CHANGED RESPONSE PREFERENCE FOR STIMULI PREVIOUSLY PAIRED WITH HIGH OR LOW HUNGER DRIVE

By

ARTHUR KAUFMAN

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Rutgers University

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Thesis Approved:

Roy Gladstone
Thesis Adviser

W. J. Griffitts

Robert MacVicar
Dean of the Graduate School

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Dedicated

To

T. S. S.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER I

INTRODUCTION AND REVIEW OF THE LITERATURE

This investigation was concerned with the modification of a response preference in the albino rat. Previously neutral stimuli were paired with either high or low states of hunger drive, and a subsequent modification of a response preference for those stimuli was noted. The review of the literature which follows will deal with several topics which are related to this experimental problem. These topics are arranged to provide for a general introduction to the present study and culminate in a section which contains those studies having the most direct bearing on the present investigation.

Acquired Motivational Value

One of the historical forebearers of the study suggested above is the problem of whether or not any learning can take place in the absence of the direct reduction of primary drives.* Anderson (1941a) hypothesized that it should be possible to show evidence of learning if stimuli which had been previously associated with the reduction of primary drives were used properly. In order to test that hypothesis, a group of rats was trained in one maze with hunger as the motivation and food as the reward

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*The terms "drive" or "drive state" as used in this paper refer to a pattern of organic stimuli assumed to be aroused by such environmental manipulations as hours of food deprivation or the sounding of a buzzer previously associated with electric shock.

in the goal box. Different groups of these subjects were then tested upon two additional mazes under the following conditions: (1) hunger with food reward; (2) hunger with no food reward; (3) satiation with food reward; and (4) satiation with no food reward. Some of the animals run under conditions (2), (3), and (4) learned the latter two mazes as quickly as those run under the hunger-with-food-reward procedure. The latter three groups were superior in performance when compared with control animals who did not undergo the hunger-with-food-reward trials on the first maze (Anderson, 1941b).

Anderson interpreted these results in terms of his hypothesis concerning externalization of drive, demonstrating at least that it is not necessary to develop a need state in a rat to motivate him to learn a new maze and that place learning can occur in the absence of primary reward. On the other hand, the present author suggests that these results might be interpreted in accordance with secondary reinforcement principles; but since Anderson points out that the anomalous condition groups /(2), (3), (4)/ showed improvement on the two additional mazes, the lack of extinction effects militates against such an interpretation. These extinction effects, however, could have been overshadowed by the increase in experience on the mazes themselves; that is with each trial the subjects became less motivated but more familiar with the particular maze and the latter factor was more influential. Such an interpretation is purely hypothetical.

In a rather impressive demonstration of drive stimuli becoming aroused by a previously neutral stimulus, Miller (1948) placed albino rats in an apparatus (now known as the Miller Box) having two compartments separated by a door. One compartment was white and had a gridded floor and the other was black with a flat wooden floor. Prior to training, the subjects were tested for compartment preference and found to have none. They were then placed individually in the white compartment, shocked and then allowed to run through a door which was then opened into the shock free black compartment. After several such trials, the subjects would run into the black compartment even when shock was not applied. In demonstrating a hypothesized acquired drive (fear or anxiety, now "externalized" or aroused by the white compartment), the subjects were taught a new habit without further shock. In order to open the escape door, the subjects had to first turn a small wheel in the proximity of the door. This they learned to do. If conditions were altered so that a new habit such as bar pressing was required before the door would open, this was learned also. The use of control groups showed that the learning of these new habits was directly dependent on having been exposed to the original shock experience. Thus, the white compartment in itself became a cue for avoidance behavior or, to put it in reductionist terms, it now aroused drive stimuli associated with the fear or anticipation of pain although no such physical stimulus was present.

Working along similar lines, May (1948) attempted to discover whether the drive value of a buzzer could be increased by pairing it with shock in a situation where no escape for the rat was possible. First an escape situation was set up, electric shock being used as the stimulus. Then a buzzer was paired with the shock, but escape into the safe compartment was blocked. The animals were then tested with the buzzer alone and when given the opportunity to escape did so to a significant degree. Control groups in which the buzzer was sounded independently of shock in the training situation were significantly lower in escape responses. What seems to be the vital point here is that the experimental animals exhibited an escape response at the sound of the buzzer when, during the previous training trials, the buzzer was paired with shock but the animals were prevented from performing an escape response.

Brown and Jacobs (1949), in an experiment utilizing a Miller Box apparatus found that rats which were exposed to a buzzer sound while being shocked learned a new response (hurdle jumping) in the presence of the buzzer alone. A control group which had not experienced the original shock situation failed to learn this new response. The authors concluded that fear reduction (escape) functions like other drive stimuli reductions to reinforce new responses. They add, however, that fear in itself does not bring about an increase in activity as does an aversive stimulus. Instead, it serves to intensify whatever response is dominant at the time in that particular situation whether it be crouching, running or hurdle jumping.

In a somewhat extended repetition of Miller's (1948) study, Griffiths (1955), utilizing a modified Miller Box found that rats do not readily associate shock, food deprivation, or water deprivation and the consequent reduction of such states with neutral cues (blackness or whiteness of retainer box) in the environment. The procedure in this case was as follows: Ss were either shocked, food or water deprived in a white colored environment and then placed in a white box, learning to operate a wheel to escape. However, in going one step further, it was noted that they also learned to operate a wheel in the black compartment to escape back into the white one. For this reason the attachment of fear or anxiety to the whiteness or blackness of the environment was discounted and a general escape association to the situation as a whole was hypothesized. Of course, the response to the wheel might have generalized to any compartment and the fact that the wheel was also associated with the white compartment could have caused it to have fear producing properties and hence accentuate that response associated with fear reduction, namely the wheel turning. Unfortunately escape latencies from the respective compartments were not compared, leaving Miller's (1948) conclusions still tenable.

Moving along to "reward" type studies, Saltzman (1949) found that rats were able to learn a simple maze problem when the only reward was an acquired or secondary reward, e.g., a familiar box in which they had been previously fed. He concluded that this study demonstrated the rat's ability to learn a simple maze when correct responses were followed by stimuli previously associated with primary food reward. This concurs with Anderson's (1941, 1941a) theoretical and empirical papers.

