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The relationship between experimental extinction and drive during extinction.

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Dissertation

THE RELATIONSHIP BETWEEN EXPERIMENTAL EXTINCTION AND
DRIVE DURING EXTINCTION

by

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TABLE OF CONTENTS

	Page
LIST OF TABLES	iii
LIST OF FIGURES	iv
I. <u>INTRODUCTION</u>	1
A. General	1
B. Studies varying drive during training	2
C. Studies varying drive during extinction	3
D. Statement of the problem	10
II. <u>METHOD</u>	13
A. Subjects	13
B. Caging	13
C. Apparatus	13
D. Procedure	16
1. Maintenance schedule	16
2. Habituation	16
3. Preliminary training	17
4. Training	18
5. Deprivation schedule	19
6. Extinction procedure	21
III. <u>RESULTS AND DISCUSSION</u>	23
A. Acquisition	23
B. Extinction	23
C. Reversals	26
D. Drive and extinction	33

	Page
1. Zero deprivation group	33
2. All deprivation groups	33
3. Hullian theory	37
4. Prediction of MacCorquodale and Meehl	37
5. First trial latencies and drive	38
IV. <u>SUMMARY AND CONCLUSIONS</u>	41
A. Summary	41
B. Conclusions	43
BIBLIOGRAPHY	45
ABSTRACTS	48
VITA CURRICULUM	57

LIST OF TABLES

Table	Page
I. Acquisition data for the various deprivation groups	24
II. Reversal data during extinction	27
III. Chi-square results for the comparison of the number of responses to extinction for the various deprivation groups	36

LIST OF FIGURES

Figure	Page
1. Diagram of the apparatus	15
2. Number of responses to extinction for each deprivation group	34
3. First trial latencies in extinction	39

CHAPTER I

INTRODUCTION

For many years, researchers have attempted to determine what variables influence the performance of organisms on experimental tasks. Thus, we note, that changes in performance have, in some fashion (general or specific) been related to such variables as the nature of the task, punishment, reward, amount of training, capacity of the organism, temporal distribution of practice, and drive.

The last variable, drive, has received particular emphasis in recent years largely due to various theoretical speculations concerning the role of drive in behavior theory. While these speculations have provided a program and stimulus for research, it is obvious that theoretical speculation can proceed more meaningfully when a larger body of empirical findings is available.

In this connection a review of the studies concerning the relation of drive to performance reveals the need for further systematic investigations. Particularly is this the case, when we examine and compare the two major areas of performance where drive has been manipulated, namely during training and extinction procedures.

In general we find that more attention has been paid to the study of drive during training than the effect of drive variations during extinction.

The present study is concerned with extending our knowledge on the latter problem, i.e., the relationship of drive to performance during the extinction procedure. This particular information is intended to contribute to the overall account of the factors responsible for the acquisition and loss of responses.

The present status of the effect of drive variation on the two major areas of performance can be clarified by a review of the studies in which drive has been manipulated during the training procedure and studies which have been concerned with drive variation during the extinction procedure.

Studies Varying Drive During the Training Procedure

Finan (9) in an experiment designed to determine the quantitative relationship of the strength of drive to the acquisition process, trained four groups of rats on a Skinner Box at 1, 12, 24, and 48 hours food deprivation. He found that there was a small but consistent tendency for the more highly motivated animals to require less time in learning to depress the bar to a 30-response criterion.

Birch (3) gave 6 chimpanzees 17 problems to solve under different degrees of food deprivation. The intervals were 2, 6, 12, 24, 36, and 48 hours. On the basis of the data obtained, Birch concluded that the intermediate conditions of motivation are the most desirable for problem

solving efficiency. He argued that when motivation is low the animals are easily distracted by extraneous factors. However, under conditions of intense motivation the animals concentrated on the goal, to the relative exclusion of other features in the situation which were essential to the solution of the problem.

MacDuff (20) ran two experiments, one under massed practice and the other under distributed practice. In each experiment 3 groups of animals were trained on a T maze, each under a different degree of motivation (12, 24, and 48 hours food deprivation).

She found in the distributed practice experiment that the greater the food deprivation intervals the fewer the responses to reach the acquisition criterion. In the massed practice experiment she found that the greater the food deprivation intervals the greater the number of trials to reach the acquisition criterion.

Dodson (6) found that, using rats as subjects, the longer the interval of food deprivation the fewer the trials necessary to learn a brightness discrimination.

Ligon (19) used a tridimensional maze in which the animal had to crawl through holes in wire mesh to get to the food compartment. The animals, during training, were divided into hunger groups of 0, 6, 12, and 21 hours each. The 21h showed the fastest learning then followed the 6, 12 and 0 hunger groups.

In another group of experiments investigators have first trained animals to a stable level and then tested the animals under different levels of food deprivation.

Skinner (28) tested four rats at four different drive levels resulting from the feeding of 0, 2, 4, and 6 grams at a constant interval beforehand. The food was placed in the apparatus (Skinner Box) and was eaten before responses to the lever were made. Thereafter, the responses were reinforced periodically for one hour. Each rat was tested several times at each drive in random order. The relationship between the rate of bar pressing and the amount eaten is roughly linear and positive.

In another study Skinner (29) ran rats on a Skinner Box under food deprivation intervals of 1, 2, 3, 4, and 5 days after the animals were allowed continuous access to food for twenty four hours. The animals were reconditioned periodically at the rate of one pellet every four minutes. The graph of the rate of bar pressing to the number of days of food starvation reveals that the rate of bar pressing increases fairly continuously to 5 days, after which the rate falls rather sharply. Skinner feels that the fall is evidently due to physical exhaustion, since the animals died soon after (seven days).

Cotton (5) trained twenty male albino rats in a straight runway for 44 days under a randomized schedule of four deprivation conditions (0, 6, 16, and 22 hours).

then ten test trials were given per day until all the S's in each group had made at least 49 responses under each condition. Mean running times decreased in approximately linear manner with increased deprivation.

Kimble (17) trained 11 animals on a panel pushing response at 24 hours hunger drive until a median asymptotic latency of .4 seconds and a median of 11 trials were reached. In random order, 12 animals were tested at 0, 1, 2, 8, 15, and 24 hours hunger. When reciprocal latency is plotted against number of hours hunger the shape of the function shows a rapid rise to 2 hours and then a slightly positively accelerated function up to twenty four hours. Significant differences were found between the 8h and 15h at the .01 level.

Yamaguchi (32) varied drive during training and during testing. He trained 5 groups of animals each at a different degree of hunger, to the limit of learning (69 reinforcements on a modified Skinner Box) on a manipulandum response. The hunger intervals used were 3h, 12h, 24h, 48h and 72h. The various hunger groups were tested at three degrees of food deprivation not experienced during training trials.

The test trials occurred between training trials 72-73, 76-77, and 80-81: each animal was given one reinforcement test trial on each of these occasions. The test trials were arranged in counterbalanced order. According to Yamaguchi stimulus generalization is indicated by the fact

that 14 out of the 15 generalized latency values (a different drive was used in training and testing) were greater than their respective non-generalized (same drive used in training and testing) latency value.

Thus the studies concerned with the manipulation of drive during training and testing indicate that the longer the food deprivation intervals:

1. The faster the rate of bar pressing
2. The faster the running time
3. The shorter the learning time, or
4. In general, the more efficient the performance during training.

