

February 20, 1959

To the Graduate Council:

I am submitting herewith a thesis written by Warren A. Young entitled "The Effect of Cue Change and Drive on a Running Response." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Psychology.

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THE EFFECT OF CUE CHANGE AND DRIVE  
ON A RUNNING RESPONSE

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A THESIS

Submitted to  
The Graduate Council  
of  
The University of Tennessee  
in  
Partial Fulfillment of the Requirements  
for the degree of  
Doctor of Philosophy

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by  
Warren A. Young

March 1959

#### ACKNOWLEDGEMENT

I would like to express my sincere appreciation to the members of my committee, Drs. W. O. Jenkins, chairman, G. R. Pascal, C. H. Swenson, Jr., H. D. Holloway, and L. E. Ebersole, for their helpful criticism and guidance. I am particularly indebted to Dr. W. O. Jenkins whose theoretical formulations provided the basis for this study. Dr. Jenkins also offered many useful suggestions regarding experimental design and statistical analysis.

I would like to thank Mr. Herman Salzberg for his moral support and for his aid in solving certain statistical problems. To Miss Karen Cornell, who spent many tedious hours typing this manuscript, I owe a special note of thanks. Without the generous donation of her time the completion of the thesis would have been much delayed.

W. A. Y.

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## CHAPTER I

### INTRODUCTION

#### Background

In studying the learned behavior of organisms, experimenters usually focus on some particular response and its relationship to systematically varied external stimuli and/or deprivation operations. Any given response can be considered to vary in three ways: It can be strengthened, it can be weakened, or it can be maintained at a more or less constant level. The strength (or weakness) of a response can be indexed in several ways. One can, for instance, measure the latency of the response, the amplitude of the response, the number of response elicitations to produce experimental extinction, the probability of response occurrence, the frequency of responding, or the percentage of "correct" responding.

One of the major problems confronting learning theorists today is to delineate the necessary and sufficient conditions to produce an increase in response strength. It is an empirical fact that, in the face of practice, a response sometimes increases in strength and sometimes decreases. What, then, are the conditions involved which produce such differential effects? In an attempt to answer this question the concept of reinforcement was introduced, the earliest modern exponent of which is Thorndike (59). Thorndike used the concept in his studies of cats in a "problem box". In this box cats were placed and provided

with means of escape. If they were successful in escaping they could secure food which was placed immediately outside of the box. The means of escape consisted of pulling strings, depressing latches, or operating other simple mechanisms. From these studies Thorndike evolved his now-famous Law of Effect which can be stated as follows (59): "Acts followed by a state of affairs which the individual does not avoid, and which he often tries to preserve or attain, are selected and fixated, while acts followed by states of affairs which the individual avoids or attempts to change are eliminated."

Although this law has been criticized on the grounds of circularity (5, 45), it nonetheless offers a clear operational criterion for predicting whether or not a response is likely to recur on a second occasion. The criterion is what the stimulus situation causes the organism to do (17). If an animal runs down an alley, receives food, and then is removed from the situation by the experimenter, he is likely to run down the alley the next time he is placed in the apparatus. However, if the animal runs down the alley, receives food, and then is shocked so that he jumps back in the presence of alley cues and food, he is likely not to run forward on the next occasion.

Thorndike, himself, and many succeeding psychologists did not consistently follow through with the operational implications of the Law of Effect. Instead, the law was interpreted to mean that when responses are followed by "satisfaction" they are strengthened and when they are followed by "annoyance" or punishment they are weakened. In effect, this interpretation focuses attention on internal states of

the organism and disregards the behavioral consequences associated with the stimulus event. That punishment or "annoyance" often seems to strengthen a response, or at least to maintain it, was noticed by Thorndike himself (59) and has been confirmed by other experimenters (11, 43, 47). Thorndike ultimately discarded that portion of his law dealing with the effects of punishment but continued to maintain his stand on the strengthening capacity of "satisfiers" (such as food for deprived organisms) and the subsequent "satisfaction" obtained.

Hull's theory of reinforcement (24) can be viewed as an attempt to translate the notion of a "satisfying state of affairs" into objective terminology and to demonstrate how such a state of affairs is a necessary condition for all learning.

#### Hull and Reinforcement Theory

In attempting to avoid the element of subjectivity and tautology in Thorndike's thinking, Hull proposed his Law of Primary Reinforcement which is oriented toward neurophysiology. The Law states (24, p. 80):

Whenever an effector activity occurs in temporal contiguity with the afferent impulse, or the perseverative trace of such an impulse, resulting from the impact of a stimulus energy upon a receptor, and this conjunction is closely associated in time with the diminution in the receptor discharge characteristic of a need, there will result an increment to the tendency for that stimulus on subsequent occasions to evoke that reaction.