Saltzman further discusses the various distinctive aspects of goal boxes, including visual as well as kinesthetic factors, and states that it is impossible to say which of the factors was most potent as an acquired reward. In considering them altogether, however, he believes them to be at least as effective or even slightly better than the primary reward value of food. He claims that this last fact "challenges a reinterpretation of the whole problem of the relative effectiveness of rewards." Estes (1949) goes so far as to state "...that since the effectiveness of secondary reinforcement clearly is not specific to the original drive, it will not be profitable to define the concept of reinforcement in terms of drive reduction."

Along this line of research, two studies, one by Bitterman, Feddersen, and Tyler (1953) and the other a slightly modified repetition by Elam, Tyler, and Bitterman (1954) led to the proposal of a discrimination hypothesis involving secondary reinforcement. Basically, the procedure was as follows: rats were trained to run down a runway and enter a white or black colored goal box. Each animal was consistently reinforced in a box of one color and non-reinforced in the box of the opposite color. Then the subjects were submitted to extinction runs, half of them running to the box with the reinforced color and half to the box with the non-reinforced color. The subjects running to the non-reinforced color took significantly longer to extinguish and had shorter running times during the extinction trials. It was concluded that the principle of secondary reinforcement was inadequate to deal with the results of the extinction trials and that some other sets of determinants were lending their influences. Myers (1958) also points out that a secondary reinforcement approach would predict shorter running times during the extinction trials for the reinforced group. He suggests that resistance to extinction could be explained as a function of the similarity between conditions of training and extinction.

Myers and Miller (1954) ran two experiments in an attempt to find a learned drive based on hunger. In Experiment I, four groups of hungry rats were given 70, 30, 10, and 0 drive acquisition trials in a Miller Box with food as a reward in the goal compartment. The subjects learned to touch a door that separated the two compartments which would then open and allow them to enter the black compartment where the food could be found. In a subsequent test, these four groups, now satiated and with no reward in the goal box, were required to open the door via a new response, namely bar pressing. All four of these groups learned to press the bar, their learning curves, having no significant differences. The authors concluded that (a) this phase of the experiment did not provide any evidence for a learned drive based on hunger and food reward and (b) that rats with no prior experience in the Miller Box (the 0 group) could learn to press the bar while satiated and unrewarded. These conclusions seem to be well supported by the results. The naive rats (0 group) learned to press the bar about as well as the most highly rewarded group which received 70 drive acquisition trials. This last bit of data appears to rule out the possibility that either prior experience or previous reinforcement affect bar pressing performance. Perhaps the authors' own title of their article, Failure to find a learned drive based on hunger; evidence for learning motivated by "exploration" would be the best way to summarize their conclusions and the implications of this phase of the study.

Since the 70, 30, and 10 drive acquisition groups were originally placed in the white compartment under hunger deprivation, the situation itself might have taken on aversive qualities which the subjects would want to avoid. Some evidence is provided for this hypothesis by Screven (1959) which will be taken up later. In the case of the 0 drive acquisition group, the exploratory drive suggestion would seem to be more potent as they had had no experience with either of the compartments prior to the testing trials. At this point, Griffiths' (1955) escape association hypothesis comes to mind* and it would seem that the concept of escape association with respect to the 70, 30, and 10 drive acquisition groups seems as adequate as the notion of exploratory drive. This suggests the possibility that two or more drives are operating which tend to nullify each other.

In Experiment II of the Myers and Miller (1954) study, rats which were satiated and subsequently unrewarded learned to press a bar in the Miller Box to gain entrance to the black compartment. These same subjects also

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*described on p. 4.

learned to press a bar in the black compartment to gain access to the white one, thus providing more evidence for learning motivated by exploration. A second group of rats which pressed the bar in the white compartment, but were not allowed to see or enter the black one, did not learn the reverse sequence. A third group trained under the same conditions as the first, but according to a massed trial schedule, also failed to learn.

Myers and Miller attempt to apply Guthrie's (1952) hypothesis of stimulus change or removal from the original learning situation as a basis for the retention of the bar pressing response to the third group of their experiment. They conclude that it is inadequate in explaining why these subjects did not learn the bar pressing sequence as did the first group. Although Guthrie's prediction would apply to the first two groups, Myers and Miller believe that the absence of learning during the massed trial situation confirms Miller's (1948) work that shock/pain/fear is necessary for learning (or drive acquisition) during massed trials.

In contrast to Myers and Miller's conclusions, it seems to this writer that Guthrie's system would have predicted little or no learning under conditions of massed practice as under such a procedure S is put back in the same compartment within a relatively short time. Guthrie clearly indicates that it is the removal from the learning situation (the bar pressing environment) that preserves the learned movements in question. Consequently, putting the subject back into the same situation should only cause interference with the previously learned movements if Guthrie's theory is used. Also, the frequent moving from compartment to compartment, excess handling, etc., would result in rather intensive stimulation which would constantly interfere with any previous learning, especially when this stimulation occurred for the most part in the original learning situation.

Acquired Motivational Value and Neutral Stimuli

One issue which has aroused a lively controversy is the question of whether or not the theory that neutral stimuli can acquire drive value has any experimental basis. Miller (1953) in a review of the literature entitled "Learnable Drives and Rewards" includes the results of 21 studies dealing with secondary rewards (e.g., Wolfe, 1936; Cowles, 1937) as evidence for learned drives. Brown (1953), on the other hand, disagrees with Miller's utilization of token reward studies as evidence for the demonstration of learned or acquired drives. He maintains that the results can be explained by assuming that such stimuli as lights, clicks, buzzers, etc. can serve as reinforcers for the maintenance and learning of responses making it unnecessary to hypothesize a new drive aroused by each token reward and/or previously neutral stimulus. Miller (1951), however, had indicated earlier his belief that the basic mechanism of motivation (strong stimulation) is the same for primary and learned drives. Similarly, he stressed that the underlying mechanism of reinforcement (reduction of strong stimulation) is the same for primary and learned drives. Thus, it would appear to this writer that Brown and Miller's positions are not as disparate as the former has indicated.

Concerning the drive arousal qualities of neutral stimuli as lights, clicks, buzzers, etc. Myers (1958) raises the interesting question of just what a neutral stimulus is and just exactly how the neutral stimulus is related to the primary reinforcer in the learning situation. Researchers have used a variety of cues and as lights, clicks, tones, tactual stimuli, different color end boxes, etc., which they assumed to be neutral. However, Myers maintains that we cannot assume equality and neutrality of these stimuli. He cites several studies which lead him to that conclusion.