Studies Where Drive Has Been Manipulated During the Extinction Procedure

Our major concern is with those experiments that employ a single drive during the acquisition procedure and drive during the extinction procedure is varied. In other words, determining the effect of the manipulation of drive on the extinction procedure while holding the drive during the acquisition procedure constant.

The first systematic study seems to have been put forward by Sackett (26) in 1939. He trained rats to respond 15 times in a Skinner Box under a six hour hunger drive.

48 hours later this group was divided into a 6 hour hunger group and a 36 hour hunger group. The animals extinguished to a criterion of no response for twenty minutes. The six hour hunger group averaged 35 responses to extinction and the 36 hour hunger group 44.85 responses. The average time for reaching the extinction criterion for the 6 hour hunger group was 31 minutes and the 36 hour group averaged 39.06 minutes.

According to Sackett, the data show that the increase in drive does not greatly increase the number of responses to extinction or the time taken to elicit them. Since a six hour hunger interval was used both in acquisition and extinction, Sackett suggests that perhaps the lack of a greater difference between the two groups may be in part due to the relation of the drive during extinction to the drive during acquisition.

It will be seen that the present study will provide evidence which bears directly on this point.

In a portion of a study presented by Perin (24) in 1942, rats were given 16 reinforcements on a Skinner Box at 23 hours hunger drive. Extinction trials were run at 1, 3, 16, and 23 hours hunger to a 5 minute criterion of no response. A graphic representation of the data shows that resistance to extinction is a slightly positively accelerated increasing function of the number of hours food deprivation for the first twenty three hours.

Perin found significant differences between the 1h and 23h, between the 3h and 16h, and between the 3h and 23h. All were significant beyond the .05 level.

Perin did not run a zero hunger group at extinction but he extrapolated from the data on the other extinction groups. Perin's extrapolations held that a zero hunger group should make 28% of the responses to extinction made by a twenty four hour group.

The intention of Koch and Daniel (18) was to put Perin's extrapolations to an empirical test, since these investigators felt that Perin's extrapolations were surprisingly high. They ran an experiment similar to Perin's with just a zero hunger group. The values obtained by Koch and Daniel were much less than those obtained by Perin's extrapolations.

Saltzman and Koch (27) investigated the effects of low intensities of hunger during extinction. Albino rats were divided into three groups of 40 animals each and were allowed 70 reinforcements on a Skinner Box at 23 hours hunger. Extinction was at $\frac{1}{2}$, 1, and two hours food deprivation. The results show that resistance to extinction increase as the hunger interval increases up to two hours. The response measures were median number of extinction responses, the time before extinction, and the median latencies of initial extinction.

Horenstein (14) performed an experiment that would combine the features in the experiments of Perin, and Koch and Daniel. She gave albino rats two training sessions of ten trials each on a panel pushing apparatus under $23\frac{1}{2}$ hours hunger. The animals were extinguished at 0, ²12, and $23\frac{1}{2}$ hours food deprivation to a 15 minute criterion of no response. When the median number of extinction responses is plotted against hours of hunger, the extinction curve shows a steep rise up to two hours, followed by a more gradual and slightly positively accelerated increase between 2 and $23\frac{1}{2}$ hours deprivation. The curve is similar to the one obtained by Perin. All obtained differences were significant beyond the .01 level except the difference between the 2 and 12 hours groups. The difference between these two groups was significant at the .05 level.

Heathers and Arakelian (12) trained albino rats on a bar pressing response and they partially extinguished half of the animals under weak hunger and the remainder under strong hunger. Two days later the animals were subjected to a second extinction session half of each group under the same degree of hunger as in the first extinction and the remaining half under the drive identical to that of the first extinction session of the other group. According to the authors the statistical pooling of results revealed a tendency of the rats extinguished twice on the same drive to

resist extinction less than those animals extinguished the second time on a drive different than the one employed in the first extinction. The experimental outcome is evidently related to primary generalization of drive stimulus intensity and suggests that primary extinction effects are to some extent specific to the primary drive or need intensity under which the extinction occurs.

In summary, the results of the above studies concerning the manipulation of drive during the extinction procedure indicates that resistance to extinction increases in a slightly positively accelerated manner from zero to twenty four hours food deprivation (Perin and Horenstein).

In addition, the studies of Sackett, and Heathers and Arakelian also suggest that the extinction effects are to some extent a function of the drive employed in training or in a previous extinction session.

Statement of the Problem

In the review of the literature above we have examined studies concerned with the relationship of drive to performance during the extinction procedure which have employed a single drive during the acquisition procedure and have varied drive during the extinction procedure. A closer examination of these few studies reveals some limitations and some questions. First of all, deprivation intervals were

never systematically varied beyond twenty four hours. How is extinction affected by deprivation intervals greater than twenty four hours? In addition, with the exception of the Sackett study, the intervals used during the extinction procedure did not extend beyond the deprivation interval used in the acquisition procedure. As a matter of fact, Sackett had only one interval in the extinction procedure which extended beyond the one used during acquisition. What is the effect on performance (measured during extinction) of increasing the drive during extinction beyond the drive intensity employed during acquisition?

Finally, we notice that in all of the experiments instrumental type tasks were employed. To what extent is the relationship between drive and extinction found in instrumental type tasks relevant to other tasks (e.g. discrimination task)?

The above considerations with respect to the limited knowledge of the relationship between extinction and the manipulation of drive during the extinction procedure led to the present investigation and its intentions to deal with the following characteristics:

1. The manipulation of drive, during the extinction procedure, beyond twenty four hours.
2. The use of deprivation intervals substantially above and below the deprivation interval used

during the acquisition procedure.

3. The use of a discrimination task rather than an instrumental type task.

The purpose of this study, accordingly, was to determine the relationship between drive and performance when drive is varied from 0 to 71 hours during the extinction of a discrimination task.

CHAPTER II

METHOD

A. Subjects

The subjects were seventy experimentally naive, male albino rats, approximately 90 days old. The subjects were of the Sprague-Dawley strain and were obtained from the Charles River Breeding Laboratories.

Ten subjects were discarded for failure to adapt to the apparatus. The weights of the remaining 60 subjects used in the experiment ranged from 209 gms. to 302 gms. The mean and median weights were both 262 grams.

Caging

The subjects lived in cages made of wood and wire mesh (18X18X12 in.). Each cage housed three rats.

The subjects were always fed in individual feeding cages also made of wire mesh and wood (8X5 $\frac{1}{2}$ X6 $\frac{1}{2}$ in.).

Water was available in both the feeding cage and home cage at all times.