In essence, Hull is stating that an increase in response strength involves temporal contiguity of stimulus and response, plus the presence of a need (drive) and its consequent reduction. Need reduction, then, replaces Thorndike's "satisfying state of affairs".

One difficulty with this law is that Hull never specified the operations by which need reduction can be measured or observed independent of whether the animal does or does not learn. Thus he does not avoid tautology and he violates one of his own rules, namely, that an intervening variable (such as drive) should be "securely anchored" at both ends of an S-R chain (29).

Miller, a prominent colleague of Hull's, has identified drive with strong (intense) stimulation, either external or internal, and drive reduction with a decrease in the intensity of that stimulation (34). He thus provides a partial measure of the vicissitudes of drives independent of the learning process (adequate techniques have not yet been evolved to measure strong internal stimulation and its decrement).

A rather troublesome difficulty which confronted Hull early in his theory construction was experimental evidence which indicated that organisms do learn, or maintain a learned response, in situations which are not closely followed by need reduction (15, 6, 57, 45). In order to account for such learning, Hull amended his Law of Primary Reinforcement to read as follows (24, p. 99): Whenever a stimulus-response connection is closely associated in time with the diminution of a need ". . . or with a stimulus situation which has been closely and consistently associated with such a need diminution, there will be an increment in the tendency for that stimulus to evoke that reaction." These external stimuli are called "secondary reinforcers" and include such things as goal box cues, food cups, the smell of food, money and

praise (in the case of humans), etc. The number of stimuli which can function as secondary reinforcers is practically infinite, and as Osgood (45) and Bugelski (5) note, secondary reinforcement, for Hullian theorists, has generally replaced primary reinforcement as the explanation for the occurrence of learning. One reason for this trend is the fact that, in food-reward experiments, need reduction usually cannot occur in close temporal contiguity with the S-R connection involved. As Hull himself observed (24, p. 98-99), there exists an appreciable delay between the beginning of mastication of food and the ultimate reduction of the nutrient need of the body cells. Hull was forced to conclude that eating of food, as such, brings about learning through secondary reinforcement rather than through primary reinforcement.

Another reason for the extensive use of secondary reinforcement as an explanatory concept is the rapidly increasing number of experiments demonstrating acquisition in situations 1) where primary need reducing agents are never present, and 2) where primary needs are apparently absent. The latter situation is best demonstrated in avoidance learning where animals retain an avoidant response to external cues even when the primary drive (pain) is no longer present. In order to be consistent with the formula "no drive, no learning" Hullians assume the existence of a "secondary drive" (fear) whose reduction increases response strength.

A mechanism to account for the presumed efficacy of secondary reinforcement has never been adequately delineated. In a recent attempt to correct this crucial shortcoming Osgood (45) has postulated that

external stimuli, originally neutral with respect to motivational properties, come to have both motivating and reinforcing value by virtue of eliciting "fractional components of the total goal reaction". The fractional goal reaction is considered to become anticipatory and to reproduce some part of the "primary drive situation". That portion of the primary drive reproduced is regarded to be the secondary drive and its reduction secondary reinforcement. A paradox is immediately apparent: The anticipatory goal reaction is assumed to function simultaneously as drive and as reinforcement. To explain this paradox Osgood suggests "that hormonal changes in the blood stream may underlie the shifting balance systems of drive and its reduction" (45, p. 433). It is hypothesized that hormone release by way of glandular reactions is conditionable. In the case of hunger drive, then, stimuli associated with the drive state itself become conditioned to the release of hormones which generate and maintain this state; stimuli associated with drive reduction, in turn, become associated with the release of hormones which accompany the satiation state. Here it must be assumed that there are specific hormones associated with satiation (none have been discovered yet). A final assumption is ". . . that changes in blood chemistry are rapid and facile enough to account for the behavior observed" (45). Granting all these assumptions, then, secondary drive and reinforcement become a function of differential, conditionable, hormone-release.

Experimental evidence to date does not support Osgood's highly elaborate and speculative hypotheses. In an experiment by Myers and

Miller (44) no evidence was found to support the idea that a secondary drive can be generated on the basis of hunger drive and food reward. Similiar findings were obtained by Simon et al. (56) in a study of the thirst drive and water reward.