Forgays and Levin (1957), and Premack, Collier, and Roberts (1957) indicate that light in itself has reinforcing properties for rats and that its reinforcement value is a function of its intensity. Fink and Patten (1953) trained rats to learn a drinking response in the presence of a complex of light, sound, and tactual stimulation. The elimination of any one of these caused a decrease in the amount of water consumed, but the size of the respective decrement was a function of the particular stimulus component which was removed.

With respect to the latter study, Myers points out that the relative intensity of each stimulus component was a variable and that, since Fink and Patten were dealing with different sense modalities, this remains questionable. Myers also points out that the difficulty of controlling past primary association to the three types of stimuli in question is indeed a formidable one. In closing he concludes that the relationship between past reinforcement and the physical properties of a stimulusis an area worthy of systematic investigation.

Drive Discrimination

Hull (1933) verified the prediction that rats can discriminate between their organic needs. He showed that they can learn to differentiate between different goal routes which lead to reinforcers for particular primary needs. In this study rats were trained to choose one route to a goal box containing food when they were hungry and choose another route to the same goal box which contained water when they were thirsty. The animals eventually learned to distinguish between the two routes on the basis of food or water deprivation, but it took a great deal of effort; in fact Hull's subjects required 180 training days with five trials a day before attaining 80% accuracy of choice.

Leeper (1935) also designed three experiments to determine whether rats could learn to adjust their responses according to their motivational or drive state, utilizing hunger and thirst as the primary motives. In Experiment I 23 subjects were trained in a tunnel maze, one arm of which led to water and the other to food. Food and water deprivation was alternated on successive days. Response accuracy attained 90% in 18 days with 5 trials daily. In Experiment II, 9 subjects were tested after they had had ample opportunity to explore an elevated maze with clearly differentiated end boxes and were trained to associate food with one and water with the other. They reached 100% accuracy within 5 days.

In Experiment III, Leeper sought to determine why Hull's animals showed very little learning after several months of training. Instead of blocking the subjects after a wrong choice as Hull had done, he allowed them to enter the goal box containing an undesired substance. Under this procedure, Leeper's animals reached 80% accuracy after only one 8 day period while Hull's animals required 25 such periods. Leeper concluded that his set of experiments demonstrated that with properly designed apparatus and procedures the learning situation would afford the maximum in cue discrimination so as to permit S to adjust his responses after a very brief period of training.

In comparing the relative success of Leeper's animals with those of Hull's, Osgood (1953), adopting a Tolmanian point of view, presumes that since Leeper had allowed his subjects to enter the incorrect goal box and perceive an inappropriate reward, that these "wrong runs" on a given day would lead the S to learn that that route led to that special significate in a distinctive goal box. Presumably, on the following day, this learning could be utilized under the appropriate motivational conditions. Hilgard (1956), employing a Lewinian explanation, said that the two paths are less different for Hull's rats and that the forces determining the choice at the starting point are more nearly in balance for Hull's rats, thus leading to poorer learning.

In seeking to develop a technique for rapid drive discrimination in the rat that would further improve upon Leeper's methods and perhaps point out in addition why Hull's (1933) animals took so long to learn, Bowles and Petrinovich (1954), utilized a method developed by Verplanck and Hayes, (1953) which suggested that in order to obtain a relatively "pure" state of hunger drive, an animal should be given only extremely dry food for 23 hours and then only water for 1 hour. At the end of this 1 hour, the subjects were found to be maximally hungry as measured by consumatory activity. In like fashion, the procedure for making an S maximally thirsty was to allow him only water for 23 hours followed by only dry food for 1 hour. As a further addition, the mazes were constructed so that the Ss' cages were located at the choice point of the "T" in order that the onset of drive stimuli should occur at that point. The subjects also were allowed to fully satiate themselves in the correct goal box. Learning proceeded at a very rapid rate and remained above 80% accuracy after seven days with one trial per day. (Leeper's animals attained this only after eight days with five trials per day, and Hull's animals after 180 days, with five trials a day).

Utilizing a single unit T-maze, Kendler (1946) trained a group of rats under simultaneous hunger and thirst, finding food in one box and water in the other. Forced choice trials were alternated with free choice trials to equalize experience with the two goal routes. On two subsequent test trials, one under hunger and the other under thirst, the subjects more often chose the goal route appropriate to their need state. According to Osgood (1953), a Hullian prediction would have denied this possibility as during the training trials, there would be no discriminability in the stimulus pattern. Kendler himself states that a possible solution to this problem would be that "only those drive stimuli which are themselves reduced become connected to a rewarded response," which is what Guthrie would have stated but in different terms; namely, the eliminated stimuli (the drive stimuli) become connected to the reward response, and since they are eliminated via this response, they cannot become connected with novel or interfering stimuli.

A clue to the nature of drive stimuli involved in drive discrimination behavior has been offered by Heron (1949). In this study, rats were trained via a single discrimination problem to go to the dark side of the apparatus on waterless days and to the light side on foodless days. Breaking these rats into three control variations produced rather interesting results: (1) when subjects were deprived of both food and water for 22 hours, they went to the <u>food</u> side 100% of the time even though it could be assumed that their need for water was greater than their need for food; (2) when subjects were allowed food and water two hours before a performance trial, they went to the <u>water</u> side 92% of the time; (3) when 4 subjects were deprived of food and water for 48 hours, after which their stomachs were bloated with water via a rubber tube--these subjects in 11 choice responses went to the <u>water</u> side 100% of the time. Heron concluded from these results, that the subjects, when their stomachs were full (with food and water or with water only), they would go to the water side; and that when their stomachs were empty, they would choose the food side, so that the drive stimuli involved in a choice response between food or water are at least in part due to the emptiness and fullness, respectively, of the stomach.

