in an individual cage where his ration could be positively controlled, and continued in the individual cage until the end of the experiment.

ration of Chows fed every other day. Both Groups V and VI, which were run concurrently, were terminated after 15 days experimentation.

Scoring Ss were credited with exploration of a unit of the maze whenever they entered a maze unit to a depth just beyond their shoulders, or, when they passed through a unit, for the first time. Subsequent entries into or passages through a unit of the maze were not scored as an exploration of that unit.

CHAPTER III

RESULTS

The data for Groups I and II, the main experimental groups, is reported in graphic form in Figs. 2 and 3. Fig. 2 is a graph of the mean performance, in maze units explored day by day. Fig 3 is a graph of mean units explored per unit time. The transformation of the data presented in Fig. 3 was included to correct somewhat for the difference in time the animals in the two groups were in the maze. In addition to the two main groups, the data from Group III is included in Fig. 3 but not in Fig. 2. Data from Groups IV, V, and VI is included in Fig. 2 but not in Fig. 3.

The two groups were analyzed using White's T for ranked scores (5), and significant differences are found between the two groups virtually throughout the experimental period. The periods treated were: Day 1, Days 2 through 8, Days 9 through 16, Days 17 through 21, Days 22 through 25.

Table 2 presents values calculated for T or T', all of which are significant, excepting one. For the period of Days 2 through 8 the obtained T value is 85, whereas a value of 81 or smaller is required for significance at the 5% level. One ready explanation for this is, that on Day 1 the satiated group explored significantly more units of the maze per unit time, while all other significant measures

were in the direction of the deprived group exploring more units per unit time. Thus, the unit per unit time values, when plotted as in Fig. 3, are seen to intersect each other between Days 3 and 4. So, on Days 2 and 3 of the period encompassed by Days 2 through 8, one group was superior in the measure employed, while on Days 4 through 8, the second group was superior.[1]

It was interesting to note that the Group I animals, when reintroduced into the maze, after being deprived of food, performed largely the same as they had done in their original satiated condition. That is, they showed no rise in units explored from day to day. E purposely introduced them in the maze at a different point from the original entry section, picking a portion of the maze which was visited least by the group as a whole during the first part of the experiment. Even so, there was apparently considerable stimulus generalization for the Ss, and their performance soon fell to the asymptotic level reached under the condition of satiation.

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1. E felt that nothing instructive would be gained by further fractionating the analysis, since significance is almost attained at the 5% level for the period when two of the days have group performances opposite in character to that for which near significance was attained. Obviously, if Days 2 and 3 were not included, significance would have been attained.

Group III was run as a control for the age differential between Groups I and II. However, since the plots of Groups I and III are almost perfectly superimposed, it is apparent that no performance differences existed between them.

Groups IV, V, and VI were not intended to be included in the statistical analysis of the main groups. They were run primarily to check out possible interpretations of the results of Groups I and II. Group IV, for example, was run in light of the Reid and Finger study previously discussed (12). Group IV rats were deprived for 15 days before being placed in the maze. Groups V and VI were run to check hunger, which is presumably additive, against thirst, which is presumably not additive, as a motive for exploration of the maze.

The performance curve for Group IV is fairly flat, though there is some initial rise and a small drop at the end. In unit per unit time measures the group is higher than Group II, though in absolute units explored Group IV is lower. E feels this is brought about by the greater starvation, and thus higher activity level of Group IV as against Group II.

Group V, during the first four days of the experiment, was on a water deprivation schedule and performed

in general like the satiated group. There was an immediate day to day decrement in performance apparent. When the immediate decrement showed up the animals were placed on a food deprivation schedule of eight grams of Purina Laboratory Chows per day on Day 5. As soon as the animals were on the food deprivation schedule an increase in exploration was noted which was similar to the increase shown by the Group II animals, and was most striking during the first 50 seconds of the 100 second exploration period.

Group VI also showed the increase in day to day performance showed by Group II, but not of such great magnitude. E felt that this might be a reflection of a sex difference in activity level. Further, in light of the findings that rats deprived of water also eat less, this group was probably not as hungry as Group V. Group V Ss showed a greater rise in exploration when food deprived than did Group VI Ss.