B. Apparatus

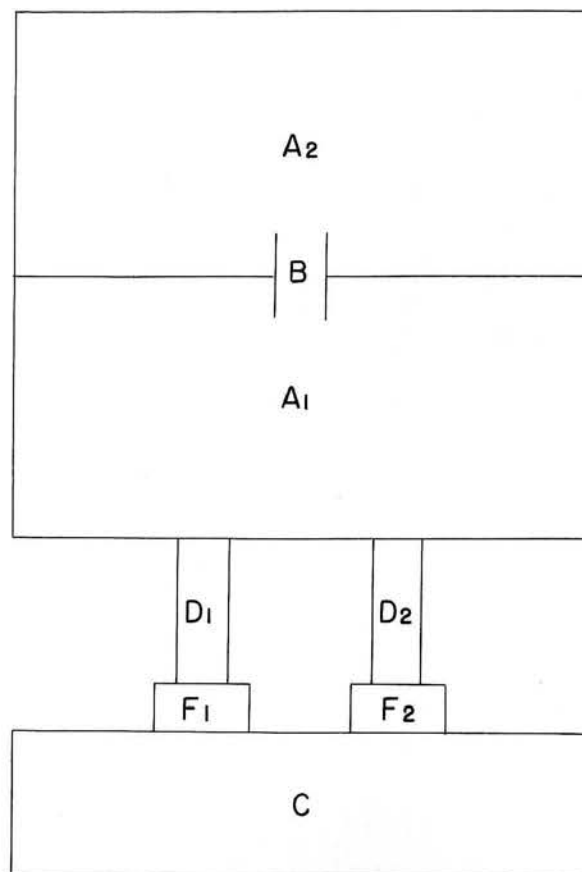
The apparatus is essentially the same as the one previously used by Spence (31). Its design (1) eliminates the necessity for handling the animals once placed in the apparatus, (2) insures reception of the stimulus cues, and (3) gives immediate reward or non-reinforcement upon

response.

The principle parts of the apparatus are shown in figure 1. A turntable divided into two portions, A1 and A2 by means of partitions stood 43 inches above the floor and moved on a pivot made by two iron pipes. The smaller pipe which was fastened to the table fitted inside a larger one, which was based on the floor. The fit of the pipes was sufficiently close so that there was no play in the table, and yet could easily be rotated by means of a pulley system operated from behind a one way mesh screen.

A one-foot alley (B) $3\frac{1}{2}$ in. in width, connected the two open sides of the table. A vertically sliding door in the middle of this alley permitted E to allow the S to pass from one side of the apparatus to the other.

The second main part of the apparatus consisted of a stand which provided a one way screen (C) behind which E was situated and which supported two elevated runways (D1, D2) $3\frac{1}{2} \times 10$ in. The latter were interchangeable, one was painted a flat white and the other a flat black. Each runway was part of a unit which also consisted of a food cup (F1, F2). The food cup consisted of a hole $1\frac{1}{2}$ in. diameter and $\frac{3}{4}$ in. deep, drilled in a block of wood ($2 \times 3\frac{1}{2} \times 4$ in.). The combination runways and food cups were fitted into grooves and further secured in place by the bottom of a sliding oneway screen. A distance of 10 in. separated the



A_1 - FRONT OF THE TURNTABLE
 A_2 - BACK OF THE TURNTABLE
 B - ALLEYWAY
 D_1, D_2 - RUNWAYS
 F_1, F_2 - FOOD CUPS
 C - ONE WAY SCREEN BEHIND WHICH
 THE EXPERIMENTER STOOD

FIGURE 1

DIAGRAM OF THE APPARATUS

two runways.

In addition to the black and white runways, two duplicate runways painted an intermediate gray were used in preliminary training.

The apparatus was situated near the center of a darkened room. Overhead, the apparatus was lighted by a 25 watt bulb incased in a porcelain reflector ($11\frac{3}{4}$ in. in diameter). The light was placed in a position that illuminated the runways and front table without casting a shadow. The light was 26 in. from the top of the alley housing.

C. Procedure

Maintenance Schedule

All the animals were first put on a seven day maintenance schedule. They were given 12 gms. of Purina Lab Chow in individual feeding cages, for one hour at the same time each day. At the end of the seven day period most of the subjects were eating all 12 grams.

Habituation

On the eighth day, an hour before feeding time, the subjects were placed on the front of the turntable (A1) three at a time, with the gray runways in place and the panel door raised. Sixteen food pellets (5.5mm, 94mg.)

were scattered on A1 and five pellets were put in each food cup. The animals were allowed 30 minutes to explore the apparatus and eat the food.

On the ninth and tenth day, an hour before feeding time, the animals were placed on the front of the turntable (A1) one at a time with the panel door lowered and five pellets in each gray food cup. Each animal was allowed to remain on the apparatus until he had eaten all the food pellets. The time on the apparatus ranged from 5 to 20 minutes.

Preliminary Training

On the eleventh day preliminary training began. An hour before feeding time an animal was placed on the back of the turntable (A2) at the entrance to the alley. In front of the turntable a single gray runway with a food pellet in the cup, was in place (right or left). The experimenter, after placing the animal at the entrance to the alley, went behind the one way screen and raised the panel door. When the animal had eaten the food pellet and returned to the front of the turntable the experimenter rotated the turntable so that now the animal was again on the back of the turntable ready for the next trial. The experimenter then raised the screen to put the gray runway in its new position (if necessary) and placed a food pellet in the food cup. If the position was to remain the

same the experimenter removed the runway and went through the same motions as he would use in putting the runway in a new position. The animal was given ten trials in this manner with the gray runway being placed on either the right or left side (experimenter oriented) in the following order: L R L R R L R L L R.

On the twelfth day this procedure was repeated with the following order being used: R L R R L R L L R L.

Training

On the thirteenth day the training for black-white discrimination began. The procedure was essentially the same as that for preliminary training except that black and white runways were now used. Both the black and white runways were put in place with only one of them containing a food pellet at the beginning of each trial (either always black or always white). Thirty animals were always reinforced on the white runway and thirty animals were always reinforced on the black runway. The non-correction procedure was used under 23 hours food deprivation, with the positive stimulus shifted according to the following orders:

L R L R R L R L L R R L R R L R L L R L

The choice of runway and the time interval between the raising of the door and the insertion of the animal's nose

into the food cup (latency) were recorded. The interval between responses was determined by the latency, the time it took the animal to go back to the front of the turn table, the time it took to rotate the turn table and the time it took to manipulate the runways. The time necessary to rotate the turntable and manipulate the runways was quite constant at 30 seconds. The time it took the animal to come back to the turntable was usually about 3 seconds.

The animal was considered to have reached the criterion of learning when he completed 18 out of 20 correct trials, the last ten being all correct. All the animals were fed at the usual time after reaching the criterion.

After the animal had reached the criterion of learning he was put into one of the following deprivation groups: 0 hours, 6 hours, 12 hours, 47 hours, and 71 hours.

Deprivation Schedule

The feeding schedule for the various deprivation groups was as follows:

0 deprivation group-given 12 grams for one hour, 23 hours, and 47 hours after reaching the acquisition criterion. On the 70th hour the animal was put in the feeding cage for 55 minutes with 12 grams of food. At the end of the 55 minute period if there was any food left in the feeding

cage it was taken out and 12 additional grams were put in the cage. If the animal had eaten all the food in the 55 minute period 12 more grams were put in the cage. The animal was considered "zero deprivation" when he would not eat any food for three minutes. In no case did this take more than 12 minutes following introduction of the 12 additional grams of food into the cage. The animal was then placed on the apparatus and the extinction procedure was begun.

6 hour deprivation group-was given 12 grams 23 hours, 47 hours, and 64 hours after reaching the acquisition criterion. The extinction procedure was begun 71 hours after acquisition.