Questioning Heron's conclusions, Miller and Kessen (1954) inserted a balloon on the end of the stomach fistula of rats. They compared the behavior of their subjects when their stomachs were distended by milk with when their stomachs were distended by the inflated balloon. It was found that in a T-maze situation their results did not support Heron's conclusions, for the milk served as a reward and led to the choice of that arm of the T-maze that resulted in milk being injected into the stomach while the inflated balloon acted as punishment and led to the avoidance of the arm resulting in balloon inflation. Now to this writer's way of thinking, these results do not really discredit Heron's conclusions. In the first place, inflating a balloon in a rat's stomach may in all probability put much more pressure on the stomach walls (hence cause pain or at least a quite overfull sensation) than the ingestion or injection of food, water, or milk. And of course it must be remembered that what the rats were essentially choosing between was milk and an inflated balloon, not food or water. Milk is of course technically a food, but also is composed of a good deal of water, and serves both hunger and thirst drives quite adequately. Unfortunately, in Miller and Kessen's report, information was lacking concerning what drive state the rats were run under. In summary, it seemed what this study demonstrated was that rats prefer nutritious milk in the stomach to an inflated balloon.

In essentially another test of Heron's (1949) stomach distension and drive cue hypothesis, Baily and Porter (1955) trained eight cats to press

2 different bars to obtain either food or water when hungry of thirsty respectively. In this study, two response measures were taken. With one, the subjects were satiated for both food and water and, unlike Heron's rats, preferred significantly the food choice response. With the other, the subjects were about 7 days thirsty (fed on dampened salted food only during this period) and 24 hours hungry when tested and in this case, unlike Heron's rats, preferred the water choice response. Now taken at face value, these results might seem to refute Heron's stomach distension hypothesis, but the following facts should be kept in mind; (1) that six out of the eight cats had had previous electrode implants in their brains, (2) that Heron's "satiated" rats were deprived of food and water for 2 hours before testing unlike Baily and Porter's cats which were tested soon after eating, and (3) that the cats were on gradual water deprivation for 6 days before testing and to increase the intensity of the thirst drive were fed salt in their food, thus introducing a variable not found in Heron's study. It would appear here that an exact repetition of Heron's experiment might have been more in order as a test of his 1949 hypothesis, as the procedural differences along with the introduction of a new variable (salt feeding) in the Baily and Porter study make it difficult to apply in evaluating Heron's work.

Baily (1954) in a somewhat more clear cut study trained rats on a discrimination problem which carried as a reward not food or water, but instead escape from very intense light. The subjects had to press one of two panels in order to remove the light. Which panel was correct was determined by which drive was active. According to the results, three groups were able to discriminate (1) thirst from hunger, (2) thirst from satiation, and (3) hunger from satiation. Hence, the drive states themselves served as cues as well as environmental stimuli.

Differentiation of Hunger Intensity

Jenkins and Hanratty (1949) tested the possibility that intensity of a drive state can serve as a differential cue. Utilizing a T-maze, rats were randomly motivated by 11½ hour and 47 hour food deprivation, the correct responses being left and right turns respectively in order to receive a food reward. During the last 25 out of 50 learning trials, the subjects learned to discriminate their responses utilizing drive strength as a cue. In addition to this, the subjects were given 3 additional trials each while under 4 and 72 hour food deprivation. The first run in both these cases was 100% "correct" in that while under 4 hour deprivation, the subjects performed the response that was the correct one for the 11½ hour deprivation schedule; and while under 72 hour deprivation the subjects performed that response deemed correct under the 47 hour deprivation schedule, thus providing for a tentative hypothesis of a generalization of drive intensity as related to drive intensity discrimination.

In comparing the cue strength of drive intensity with that of a "neutral" environmental stimulus on a panel press problem, Baily (1955) found that the presence or absence of hunger drive and an audible sound of short duration were equally as effective as discriminative cues. This essentially supported the results of his 1954 study in which drive states were used as cues also. An interesting possibility for further research comes to mind here; namely, which can better serve as a differential cue--different intensities of the same drive as in the Jenkins and Hanratty study (1949), or two different drive states as in the Baily (1954) experiment.

In an experiment to condition a response based on primary hunger drive, Calvin, Bicknell and Sperling (1953) placed two groups of rats in individual striped boxes for a half hour a day for 24 days. One group received this experience while under 22 hour food deprivation and the other while under 1 hour deprivation. In four subsequent testing trials 12 hours apart while under 12 hour deprivation all subjects were fed in the striped boxes. The results showed that the group which experienced 22 hour food deprivation experience ate significantly more than the group which had the 1 hour experience, suggesting that a "neutral" stimulus could acquire motivating (or drive arousal) properties from association with a relatively strong drive state. The authors also interpreted their results as an indication that primary reinforcement is not essential for the establishment of a conditioned drive. However, in the design of this experiment, it was possible that what actually was conditioned was an increased activity rate in the 22 hour group, and greater conditioned activity can manifest itself in more energetic eating behavior (and hence more eating), especially when subjects are tested under 12 hour hunger drive.

Campbell and Sheffield (1953), for example, measured the random activity of 12 rats for a period of seven days in a carefully controlled _constant_ environment. Seeking the relation of random activity to food deprivation they found that, as hunger increased, an environmental change consistently produced a greater increase in activity, the main implication here being that hunger drive seems to involve lowered thresholds of response rather than internal stimulation to activity in and of itself. As a further proof of this the subjects were even kept three days without food, and, with no external stimuli allowed to affect the unvarying conditions, it was found that there was significantly little change in activity rate over this period. Since the Calvin et al. environmental controls were not nearly as constant as Campbell's and Sheffield's, it could be assumed that a greater conditioned activity rate produced the eating response difference in the Calvin study.

Siegal and MacDonnell (1954) in a repetition of the Calvin, Bicknell and Sperling (1953) experiment found no significant differences in subsequent eating behavior responses between the high drive (22 hour deprivation) and low drive (1 hour deprivation) groups. This of course does not leave much interpretation left to explain why in the latter study, significant differences were obtained, with the exception to the conditioned activity hypothesis based on the Campbell and Sheffield (1954) experiment. The conflicting results obtained in the Calvin et al. and the Siegal and Sperling studies still require explanation.