FIGURE 2

MEAN MAZE UNITS EXPLORED DAILY BY ALL EXPERIMENTAL GROUPS

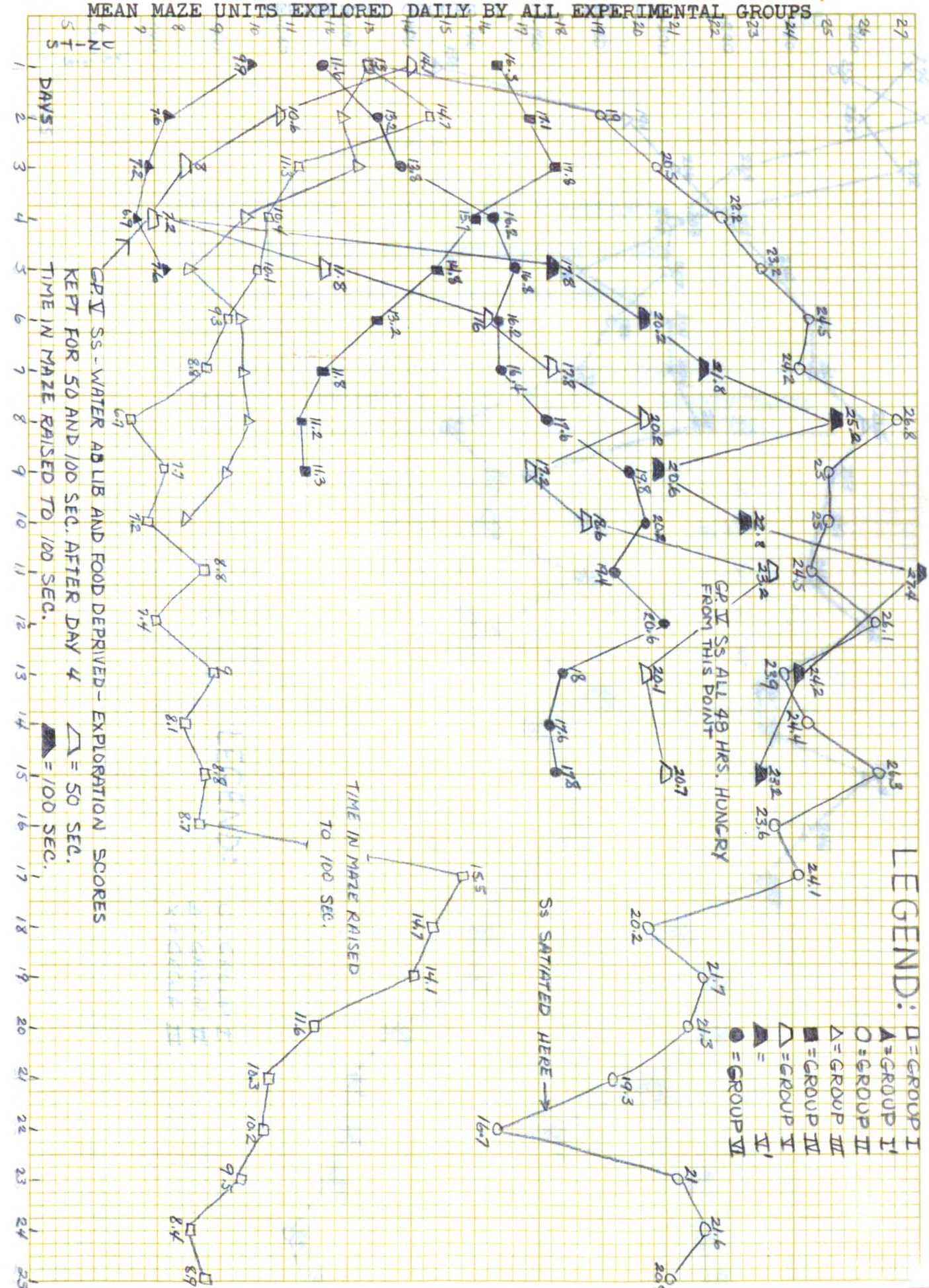

FIGURE 3

MEAN MAZE UNITS EXPLORED DAILY, IN UNIT PER UNIT TIME SCORES, FOR EXPERIMENTAL GROUPS I, II, AND III

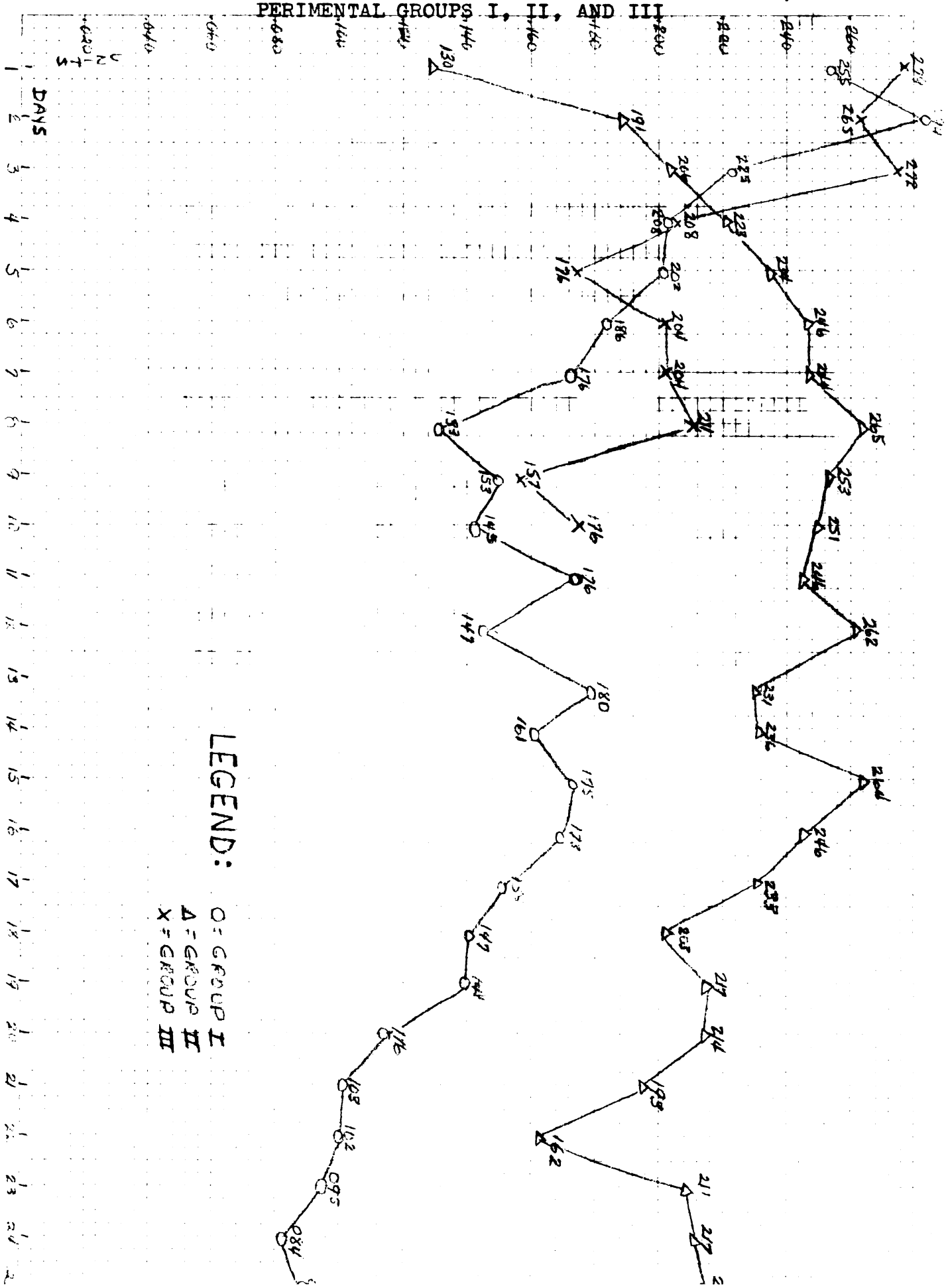

TABLE 2

OBTAINED T OR T' SCORES FOR DIFFERENCES IN UNIT PER UNIT TIME EXPLORATION SCORES OF SATIATED AND DEPRIVED GROUPS

DAYS	WHITE'S T OR T' VALUE	SIGNIFICANCE LEVEL
1	T = 68	1 %
2-8	T' = 85	n.s.
9-16	T' = 67	1 %
17- 21	T' = 63	1 %
22-25	T' = 58	1 %