12 hour deprivation group- was given 12 grams for one hour, 23 hours, 47 hours, and 58 hours after acquisition. Extinction procedure was begun 71 hours after acquisition.

23 hour deprivation group-was given 12 grams for one hour, 23 hours, and 47 hours after acquisition. Extinction procedure was begun 71 hours after acquisition.

47 hour deprivation group-was given 12 grams for one hour, 23 hours, after acquisition. Extinction procedure was begun 71 hours after acquisition.

71 hour deprivation group-was not fed. Extinction procedure was begun 71 hours after reaching the acquisition criterion.

The basis for the inclusion into a particular hunger

group was the number of responses to reach the acquisition criterion. The first few animals were randomly placed into different deprivation groups. The rest of the animals were placed in certain hunger groups to equalize the mean number of responses to reach the acquisition criterion for each hunger group.

Extinction Procedure

71 hours after reaching the learning criterion the animal was placed on the apparatus with both the black and white runways in place. The same procedure as used in training was employed except that now the food cups did not contain any food pellets. The runways were manipulated in the same orders and manner as before.

The discrimination response was considered extinguished when the animal made no response for a period of three minutes. A response was recorded when the animal inserted his nose into the food cup. The time interval between the raising of the panel door and the insertion of the rats nose into the food cup was recorded as the response latency. This interval was recorded to the nearest tenth of a second by a stopwatch.

The above method of extinction was chosen in preference to the method where both the previously positive and negative stimuli are now reinforced until the animal is

responding to a chance manner to either stimulus. This method was not used in the present experiment since the experimenter preferred to keep the study in the extinction framework of other studies concerned with the relationship of drive to cessation of response.

CHAPTER III

RESULTS AND DISCUSSION

Acquisition

Data concerning the number of responses to reach the acquisition criterion and the number of correct (reinforced) responses elicited in reaching the acquisition criterion for each hunger group are presented in Table I. An analysis of variance applied to the acquisition data revealed no significant differences, at the 5% level, between the different deprivation groups.

In the same table we notice that the number of animals reinforced on the back runway and the number of animals reinforced on the white runway with the exception of the 7lh are almost evenly distributed for each deprivation group. The mean number of responses to reach the acquisition criterion for the black and white reinforced groups was 69.2 and 71.6 respectively. This difference was not significant at the 5% level.

Extinction

At the present state of knowledge it appears that the three classes of variables that influence the extinction procedure are:

1. The conditions existing during acquisition.
2. Those conditions intervening between

TABLE I

ACQUISITION DATA FOR THE VARIOUS
DEPRIVATION GROUPS

	<u>DEPRIVATION GROUP</u>					
	<u>0h</u>	<u>6h</u>	<u>12h</u>	<u>23h</u>	<u>47h</u>	<u>71h</u>
Number of responses in acquisition						
Mean	70.5	70.7	69.8	70.3	70.0	71.0
Median	70.5	69.0	65.5	59.0	60.0	69.5
<hr/>						
Number of reinforced responses in acquisition						
Mean	47.7	47.4	47.1	47.8	47.4	43.4
Median	49.0	49.0	45.0	40.0	44.0	44.0
<hr/>						
Number of animals reinforced on the black runway	5	5	4	4	5	7
Number of animals reinforced on the white runway	5	5	6	6	5	3

acquisition and extinction.

3. Those conditions present at the time of extinction itself.

This study deals with one of the variables in the third group. In this connection, it will be recalled that the major concern of this study stemmed from the fact that limited information was available on the effect of drive on extinction. Moreover, an examination of the few studies performed in this area indicated certain gaps in our knowledge. In the first place there were no studies which systematically varied the hunger drive beyond twenty three hours during the extinction procedure. In addition no studies were found in which the drive during the extinction procedure was systematically varied beyond the drive used in the training procedure. Finally, in the few investigations studying the relationship of drive to extinction, only instrumental-type tasks were used.

While the nature of the task used in this area was not a crucial issue, it was felt that a more systematic study of the relationship of drive to extinction could at the same time determine how this relationship appeared in a different experimental task. Accordingly a discrimination task was employed.

The results of this experiment revealed that the extinction curve for a discrimination task was practically

identical to that found for instrumental tasks. However an interesting finding was seen in the fact that an appreciable number of animals ceased responding altogether without making a response to the previously negative stimulus. That is, some animals made no reversals before the criterion of experimental extinction was met.

An analysis of the reversals during the extinction procedure in Table II reveals that 24 animals made no reversals. In the same table, we note, that when the mean number of reversals responses for each deprivation group is considered, there is a tendency for the animals with the greater drive to make more reversals. This may be related to the fact that a positive correlation of .82 was obtained when the number of reversals for each animal was compared to the number of responses to extinction. We note also that the 0h, 6h, and 12h had much fewer reversal animals with the 0h having no animals that made any reversals.

It is difficult to evaluate the data on reversals, since to the experimenter's knowledge, no other study has used the present extinction procedure where both choices are not reinforced.¹

¹Anderson (1) employed an extinction criterion of 50% response choice by placing food in both choices.

TABLE II

ANALYSIS OF REVERSALS OBTAINED DURING THE
EXTINCTION PROCEDURE AS A FUNCTION OF
DRIVE

	<u>DEPRIVATION GROUP</u>					
	<u>0h</u>	<u>6h</u>	<u>12h</u>	<u>23h</u>	<u>47h</u>	<u>71h</u>
Number of reversal animals	0	2	6	10	9	9
Mean number of reversals	0	.4	.9	3.9	3.0	4.3
Mean number of responses to extinction	3.4	10.4	13.9	37.9	34.0	29.6

However, certain comparisons may be possible with those studies where reversal of a discrimination was the major concern. The usual procedure employed, in such studies, is to withhold reinforcement from the previously positive stimulus and reinforce the former negative stimulus.

In these studies the occurrence of certain experimental procedures make it unlikely that there would be any non-reversal animals. One of the following experimental features is usually found:

1. The animal during acquisition is still making an appreciable number of responses to the negative stimulus. For example, in the experiments concerned with the continuity and non-continuity controversy, Spence (31) and others (25, 4) reversed the positive and negative stimuli before the animal was responding in a better than chance manner to either the reinforced or unreinforced stimulus.
2. Another experimental feature: the animal is given periods of rest and removed from the apparatus. In these studies (2, 11) after the animal had learned the original discrimination the positive and negative stimuli were reversed. If the animal did not respond in a short period of time (usually

two minutes) he was removed from the apparatus and returned a short time later (eg. 30 seconds). This procedure was repeated until the animal responded.

3. In some studies (21) a noxious stimulus is used to compel the animal to respond. This feature is usually found in the use of the Lashley Jumping Box. If the animal does not respond in a period of thirty seconds he is forced to do so by a blast of air.
4. Some experimenters (8) use guidance and forced-choice to ensure a response to the new positive stimulus. The positive stimulus is left on the same side for four consecutive trials. If the animal still doesn't respond to the positive stimulus after four trials, he is given "guidance" by being placed closer to the positive stimulus than the negative stimulus.

Thus, in the above studies we see that methods used make it quite likely that an animal will make a reversal sooner or later.

Though there are no empirical data with which to compare the reversal results of the present study, a theoretical analysis of the phenomenon of no reversals can be put forth on the basis of Spence's theory of discrimination.