Some sort of explanatory hope is held out for the Calvin et al. interpretation of their results by Baker's (1953) study. In this experiment the records of the feeding behavior of 50 rats were obtained for a 10 day period under absolutely uniform environmental conditions. The subsequent analysis showed that no particular feeding rhythms were noted for any of the 50 subjects, even when each individual record was analyzed. As a suggestion, Baker concluded that feeding rhythms strongly depend upon cues from the environment as temperature, light, etc. In addition, social cues, prior feeding experiences and such may be contributing factors. When such cues have been removed, aperiodicity characterizes the feeding behavior. In all fairness to Baker, he made no statement concerning conditioned drives, so one must be cautious in applying it to the Calvin et al. study. However, he does imply that if any eating rhythms or behaviors are to follow any sort of regularity or predictability, it is the environment (manipulated or otherwise) that will provide the controlling cues.

Screven (1959), in considering the contrasting results obtained in the Calvin et al. and Siegal studies, attempted to get decisive evidence for a conditioned hunger drive. He hypothesized that rats would leave an environment they had previously associated with hunger, making the assumption that an intense state of hunger drive possessed aversive internal qualities which could become associated with environmental cues. Utilizing several distinctive triangular shaped white boxes he retained 22 rats for 30 minutes a day over 45 days, each subject staying in one box. Half of the subjects were placed in their respective boxes while under 22 hour food deprivation, and the other half while under 1 hour deprivation. During the two test trials, a black compartment was attached to the side of the white triangular ones, and each subject was placed in the white box and allowed to move from box to box at his own volition, the compartments being separated only by a black curtain. The response measures taken were (1) number of seconds out of 600 spent in the black compartment, and (2) the number of entries into the black compartment. During the first day of testing the subjects were run while under 1 hour deprivation and during the second day of testing they were 22 hours hungry.

The mean number of seconds spent in the black compartment by the 22 hour group was significantly greater than that of the 1 hour group for each of the two test trials. However, the mean number of entries into the black compartment was also significantly greater for the 22 hour group when compared with the 1 hour group. Screven indicates that these results may have been the result of several factors. First the 22 hour group on the first day of testing was run under 1 hour deprivation. There would be fewer common elements for this group in the test situation than in the training situation, thus causing more exploratory behavior on the first test trial. In addition, these subjects were also used in the second test trial under 22 hour deprivation; the effects from the first trial would tend to carry over as well as the contrast in drive state. The 1 hour group was first tested under the same 1 hour hunger drive and on the second test trial, even though while under 22 hour deprivation, nevertheless had had previous experience in the black box which could have served to overcome exploratory tendencies initiated by the unfamiliar drive state. In other words, the 22 hour group was subjected to relatively more novel cues on both test days.

In passing, it should be mentioned that Screven could have counterbalanced his experimental design so as to control for color and should have run half of the subjects in each of his experimental groups under 22 or 1 hour food deprivation on the first test day, reversing the deprivation state for each respective animal on the second test day. The effects of not providing this latter control factor have been summarized above.

Since the response measures in Screven's experiment were determined in large part by the movement of the animal, the possibility that the white compartment evoked greater conditioned activity in the 22 hour group than in the 1 hour group seems even more probable than in the study by Calvin, Bicknell and Sperling (1953) where the response measure was amount of food injested.

Summary and Conclusions

The study to be reported deals with an attempt to condition rats to respond with a preference in a two choice situation. First, under forced choice, forty rats were motivated to select two goal routes an equal number of times. This was then followed by associating the stimulus elements of these goal routes with the states of high and low hunger drive in the absence of a consumatory response. Several variables are pertinent and this review was undertaken in order to discover what is known about those variables.

Previous studies have indicated that it is possible to train rats to respond to previously neutral stimuli in much the same manner as they respond to stimuli associated with pain, or hunger, or thirst. These investigations have been carried out under the following conditions: (1) by associating neutral stimuli with a reduction in primary drive which has been preceded by a discriminative goal seeking response; (2) by utilizing drive states of hunger and thirst as respective cues for previously neutral goal routes leading to either food or water; and (3) by using high and low hunger drive states as respective cues for correct responses in the presence of previously neutral stimulus elements.

Several attempts have been undertaken to condition rats to respond differentially to previously neutral stimuli that have been paired with the resultant internal stimuli of hunger and satiation in the absence of goal seeking or consumatory responses. The results of these investigations have either conflicted or have been confounded by other variables.

CHAPTER II

STATEMENT OF THE PROBLEM

The question of whether or not previously neutral stimuli can elicit a response preference when those stimuli have been paired with either a high or low degree of hunger drive essentially remains unanswered. Jenkins and Hanratty (1949) and Baily (1955) have adequately demonstrated the effectiveness of drive stimuli as cues, but only in the case where "correct" utilization of the particular cue led to a needed substance (food) and the elimination of a noxious stimulus (intense light) respectively. In other words, two intensities of hunger drive could function differentially as cues for different responses, provided that these responses resulted in primary reinforcement.

Concerning attempts to use hunger drive for conditioning purposes in the absence of learned responses leading to primary reward, Calvin, Bicknell, and Sperling (1953) and Siegel and MacDonnell (1954) obtained positive and negative results respectively, the latter investigation being a replication of the former. Screven (1959), making the assumption that a 22 hour state of hunger drive possessed aversive qualities which could become associated with environmental cues attributed his "positive" results to differences in exploratory activity between his experimental groups. In these three investigations the hunger deprivation states were 22 hour and 1 hour respectively for each of the experimental groups. None of the subjects underwent both high and low hunger deprivation in respectively distinguishable stimulus situations.

Thus, there has been no conclusive demonstration of a change in preference for stimuli which have been paired with differential states of hunger drive in the absence of consumatory responses or actions leading to primary drive reduction. Studies of this type employing a procedure whereby all subjects are retained in separate stimulus situations while under high and low hunger drive respectively are totally lacking.

The purpose of this study was to discover whether or not differential hunger drive in the albino rat could be utilized to condition differential responses to stimulus elements in the environment as indicated by a response preference in a two choice situation. The null hypothesis which was tested was as follows: In a two choice situation where each respective set of stimulus elements has been paired with high or low hunger drive, no modification in preference for those stimuli would occur.

CHAPTER III

METHOD AND PROCEDURE

Subjects

The subjects were 20 male and 20 female (N = 40) experimentally naive Sprague-Dawley albino rats. They came from the stock raised at the Old Chemistry Building at Oklahoma State University. At the start of the present investigation, they ranged in age from 110 to 120 days old.