CHAPTER IV

DISCUSSION OF RESULTS

The results of this experiment at first glance seem to indicate clearly that the rats in the food deprived group "learned" to explore the maze with no reward other than the novel stimulation involved in traversing it. Then as the intra and extra-maze cues began to become satiated, the rats "extinguished", at least in some degree. While it is possible, even probable, that learning of this kind did take place, it is by no means as clear-cut as it would seem at first . For one thing, the study of Reid and Finger (12) shows a rise in general activity for at least as long as 35 days in the hour preceeding feeding. Since the food deprived animals in this experiment were not deprived 35 days for the entire course of the experiment, the rise in total units explored could not be explained solely in terms of a rise in general activity level. This explanation would be unable to account for the decrement in performance during the last few days. Too, an explanation strictly in terms of a general activity rise would be widely at odds with the performance of the two main groups after the feeding schedules were reversed.

The decrement in performance of the hungry group in the last ten days of the experiment suggest strongly

that a factor such as Denny's postulate of stimulus satiation is operating. The particularly telling results which favor an acquisition-extinction interpretation, is the maintenance of a comparable level of performance by both of the first two groups after the feeding conditions were reversed. This would seem to indicate a more or less permanent learned performance in the maze. Finger (6) showed, that in an activity wheel measure of general activity level the satiation syndrome[1] was a rather lasting affair, with recovery of normal activity level paralleling recovery of weight lost during the deprivation schedule. If what this experiment measured was pure activity level, why was there such an immediate recovery of past performance level by the Group II animals, who showed only one day of performance depression after being satiated.

When one examines the first days exposure to the experimental maze it seems clear that Montgomery (10), was correct in stating that satiated animals explore more than hungry ones. At least, when on Day 1 the two groups explored the same amount of the maze, the satiated animals

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1. The satiation syndrome is characterized by a marked depression in general activity level following a shift from a food deprivation feeding schedule to ad lib feeding.

took half as much time as the hungry ones. Why then, is the later performance of the two groups so much at variance with Montgomery's results? Some light may be thrown on this finding by comparing the mazes used in the three experiments which give such controversial results. In Montgomery's experiment, a single, fairly small "Y" maze was used. In Thompson's (14) study, where no difference was found, a rectangular maze 15" X 30", divided into seven units 3.5" X 15" was used. And, in Alderstein and Fehrer's study (1), in which the hungry Ss explored more than the satiated ones, a large maze 45" X 22.5", divided into a large number of possible pathways, was used. Thus, in increasing the visual, spatial complexity of the maze, the amount of motor activity necessary to traverse the maze was also increased. It is apparent that Montgomery, who found that satiated animals explore more than hungry ones had the smallest, least complex maze, and minimized the amount of locomotion necessary for Ss to traverse the maze. Thompson, who shows no real superiority of either group over the other, used a maze of medium size and complexity, and Alderstein and Fehrer, who clearly showed that hungry animals explore more than satiated ones used the largest, most complex maze of the three. Montgomery clearly realizes the importance of this variable, and specifically states

that larger and more complex mazes elevate the exploratory performance of hungry rats above that of satiated ones.

As for the three additional groups run by E, Denny, and Lincoln, Group IV is the most difficult to interpret, though in general Reid and Finger's study seems to be adequate for their interpretation. These animals, following from Reid and Finger's study, were undoubtedly reduced in body weight to a point near maximum weight reduction. Therefore, a state near physiological stability had been reached before their introduction into the maze. In other words, the Ss were as "hungry" as they were going to get. This interpretation is given support by a very recent study reported by Reid and Finger (13) in which they expanded the framework of their original study, by testing the animals one day on an activity wheel at selected days during the deprivation schedule. They found that when the animals were tested only one day, fifteen days deprivation was the point of maximum activity.

Yet another study by the same two men (14) was designed to parcel out any performance increments due to the Ss learning to run for the reward of being fed immediately after they were taken off the activity wheel (an integral part of the design in the first study). They found that the performance of a group fed immediately

after being taken off the activity wheel, diverged widely from a group for which one hour in a delay box was interpolated between the time they were taken off the activity wheel and the time they were fed. The activity of the group fed immediately, paralleled the activity of the delayed group for the first eight days of the study, but after Day 8, the activity for the immediately fed group rose faster than that for the delayed group. The two groups, when compared for the first five and last five sessions on the activity wheel, were significantly different in performance during the last five sessions, at beyond the 2% level of confidence.