Spence (30) states that the positive stimulus in a discrimination task receives an increment of excitatory potential when ever the response to it is reinforced and that the negative stimulus receives an increment of inhibitory potential when ever the response to it is not reinforced.

He further states that the strengthening of the response to the positive stimulus will automatically strengthen (to a lesser degree) the response to the negative stimulus through generalization of reinforcement. Similarly, non-reinforcement of the response to the negative stimulus will simultaneously tend to weaken the response (to a lesser degree) to the positive stimulus through the generalization of extinction. To the extent that the stimuli are dissimilar (eg. black vs. white) the primary effect of reinforcement or extinction will be greater than the generalized effect, and after a sufficient number of reinforced vs. non-reinforced repetitions the excitatory potential to the positive stimulus will be much higher than that of the negative stimulus so that the animal will now always respond to the positive stimulus.

Turning now to the phenomenon of no reversals obtained in the present experiment an analysis may be made, on the basis of the above theory, in the following manner:

In extinction, when the animal responds to the previously reinforced stimulus, an increment of inhibitory potential is built up to that stimulus. This inhibitory effect is generalized to the previously unreinforced stimulus so that it too receives an increment of inhibitory potential which is added to the inhibitory potential that it already accumulated during the training procedure. As the animal continues to respond to the previously positive stimulus (because of its high excitatory potential built up during training) the inhibitory potential to it accumulates until it is greater than its excitatory potential. This results in the cessation of response to the former positive stimulus. Meanwhile, through generalization of the extinctive inhibition from the former positive stimulus, the previously unreinforced stimulus has accumulated enough inhibitory potential to overcome any generalized excitatory potential it may possess so that the animal will not respond to this stimulus as well.

This same type of rationale would hold as well for the case of reversal animals. That is, during extinction when the animal ceases to respond to the previously positive stimulus it will respond to the negative stimulus since if the latter's excitatory potential is greater than its own inhibitory potential, in spite of the fact that it has received generalized increments of inhibition with non-reinforcement of the positive stimulus. Now when the animal

responds to the previous negative stimulus increments of primary inhibitory potential result until the inhibitory potential becomes much greater than its excitatory potential. Finally the inhibitory potential of both the former positive and negative stimuli will exceed their own excitatory potentials and the animal will cease responding to either stimulus.

From the above statements the problem now arises as to why some animals (during extinction) was the inhibitory potential from the generalization of extinction from the positive stimulus not made greater than the negative stimulus's own excitatory potential and why in some animals was it made greater than the excitatory potential.

The variables that may effect the relationship between excitatory potential and inhibitory potential are the number of wrong responses, the number of correct responses, and the ratio of right responses to wrong responses.

Further experimentation is needed in which these factors may be isolated and their effect on the relationship between inhibitory potential in this situation (extinction of a discrimination) determined. Once the effect of these factors on the relationship between excitatory potential and inhibitory potential is determined a more comprehensive theoretical analysis of the phenomenon of reversals during the extinction procedure may be made.

The Relation of Drive to the Number of
Responses to Extinction

Before proceeding to the overall relationship between degree of drive to the number of responses to extinction, an examination of the zero hunger group is in order because of its relation to recent empirical studies. The studies stem from Perin's extrapolations of his extinction curve for the zero hunger group. According to Perin, the number of responses for the zero hunger group should be about 28% of the number of responses made at 24 hours food deprivation.

In the present study while some responses were made by the zero deprivation group the number was considerably below 28% of the 23 hour deprivation group. This present finding is in agreement with the simillarily low values found by Koch and Daniel, and Horenstein for the zero group.

Turning to the major data we note that the curves of mean and median number of responses to extinction in Figure 2 show a slightly positively accelerated increasing function up to 23 hours followed by a gradual decline to 71 hours. The curves up to 23 hours are much steeper than the curves from 23 hours to 71 hours and the median and mean curves show little difference in shape.

According to Bartlett's Test (7) the assumption of homogeneity of variance was not met so the Median Test (23)

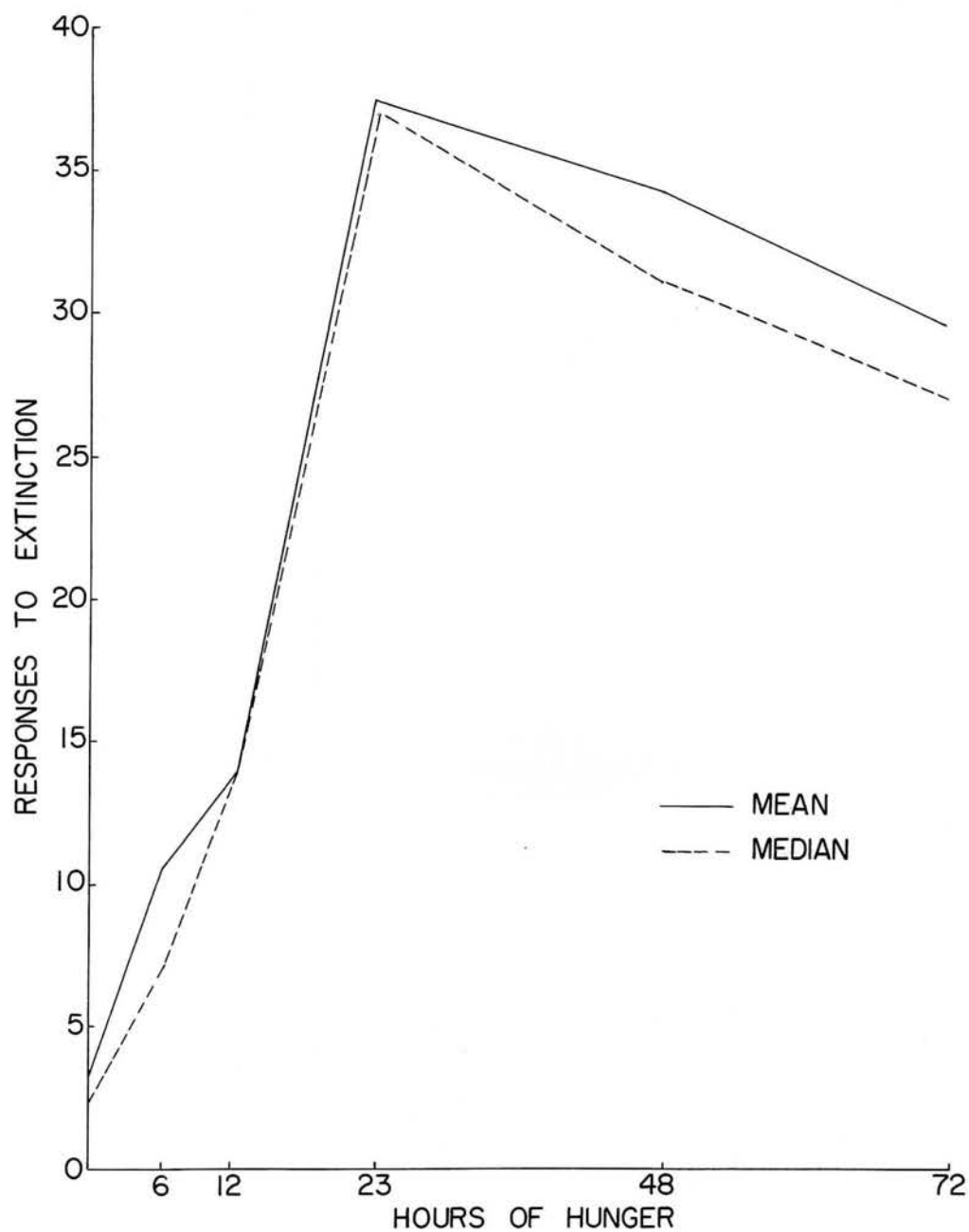


FIGURE 2

THE NUMBER OF RESPONSES TO EXTINCTION FOR
THE DIFFERENT HUNGER GROUPS

a non-parametric technique was used to test the difference between the various groups. The Chi-square values and levels of significance are presented Table III. There were no significant differences between the 0h, 6h, and the 12h groups nor between the 23h, 47h, and the 71h groups. There were, however, significant differences, in every case, when the 0h, 6h, and 12h groups were compared with the 23h, 47h and the 71h groups.