Apparatus

Several items of apparatus were used. Sixteen home cages measuring 9 X 9 X 14 inches were utilized as living quarters. Each cage housed either 2 or 3 subjects apiece, having been placed in these quarters at approximately 90 days of age.

The experimental apparati consisted of a single unit Y-maze and 42 No. 10 size food cans.

The Y-maze was constructed of 1/2 inch board and stood 4 inches high. The start-box consisted of a metal aluminum painted cage measuring 10 X 6 X 5 inches with a sliding door 3 1/2 inches square located in front. The back of the cage was composed of a solid metal panel and served as a hinged door. The subject could be placed in this cage and the door could be subsequently closed behind him. The stem of the maze was 15 1/2 inches in length and the arms were 15 inches long.

The width of the maze from wall to wall was 4 inches throughout. The floor was constructed of 1/2 inch board and the ceiling consisted of 3/8 inch hardware cloth.

The sides and floor of the stem were painted with two coats of flat grey paint. This grey color extended 1/2 inch into each arm ending upon a 3/8 inch high wooden barrier, also painted grey, which fitted across the entrance to each arm. Each arm was fitted with 1/4 inch fiberboard paneling which covered the walls and floor and which extended from the 3/8 inch wooden barrier near the arm entrance to the far end of the alley, bordering on the goal apparatus. The sides of each of these sets of paneling for each arm were equipped with 1/4 inch slots for guillotine type doors which were located 1/2 inch from the grey barrier at the entrance to each arm and 3/4 inch from the goal end of the arm. These four guillotine type doors were constructed out of 1/4 inch fiberboard. Located at the entrance and end of each arm, they were designed to prevent retracing once the rat had stepped across the 3/8 grey barrier at either arm entrance or had entered either goal apparatus.

One of these sets of paneling which fitted into either arm was painted along with its two accompanying guillotine doors a flat black and the other set of paneling with its doors was painted a flat white; each set of paneling receiving two coats of its respective color. Each set of paneling, including its doors, could be inserted into either arm and could easily be interchanged from one arm to the other, thus making it possible to have a black alley on the left and a white alley on the right or vice versa.

Each arm of the maze ended upon a goal apparatus which consisted of a No. 10 size food can of the type normally utilized by commercial eating establishments. Such a can measures 6 inches in diameter and 7 inches in height. The top of these cans were removed and fitted with removable circular cage covers composed of 3/8 inch hardware cloth. A 3 1/2 inch square was cut from the side of each can, the bottom side of which bordered on the circular base. These cut out squares served as entrances to these goal "cans" which were placed at the end of both arms of the maze with the square entrances forming a snug fit with the end of each alley. As with the sets of paneling, one of these goal cans was painted inside with two coats of flat black paint and the other with two coats of flat white paint. Also these goal cans were interchangeable from one arm to the other and were always placed so that the color corresponded with that of the respective arm.

The remaining 40 cans were painted in the same manner as the two goal cans, twenty of which were painted black and the other twenty painted white on their interior walls and bases. The tops here were also removed, but otherwise the cans were left intact. These cans served as retaining apparati, each holding one rat. Up to thirty of these retainer cans could be placed in three columns on a rectangular shaped table measuring 6 X 2 1/2 feet. Seated about a half inch above the cans placed on the table was a massive wood framed 1/2 inch hardware cloth cover measuring 5 1/2 X 2 feet. This cover served as a community roof under which the cans could be housed, and from which they could be removed easily in order to deal with the rats. This community roof was held up by corner supports. It served the purpose of keeping rats from crawling out of the retainer cans.

Procedure

The subjects were randomly assigned among eight treatment groups of 5 rats apiece, each group having no more than three animals of one sex. All subjects were put on a feeding schedule in which food was available for 1 hour per 24 hour period. The food consisted of a farm feed mixture, Superior Egg Crumbies. Water was available at all times when Ss were in their home cages. This constituted the feeding procedure throughout the *entire* experiment. The first 10 days were spent in letting the subjects become accustomed to this feeding schedule and in taming effects by handling each S for two minutes after the feeding hour.

Beginning on the eleventh day of the experiment (Stage I) and continuing for 20 days, all Ss were given one forced choice trial per day in the Y-maze. Half of the subjects were run 1 hour *before* the feeding period or under 22 hour hunger drive, and the other half run 1 hour *after* the feeding period or under 1 hour hunger drive. These two conditions were known as XXII and I corresponding to 22 hour and 1 hour hunger drive. For half of the Ss run under each of these two conditions, the black alley and the black goal can were *always* on the left, and the white alley and the white goal can *always* on the right. For the other half of the Ss under each of the hunger drive conditions, this procedure was reversed.

Each subject was run in a different trial sequence in order to avoid later scores due to position habits, simple alternation, and double alternation (after Gellerman, 1933). For example, the left-right sequence over the 20 forced choice trials for subject No. 1 was rrlllrlrrlrrrllrlrll. On each of these trials, the subject was placed in the start box, the sliding door then being opened. As soon as S stepped into the grey alley stem, the door closed behind him. Upon entering the predetermined alley choice for that particular trial (the door at the entrance of the other alley being closed) S was prevented from retracing as the guillotine door closed behind him as soon as his hind feet were across the grey barrier at the entrance of the alley. When S had transversed the alley and stepped into the goal can with all four feet the guillotine door at the far end of the alley was closed trapping him in the goal situation. At the far end of the goal can food had been sprinkled on the floor and S was permitted to eat for 1 minute before being returned to the home cage. If, after 3 minutes, a subject refused to leave the start box, he was taken out and placed in the appropriate goal can for that particular trial.

Beginning on the 31st day of the experiment (Stage 2) and continuing for 40 days, each subject was placed in a retainer can for one half hour per day. For 20 of these 40 trials, S was under 22 hour hunger drive and for the other 20, he was under 1 hour hunger drive. Half of the subjects in both the XXII and I groups for whom the black and white alley arms were on the left and right respectively were always placed in a black retainer can while under 22 hour hunger drive and a white retainer can while under 1 hour hunger drive. The other half of the subjects in these subgroups were placed in a white retainer can while under 22 hour hunger drive and a black retainer can while under 1 hour hunger drive. No food or water was available in any of these retainer cans at any time. Of those subjects in the XXII and I groups for whom the black and white alley arms were always on the right and left respectively, the above procedure was also followed.