It appears then, that from the results of other studies, and particularly from first day data in this study, that Montgomery's assertions may be correct for visual, tactual, exploration where locomotor, or general activity requirements are low. On the other hand, in studies like this one where the animal is required to undergo a lot of physical activity in the form of point to point locomotion to explore the environment in which he is placed the deprived animal explores more, except possibly during the first few experiences in the maze.

There are also some indications that the explanations of Alderstein and Fehrer and Campbell and Sheffield

which revolve about lowered thresholds of reaction to novel stimuli, seem to have relevance here. The maze used by E in this problem was large and complex, but no attempt was made to maximize novel stimulation in the maze. Further, as can be seen in the diagram of the maze, it is mostly made up of inter-connected "Y" mazes. Therefore, it is possible for animals with a somewhat higher threshold of reaction to novel stimuli, to generalize a good deal from one part of the maze to another, and for their performance to show a decrement rather than an increment. It would seem that these animals, too, learned an activity pattern to the maze, since they also showed a tendency to persist at the same level of performance after the feeding schedule was changed.

Lastly, it would seem that, in the design of this experiment, one cannot leave the possibility of activity learning through reinforcement out of the interpretation, since the delay between running in the maze and being fed was only 20 minutes for the food deprived group. In addition, as was pointed out earlier, predictions based on the theorizing of M. R. Denny seem to be supported to some degree by the results of this experiment.

In summary, it seems likely, that in complex maze situations to which animals are exposed a minimal amount

of time each day, that at least three factors influence their performance, two of which are strongly indicated in this study. These factors are; the feeding schedule of the animals, the novelty of intra and extra-maze stimuli, and the size and complexity of the experimental maze.

CHAPTER V

SUMMARY AND CONCLUSIONS

The present problem arose from the empirical disagreements present in the literature on whether satiated or deprived animals explore at a greater rate. Montgomery (10), reported that satiated animals explored more than deprived ones. Alderstein and Fehrer (1), and Dashiell (3), have reported the opposite -- that deprived animals explore more than satiated ones. One author, Thompson (14), found no differences between satiated and deprived animals in amount of exploration.

It was noted that literature on general activity measures was consistent in reporting that deprived animals are more active than satiated ones.

The question was then raised if perhaps the amount of activity required of the S to explore the maze (e.g. point-to-point locomotion) might not have relevance in determining whether deprived or satiated animals explore more. A survey of the literature showed that studies which reported that satiated animals explored more, in general used small, compact mazes, while studies which reported that deprived animals explored more utilized relatively large, complex mazes.

One other consideration underlying the planning of this study was a prediction based on an unpublished theoretical paper by Denny.(4). On the basis of two postulates

from the formal system it was predicted that Ss would learn to explore the maze for no other reward than the approach to novel stimuli, and that eventually these stimuli would lose their newness or novelty and the Ss would extinguish their previously learned maze exploring habit.

Forty-three animals were used as subjects in the experiment, but the statistical analysis was confined to the two largest groups which contained 21 animals. In general, the findings were that hungry rats explored more than satiated ones. There was one notable exception however; On Day 1 when exploration was held constant it was found that satiated rats explored nearly twice as fast as hungry ones. Other general findings were that age does not seem to have any effect on the character of exploration and only a minimal effect on the ammount. Males generally seem to explore less than females. Extended pre-experimental deprivation periods tend to knock out or at least minimize the incremental learning to explore more and more of the maze. If satiated animals can be said to learn any response to the maze situation, it is one of a decremental character--of learning to explore less and less of the maze from day to day.

Due to the exploratory nature of the experiment,

no formal hypotheses were tested or advanced. All of the informal hunches were partially borne out, and none were completely verified. Deprived animals did explore more, but not on the very important first day's exposure to the maze. The animals in the deprived group did appear to acquire, and then extinguish a habit to explore more and more of the maze, but not the satiated group, and not the group which was deprived for two weeks before being tested.

No formal conclusions were drawn from this study, but it did seem to indicate at least two important variables in studies of this type, and a third variable seemed apparent from surveying the literature. Indeed, this third variable was specifically mentioned by one investigator -- Montgomery.

These variables were: Feeding schedule of the Ss, novelty of intra and extra-maze stimuli, and size and complexity of the experimental maze.

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