The curves for the number of responses to extinction up to twenty three hours closely resemble those of Perin and Horenstein. Concerning Perin's graph Hull (16) states that this function is believed to hold only up to the number of hours of hunger employed in the original habit formation. In other words, that portion of the curve that extends beyond the deprivation interval used doesn't necessarily continue in a positively accelerated manner.

It should be noted, that when we compare the extinction curves up to twenty three hours food deprivation, there is a striking resemblance between results in the use of instrumental type tasks and the discrimination task.

In considering the curves beyond twenty three hours it would be reasonable to expect that animals which had been deprived of food for much longer intervals than twenty three hours would persist longer in making responses that one time led to food. But rather than a rise in the curve beyond

TABLE III

CHI-SQUARE RESULTS OBTAINED BY THE USE OF THE MEDIAN
TEST FOR THE COMPARISON OF THE NUMBER OF RESPONSES
TO EXTINCTION FOR THE VARIOUS DEPRIVATION GROUPS

<u>HUNGER GROUPS</u>	<u>CHI-SQUARE</u>	<u>LEVEL OF SIGNIFICANCE</u>
0-6	1.8	Not significant at .05
0-12	1.8	Not significant at .05
0-23	16.2	Beyond .01
0-47	16.2	Beyond .01
0-71	16.2	Beyond .01
6-12	.2	Not significant at .05
6-23	9.8	Beyond .01
6-47	11.8	Beyond .01
6-71	5.0	At .05
12-23	7.2	Beyond .01
12-47	5.0	At .05
12-71	5.0	At .05
23-47	.2	Not significant at .05
23-71	1.8	Not significant at .05
47-71	.2	Not significant at .05

twenty three hours we find that the curve gradually declines with 47 and 71 hours of food deprivation.

This peak at, twenty three hours, is anticipated by Hullian theory. According to Hull (15) drive acts both as multiplicative factor (with habit strength) to produce reaction potential, and as a cue stimulus. That is, if an animal is trained under a certain drive and subsequently performs under a stronger drive, this stronger drive, on the one hand, increases reaction potential, (in its capacity as a multiplicative factor) but, at the same time, it operates to reduce the reaction potential since its cue value is a generalized one on the stimulus generalization gradient.

Yamaguchi found, as in this study, that response strength was greatest when measured under the same drive used in the training procedure.

That the strength of the response measured after training is somewhat dependent upon the extent of the drive used during training is also indicated in the Sackett, and Heathers and Arakelian studies.

The shape of the total gradient was predicted by MacCorquodale and Meehl (22) following an examination and consideration of certain implications from the Hullian formulation of the dual role of drive. They hypothesized that the shape of the drive stimulus gradient would be as follows:

"Essentially, we suggest that the steepness of the generalization gradient for drive as a stimulus is much greater on the low (weak drive) side of the point conditioned than it is on the high (strong drive) side. That is to say, when we increase the level of the animals drive, while it is true there is a loss from the standpoint of habit strength to generalized habit strength, the loss is not so nearly as pronounced as it is when we move to the lower state of drive on the continuum".

As can be seen from an examination of the above statement, the gradient obtained in the present study very closely resembles the one predicted by MacCorquodale and Meehl.

Also concerning the shape of such a gradient Hull, himself, (15) states that when a response is conditioned to a weak stimulus and generalizes to stronger stimuli, the resultant gradient will be convex in shape. In the present experiment this would be the graph from 23 hours to 71 hours. This portion of the curve is practically a straight line. Hull also states that when a response is conditioned to a strong stimulus and generalizes to weaker stimuli, the resultant gradient is concave in shape. This portion of the graph (from 23 hours to 0 hours) in the present experiment is concave in shape.

First Trial Latencies During Drive Manipulation

The effect of different hours of deprivation on performance prior to the introduction of the non-reinforcement effect is readily seen in Figure 3.