To put it in simplified summary, 20 subjects were placed in black cans while under 22 hour hunger drive and in white ones while under 1 hour hunger drive. For the other 20 subjects, this procedure was reversed. The former group was called Group "B" and the latter group Group "b", the capital "B" and small "b" signifying the conditions where the black can was paired with 22 and 1 hour hunger drive respectively. For purposes of simplification it is easier to discuss these experimental conditions in terms of one color (black) only. Thus far there are 4 groups to keep in mind: XXII-B; XXII-b; I-B; and I-b.

As a precaution against the occurance of place habits, the day by day sequence of placing the subjects in the appropriately colored cans to be paired with 22 or 1 hour hunger drive was arranged for each animal (after Gellerman, 1933). For example, letting "h" represent 22 hour hunger drive and "s" represent 1 hour hunger drive (or satiation), the trial order over the 40 days for subject No. 1 was hhsshhshssshsshsshhh-ssshhshshhshhssshhsh.

The procedures for both h and s trial days are outlined in Table I. All subjects underwent 20 periods of each according to the procedures described above.

Since step 1 was the same for both h and s days, there was no delay or difficulty in switching the subjects from h to s days or vice versa. The 1 hour interval between feeding periods and being put into or removed from the retainer cans was used to minimize any consumatory response association which might later lead to a preference for either an h or s can. Although the subjects were previously fed in the two goal cans which, except for their cut out entrances, were identical to the s and h retainer cans, they nevertheless were fed an equal number of times in each goal can and were not required to learn any response discrimination

TABLE I

PROCEDURES FOR h (HIGH DRIVE) AND s (SATIATION) TRIAL DAYS

Step	h day	s day
1	S food deprived 21 1/2 hours in home cage	S food deprived 21 1/2 hours in home cage
2	S placed in h retainer can for 1/2 hour	S fed in home cage for 1 hour
3	S placed in home cage, food withheld 1 hour	S deprived of food in home cage for 1 hour
4	S fed in home cage for 1 hour	S placed in s retainer can for 1/2 hour
5	Repeat step 1	Repeat step 1

in order to obtain food, having been forced to each arm an equal number of times. Thus, any later response preference for a goal can corresponding to an h or s retainer can could be explained in terms of the differential hunger states that were associated with the s and h retainer cans.

Beginning on the 71st day of the experiment (Stage 3) and continuing for 10 days, all subjects were given 1 test trial per day in the Y-maze. The respective color positions of the black and white arms were the same for each subject as in the original 20 forced trials. The 4 groups of Ss were further subdivided. Of these 4 groups (XXII-B, XXII-b, I-B, and I-b) half the animals in each group were tested while under 22 hour hunger drive and the other half while under 1 hour hunger drive. Thus, there were a total of 8 experimental groups in the final stage of the experiment: XXII-B-22; XXII-B-1; XXII-b-22; XXII-b-1; I-B-22; I-B-1;

I-b-22; and I-b-1. Table II shows in a factorial fashion each stage of the investigation.

TABLE II

FACTORIAL BREAKDOWN OF ALL EIGHT EXPERIMENTAL GROUPS

Stage of experiment	Degree of hunger deprivation							
20 forced choice trials (stage 1)	XXII				I			
40 retainer trials (stage 2)	B		b		B		b	
10 free choice test trials (stage 3)	22	1	22	1	22	1	22	1

On each of the 10 test trials, the subject was placed in the start box. As in the previous forced choice trials, once he left the start box, no retracing was permitted. The guillotine doors that led into the two arms were *both* left open, permitting the subject to make a *free choice* of arm to enter. His hind feet crossing the 3/8 inch barrier at either arm entrance constituted the response choice on each trial. Once this choice was made, the guillotine door to that entrance was closed. When the subject ran down the alley and entered the goal can with all four feet, the door at that end of the alley was closed and S remained in the goal can for 10 seconds before being removed to the home cage. At no time during the test trials was food available in either goal can.

CHAPTER IV

RESULTS

The number of times out of ten trials each subject chose the black alley was totaled. For each rat the number of black alley choices and the group totals and means are shown in Table III. The mean for the eight experimental groups was 8.10 leaving a mean of 1.90 for white alley choices. Since the number of white alley choices was 10 -- black alley entries, it was unnecessary to make this further calculation for each subject.

A 2 X 2 X 2 factorial analysis of the sums of black alley choices for the eight experimental groups was employed to test for significance among the pertinent variables. The results of this analysis are presented in Table IV. The Bartlett Test (after Edwards, 1950) indicated homogeneity of variance among the eight groups (Chi-square = 2.18; 7 degrees of freedom; not significant at the .05 level). This affirms that the group variances did not vary sufficiently to yield a significant F-ratio.

Only one F-ratio was significant at the .05 level of confidence. This was obtained for those treatment groups where the color black was paired with either 22 hour or 1 hour hunger drive (B vs. b in the stage 2 retainer trials). Those 20 subjects who underwent treatment "b" tended to show a significantly greater preference for the black alley than did the other 20 who experienced treatment "B" (M_b = 8.55; M_B = 7.65).

TABLE III

NUMBER OF BLACK ALLEY CHOICES FOR EACH SUBJECT

Subject	XXII*	XXII	XXII	XXII	I	I	I	I
	B	B	b	b	B	B	b	b
	22	1	22	1	22	1	22	1
1	7	8	10	7	8	9	10	10
2	8	6	9	9	6	7	8	10
3	9	7	10	8	7	9	10	8
4	10	9	9	9	8	7	8	7
5	6	9	7	5	6	7	9	8
Sub-group total	40	39	45	38	35	39	45	43
Sub-group mean	8.0	7.8	9.0	7.6	7.0	7.8	9.0	8.6

*XXII stands for 22 hour hunger drive during stage 1.

I " " 1 hour hunger drive during stage 1.

B " " 22 hour hunger drive paired with black during stage 2.

b " " 1 hour hunger drive paired with black during stage 2.

22 " " 22 hour hunger drive during stage 3.

1 " " 1 hour hunger drive during stage 3.