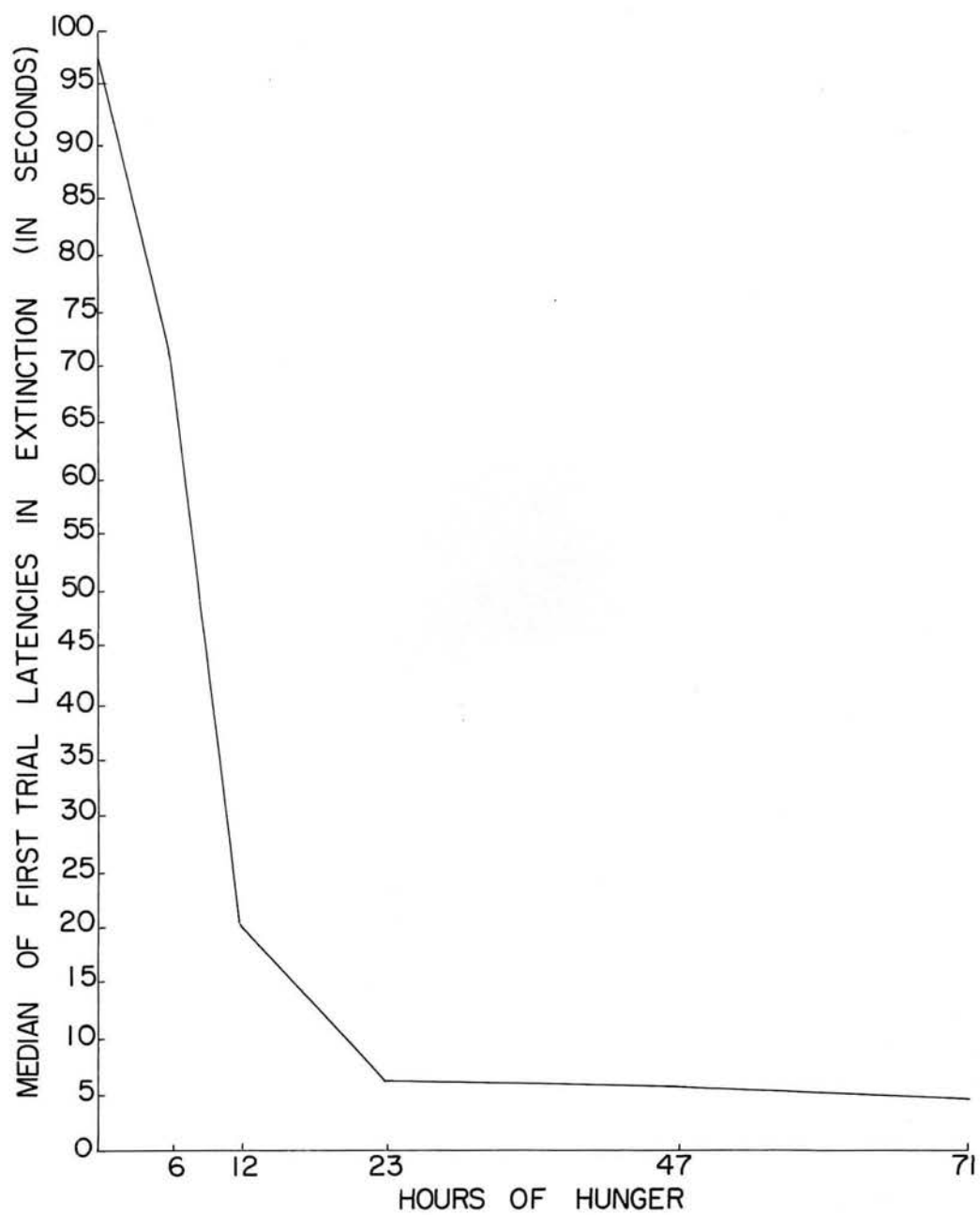


FIGURE 3

MEDIAN OF FIRST TRIAL LATENCIES IN EXTINCTION
FOR THE DIFFERENT HUNGER GROUPS

The graph of the medians of the first trial latencies reveal an inverse relationship between the number of hours of hunger and the first trial latency. The curve shows a very steep fall to 23 hours with a more gradual decline to 71 hours. The differences between the 0h, 6h and 12h groups appear much greater than the differences between the 23h, 47h and 71h groups.

Since the 47h and 71h groups have shorter median latencies than the 23h no apparent generalization effects are indicated. It would seem that in this measure of performance the energizing factor of drive exerts a greater influence than the cue factor.

CHAPTER IV

SUMMARY AND CONCLUSIONS

The present investigation was concerned with the relationship between drive and performance when drive was varied during extinction of a discrimination task. Following the acquisition of a black-white discrimination response under 23 hours of food deprivation, six groups of rats were extinguished under the following food deprivation intervals: 0 hours, 6 hours, 12 hours, 23 hours, 47 hours, and 71 hours.

The graphs of the mean and median number of responses to extinction showed a slightly positively accelerated increasing function up to 23 hours followed by a more gradual decline to 71 hours. There were no significant differences between the 0h, 6h and 12h groups nor between the 23h, 47h and 71h groups. There were, however, significant differences, in every case, when the 0h, 6h and 12h groups were compared with the 23h, 47h, and 71h groups.

The curves up to 23 hours closely resemble those of Perin, and Horenstein. A consistency in the use of different experimental tasks, in the concern with the influence of drive on extinction, is revealed since Perin, and Horenstein both used instrumental type tasks and a discrimination task was used in the present experiment.

The maximum number of extinction responses at 23 hours was anticipated by Hullian theory on the basis of drive as

both a multiplicative factor and as a cue for excitatory potential.

The curves for the number of responses to extinction reveal that the curve from 0 to 23 hours is much steeper than the curve from 23 to 71 hours. This was predicted by MacCorquodale and Meehl who hypothesized such a gradient from a consideration of certain implications of the Hullian formulation of the dual role of drive. It was noted that Hull's prediction of the shape of such a gradient conformed somewhat to the shape of the gradient obtained in the present experiment.

The small number of extinction responses for the zero deprivation group agreed with the findings of Koch and Daniel, and Horenstein who found that the performance of the zero deprivation group during the extinction procedure was much less than would be expected from Perin's extrapolations on the zero deprivation group.

An incidental but unexpected result was seen in the fact that 24 out of the 60 subjects made no reversal during the extinction procedure. This finding was discussed in relation to Spence's theory of discrimination and it was concluded that more experimental evidence, concerning reversals during the extinction procedure, was needed to allow a more comprehensive theoretical analysis of the phenomenon of no-reversals.

The graph of the median of the first trial latencies

during extinction did not have the same shape as the curves of the number of responses to extinction. The graph of the latencies revealed an inverse relationship between the number of hours food deprivation and first trial latency during the extinction procedure. It was suggested that the apparent lack of generalization effects in the latency curve may be due to the fact that in this measure of performance the energizing factor of drive exerts a greater influence than the cue factor.

The present experimental findings suggest the following conclusions in respect to the three limitations and questions posed at the beginning of this study:

1. The maximum performance during extinction will be found for animals in which drive during acquisition and extinction is identical.
2. The performance curve at the time of extinction will show a gradual decline for animals whose deprivation intervals extend beyond the deprivation interval employed in training.
3. The use of instrumental type tasks and discrimination tasks give similar results for the effect of drive manipulation during the extinction procedure on performance measured during extinction.

In addition the present experimental findings indicate that:

1. An appreciable number of animals during the extinction of a discrimination response will show few or no reversals before the extinction criterion is met.
2. The dual role of drive may have different consequences for different response measures.

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ABSTRACT

INTRODUCTION

For many years experimenters have attempted to determine what variables influence the performance of organisms on experimental tasks. The drive variable has received particular emphasis in recent years largely due to various theoretical speculations concerning the role of drive in behavior theory. While these speculations have provided a program and stimulus for research, it is obvious that theoretical speculation can proceed more meaningfully when a larger body of empirical findings is available.

The few studies concerned with the relation of drive to performance reveal that more attention has been paid to the study of the effects of drive during training than the effect of drive variations during extinction.

The status of the effect of drive variation on the two major areas of performance was first clarified by a critical review of the studies in which drive has been manipulated during the training procedure and the studies concerned with drive variation during the extinction procedure.

The investigations on the effect of degree drive, during training reveal that, in general, the longer the food deprivation intervals the more efficient the performance during training.

The studies which held drive constant during acquisition and varied the drive during the extinction procedure indicate that resistance to extinction increases in a positively accelerated manner from zero to twenty three hours (Perin, and Horenstein). Furthermore, the studies of Sackett, and Heathers and Arakelian suggest that extinction is to some extent effected by the drive employed in training or the drive used in a previous extinction session.

STATEMENT OF THE PROBLEM

In the review of the literature concerned with the relationship of drive to performance during the extinction procedure, some gaps in our knowledge become apparent. First of all, deprivation intervals during extinction were never systematically varied beyond twenty four hours. In addition, with the exception of a study by Sackett, the intervals during the extinction procedure did not extend beyond the deprivation interval used in the training procedure. Sackett, as a matter of fact, had only one interval in the extinction procedure which extended beyond the deprivation interval used during the training procedure. Finally it was observed that in all of the experiments in this area only instrumental-type tasks were employed.

The above considerations led to the present investigation and its intention to deal with the following characteristics:

1. The manipulation of drive, during the extinction procedure, beyond twenty four hours.
2. The use of deprivation intervals substantially above and below the deprivation interval used during the acquisition procedure.
3. The use of a discrimination task rather than an instrumental type task.