The tests for significance among the treatment effects of hunger drive for both stage 1 (forced choice maze trials) and stage 3 (free choice maze trials) yielded F-ratios which were not significant at the .05 level. None of the interactions were significant at the .05 level either. These non-significant F-ratios indicate that the differential response preference for the black alley between Groups B and b was unaffected by intensity of hunger drive either during the test trials or

TABLE IV

ANALYSIS OF VARIANCE OF SUMS OF BLACK ALLEY CHOICES FOR ALL EIGHT EXPERIMENTAL GROUPS

Source	Sum of Squares	d.f.	Mean Square	F
Between groups				
Stage 1*	.00	1	.00	.00
Stage 2	8.10	1	8.10	4.79**
Stage 3	.90	1	.90	.53
Interaction				
Stage 1 X stage 2	2.50	1	2.50	1.48
Stage 1 X stage 3	2.50	1	2.50	1.48
Stage 2 X stage 3	3.60	1	3.60	2.13
Stage 1 X stage 2 X stage 3	.00	1	.00	.00
Within groups	54.00	32	1.69	
Total	71.60	39		

*Stage 1 stands for the 20 forced choice maze trials.

Stage 2 " " " 40 retainer trials.

Stage 3 " " " 10 free choice maze trials.

**Significant at the .05 level.

forced choice trials.

Inspection of the data in Table III shows that 39 of 40 subjects selected the black alley 6 or more times out of the ten test trials.

Chance expectency for this phenomena is 20 out of 40 or .50. According to the binomial expansion the probability of obtaining as high a ratio as 39/40 is beyond .0004. Regardless of the experimental manipulations, the subjects as a whole showed a very marked preference for the darker alley.

CHAPTER V

DISCUSSION

The only F-ratio which was significant at the .05 level (F = 4.79; 1/32 degrees of freedom) was for the variable of hunger drive in stage 2 (retainer trials). However, this was the crucial test of significance for the null hypothesis. It indicates that those subjects who underwent treatment b (low drive paired with black) showed a significantly greater preference for the black arm than those subjects who experienced treatment B (high drive paired with black). The null hypothesis of no modification in preference for stimuli previously paired with either high or low hunger drive is therefore rejected. Since the variable of hunger drive in stages 1 and 3 yielded such low F-ratios, the rejection of the null hypothesis seems more justifiable.

This investigation thus indicates that albino rats can be conditioned to change their preference for stimuli as a result of pairing those stimuli with different levels of hunger drive. A further elaboration of this conclusion is that the color elements of the alley arms acquired either aversive or rewarding properties as a function of having been paired with high or low hunger drive respectively. This elaboration, however, raises several questions which cannot be answered within the framework of this study: namely, did the subjects respond to the aversive properties of the color paired with high hunger drive; or did they respond to the rewarding properties of the color paired with low hunger drive; or on the other hand, were their responses a result of an interaction effect between the acquired aversive and rewarding properties of the respective color stimuli?

An alternative explanation of the results obtained in investigations similar to this is that differentially conditioned activity rates are responsible for the performance differences of treatment groups B and b. This conditioned activity hypothesis was considered previously as a possible explanation for the results obtained in the Calvin, Bicknell, and Sperling (1953) and Screven (1959) studies. In these two studies the experimental groups experienced _either_ high _or_ low hunger drive during the training trials. Thus a possible basis for differentially conditioned activity rates was present. In the present study, the B and b treatment groups underwent _both_ high _and_ low hunger drive during the retainer trials. Since both B and b groups underwent both drive state experiences, there was no possibility of differentially conditioned activity rates as a function of dissimilar experimental manipulations.

The results obtained in the present investigation tend to support the positive results of Calvin, Bicknell, and Sperling (1953) rather than the negative findings of Siegel and MacDonnell (1954) who replicated the former study if, in the former study, the eating differences are interpreted to be a function of pairing high and low hunger drive with neutral stimulus elements. The results of the present study also suggest that, at least to some degree, the positive findings of Screven (1959) are attributable to conditioned avoidance responses instead of confounding factors.

Before all the test trials were completed, it appeared likely that the results would indicate a significantly greater preference on the part of the subjects for the darker alley. This proved to be the case in all treatment groups. The subjects on the average selected the black alley 8.10 times out of ten trials. Their scores ranged from 5 to 10 with only one subject having a score of 5 and no subjects scoring less than 5. This obtained preference for the darker alley supports the findings of Krechevsky (1932, 1936) who indicated that rats tend to prefer darker rather than lighter visual stimuli.

The obtained preference for the darker alley lends support to the suggestion by Myers (1958) that all neutral stimuli are not equally "neutral" to begin with. In an investigation such as this one, it is conceivable that the selection of the visual stimuli would have an important bearing on the subsequent results. If the preference for the black arm had been a little greater than it actually was, no significant differences would have been detected among treatment groups. Thus future investigations of this type would do well to take in account pre-experimental stimulus preferences as well as the necessary counterbalancing procedures, thereby maximizing the chances of detecting significant differences among treatment groups.

SUMMARY

This experiment was undertaken in an attempt to demonstrate a changed response preference in a two-choice situation. Forty albino rats were first given 20 forced choice trials in a Y-maze with black and white goal routes. The colors of these goal routes were then respectively paired in a counterbalanced order with high and low hunger drive for all subjects. Subsequent free choice test trials in the Y-maze revealed the following findings:

1. Regardless of the experimental manipulations the subjects on an average showed an extremely high preference for the black colored arm. This preference was significant at well beyond the .01 level of confidence.

2. Despite this overall preference for black, those subjects which had had black paired with low hunger drive tended to show a higher response preference for the black alley than did those subjects which had had black paired with a high degree of hunger drive. The obtained differences were significant at the .05 level of confidence.

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VITA

Arthur Kaufman

Candidate for the Degree of

Master of Science

Thesis: CHANGED RESPONSE PREFERENCE FOR STIMULI PREVIOUSLY PAIRED WITH HIGH OR LOW HUNGER DRIVE

Major Field: Psychology

Biographical:

Personal Data: Born in Newark, New Jersey, May 26, 1935.

Education: Attended grade school in Newark, New Jersey; graduated from South Side High School in Newark, New Jersey in 1953; received the Bachelor of Arts degree from the Newark Colleges of Rutgers University, with a major in Psychology, in June, 1957; attended Louisiana State University for one year of graduate work; completed the requirements for the Master of Science degree at the Oklahoma State University in August, 1960.

Professional Organizations: Member of Psi Chi, National Honorary Society in Psychology.