To summarize, the purpose of this study was to determine the relationship between drive and performance when drive was varied from 0 to 71 hours during the extinction of a discrimination task.

Procedure

60 albino rats were trained to make a black-white discrimination under 23 hours hunger, to a criterion 18 out of 20 correct trials, the last 10 being correct. 30 animals were reinforced on black and 30 animals were reinforced on white. The animals, on the basis of the number of responses to meet the criterion of acquisition, were put into food deprivation groups so that the mean number of responses to reach the acquisition criterion was made equal for each group.

71 hours after the animals had reached the acquisition criterion the animals were placed on the apparatus and were extinguished (no food was available at either stimulus) to a three minute criterion of no response. At the beginning of the extinction procedure each animal was under one of the

following food deprivation intervals: 0 hours, 6 hours, 12 hours, 23 hours, 47 hours and 71 hours. (10 animals to a group).

RESULTS AND DISCUSSION

An analysis of variance applied to the number of correct responses made in reaching the acquisition criterion and total number of responses made in acquisition revealed no significant differences (at the .05) level between the various hunger groups. The difference in the mean number of responses to reach the acquisition criterion between the black and white reinforced groups was not significant at the .05 level.

Before proceeding to the major results of the experiment two incidental, but important findings, were discussed.

The first concerned the reversal data obtained in the extinction procedure. A somewhat unexpected finding was noted in the fact that during the extinction procedure 24 animals made no reversals. It is difficult to evaluate this finding, since to the experimenter's knowledge, no other study has used the present extinction procedure, i.e., where both choices are not reinforced. In the studies concerned with reversals the experimental features are usually manipulated so that the animal will make a reversal.

Though there are no empirical data with which to compare the reversal results of the present study, a theoretical account was made on the basis of Spence's theory of

discrimination. It was concluded that more experimental evidence, concerning reversals during the extinction procedure, was needed to give a more comprehensive theoretical analysis of the phenomenon of no reversals.

The second incidental finding concerns the performance of the zero hunger group and its relation to recent empirical studies. These studies stemmed from Perin's extrapolations which held that a zero hunger group should make 28% of the number of responses to extinction made by a 24 hour group.

In the present study while some responses were made by the zero deprivation group the number was considerably below 28% of the 23 hour deprivation group. This present finding is in agreement with the similarly low values of Koch and Danial, and Horenstein.

Turning to the major results we find that the graphs of the mean and median number of responses to extinction show a slightly positively accelerated uncreasing function up to 23 hours followed by a gradual decline to 71 hours. The curves up to 23 hours are much steeper than the curves from 23 to 71 hours and the overall mean and median curves show little difference in shape.

The median test revealed no significant differences (at the .05 level) between the 0h, 6h, and the 12h groups nor between the 23h, 47h and 71h groups. There were, however, significant differences in every case when the 0h, 6h and 12h groups were compared with the 23h, 47h and

the 71h groups.

The curves for the number of responses to extinction up to 23 hours closely resembles those of Perin, and Horenstein. When we compare the results up to 23 hours with those obtained by Perin, and Horenstein a consistence in results (shape of curve) in the use of instrumental type tasks and the discrimination task is revealed.

In considering the curves beyond twenty three hours it would be reasonable to expect that animals deprived of food for much longer intervals than twenty three hours would persist longer in making responses that previously led to food. But rather than a rise in the extinction curve beyond twenty three hours we found that the curve gradually declines with 47 and 71 hours food deprivation. This peak at 23 hours was anticipated by Hullian theory. According to Hull, drive acts both as a multiplicative factor (with habit strength) to produce reaction potential and as a cue stimulus. That is if an animal is trained under a given drive and subsequently performs under a stronger drive, this stronger drive on the one hand increases reaction potential (in its capacity as a multiplicative factor) but at the same time it operates to reduce reaction potential since its cue value is a generalized one on the stimulus generalization gradient. This finding and rationale was consistent with those of Yamaguchi, who found that response strength was

greatest when measured under the same drive used in the training procedure, and those of Sackett and Arakelian.

The shape of the total gradient obtained in the present experiment was predicted by MacCorquodale and Meehl. Following an examination and consideration of certain implications from the Hullian formulation of the dual role of drive these writers hypothesized that the shape of the drive stimulus gradient would be as follows:

"Essentially we suggest that the steepness of the generalization gradient for drive as a stimulus is much greater on the low (weak drive) side of the point conditioned than it is on the high (strong drive) side. That is to say, when we increase the level of the animal's drive, while it is true there is a loss from the standpoint of habit strength to generalized habit strength, the loss is not so nearly as pronounced as it is when we move to the lower state of drive on the continuum."

The gradient obtained in the present study very closely resembles the one predicted by MacCorquodale and Meehl.

Also concerning the shape of such a gradient Hull, himself, states that when a response is conditioned to a weak stimulus and generalizes to stronger stimuli, the resultant gradient will be convex in shape. In the present experiment this would be the graph from 23 hours to 71 hours where the curve is practically a straight line. Hull also states that when a response is conditioned to a strong stimulus and generalizes to a weaker stimulus the resultant gradient is concave in shape. This portion of the curve (from 0 to 23 hours) in the present experiment was found to be concave in shape.

The graph of the median of the first trial latencies during extinction as a function of hunger reveals an inverse relationship between the number of hours of hunger and the first trial latency. No apparent generalization effects are indicated since the 47h and 71h groups have shorter median latencies than the 23 hours group. It would seem that in this measure of performance the energizing factor exerts a greater influence than the cue factor.

The present experimental findings suggest the following conclusions in respect to the three limitations posed at the beginning of this study:

1. The maximum performance during extinction will be found for animals in which drive during acquisition and extinction is identical.
2. The performance curve at the time of extinction will show a gradual decline for animals whose deprivation intervals extend beyond the deprivation interval employed in training.
3. The use of instrumental type tasks and discrimination tasks give similar results for the effect of drive manipulation during the extinction procedure on performance measured during extinction.

In addition the present experimental findings indicate that:

1. An appreciable number of animals during the extinction of a discrimination response will show few or no

reversals before the extinction criterion is met.

2. The dual role of drive may have different consequences for different response measures.

VITA CURRICULUM

I was born in Boston February 21, 1927, to Domenica and Salvatore Cautela.

I attended the first seven grades at the Dearborn School in Boston. After three years at the Central Junior High School in Quincy, Massachusetts, I went to Quincy High School and graduated in 1944.

In 1944 I entered Boston College but could not complete the first year because of a call to military duty. After a year and a half in the Navy as a Medical Corpsman I re-entered Boston College in September of 1946. I obtained my B.A. with a psychology major in June of 1949. In 1949, I was admitted to Boston University as a candidate for a Master of Arts Degree in Psychology. I obtained this degree in June of 1950.

I began study for a Ph.D. degree in September 1950. In 1950 I also became part time research assistant on the staff of Harvard University at the Boston Psychopathic Hospital. My duties consisted of being a statistical consultant and the administering of psychological tests to patients. I held this position for a year and then in September of 1952 I was appointed to the faculty of Boston College as a full time instructor in psychology, a position which I still retain.

In the summer of 1952 I was employed as a research assistant by the Atomic Energy Commission. I conducted learning experiments with dogs.

In August 26, 1952 I married Claire Marie Walsh and in June 19, 1952 we had a son.