### The Contiguity Position and Reinforcement Theory

Whereas Hull and his followers insist that drive reduction is a necessary condition for learning, the contiguity position as expounded by Guthrie (17), Jenkins (25), and Voeks (60) postulates that learning occurs whenever a stimulus is contiguous with a response. The stimulus-response connection is eliminated only when a stimulus previously associated with a given response accompanies another response which is incompatible with the first. Voeks (60) has termed this the principle of postremity. Thus, whatever an organism does last in any situation is the most probable thing it will do the next time the stimulus recurs. Reinforcement, from the contiguity standpoint, consists simply in preventing the attachment of a new (more postreme) response to old stimulus cues. The prevention is considered to take place by introducing a kind of stimulation following the response that changes the organism's behavior (25). The reinforcing process, then, does not enter into the acquisition of a habit at all--in contrast to Hullian theory--but merely serves to protect a habit which is already at full strength after the first association. Contiguity theory, unlike the drive reduction position does not have to wrangle with the knotty problem of explaining how a reinforcing event works backward in time to produce an "increment" in the strength of a prior stimulus-response connection (45, 58).

Since contiguity theory maintains that a stimulus-response association is formed at maximum strength on the first trial, learning must be viewed as a one-trial, all-or-none affair rather than a gradual process. The fact that most learning seems to be gradual is explained by Jenkins as follows (25):

. . . One-trial conditioning will occur whenever the same cues are represented on a second occasion. This is clearly a difficult task. The complex sensory feedback from the external environment need only differ slightly on a second trial and generalization decrement will play a prominent role. On each occasion some subset of the totality of cues becomes associated with the class of behavior. Since these subsets are almost infinite in number--even in the simple situation represented by the Skinner box--several thousand removals of the organism (reinforcements) should add increments to response strength so that resistance to extinction will be increased over several hundred occurrences.

The function of repetition, then, is to expose the animal to more and more sub-sets of the total stimulus situation so that the response may become attached to them. In this sense the response gains strength, i. e., the probability of its occurrence increases over trials as the number of unconditioned sub-sets decreases.

As the contiguity position contends that reinforcement is simply a matter of cue change following a response, it must explain why some stimuli (such as food for deprived organisms) are more effective in increasing response strength than others. Jenkins (25) states the position as follows:

One basic question that comes up is how, by the contiguity principle, can we decide a priori the rank order of effectiveness of cue changes? Which cues presented after the response should have greatest effect in "stamping in" the behavior? Another way of putting the question is: Why is food so universally used for deprived organisms and why is it so effective in producing an alteration in behavior? And why are other removal methods less effective than food? A basic way of looking at this latter point

is to consider whether there are ways of removing organisms from situations that are more effective--lead to faster learning and greater resistance to extinction--than food for a hungry organism. The answer from the present standpoint is that the more the behavior of the organism is changed by the post-response cue, the greater the increment in response strength. The more effective cue for removing the organism from the situation is the one that produces more of a change in the behavior of that organism. The change in behavior may be a gross increase or decrease in activity.

(The rat in the Skinner box appears to expend more energy and give out with more behavior in approaching and manipulating the food than it does in pressing the bar.) In any case, the rat is effectively removed from the situation by presentation of food so that when it finishes eating and reorients to the lever, it is put back in a very similar stimulus setting to that previously encountered. Learning to associate other reactions with this cue situation has been prevented by occupying the rat with an entirely different class of behavior.

As the above quotation illustrates, the contiguity position is in close agreement with Thorndike's Law of Effect (as stated, not as generally interpreted). Emphasis is placed on what the reinforcing stimulus causes the organism to do rather than on its neurophysiological or neuro-chemical after-effects. Drive is not a necessary condition for learning although it may be important, at times, to insure or facilitate elicitation of the response-to-be-conditioned (17). Drive reduction, when it occurs, is subsumed under the principle of cue change as is drive increment. Since any stimulus evoking a behavioral change functions as a reinforcer the contiguity position has no need for the secondary reinforcement concept.

#### Experimental Evidence for the Contiguity Position

Within recent years a growing body of research, exploring the acquisition of behavior in situations where primary need reducers (food or water) are absent, has sorely pressed drive reduction theory

and added experimental support to the contiguity position (which, heretofore, had been criticized as being unamenable to research).

A comparatively early study (1942) by Seward (49) was designed to test the contiguity hypothesis that the function of reinforcement is to remove stimuli and thus prevent unlearning of the postreme response. Two groups of albino rats were placed in a typical Skinner box and the first group was given a food reward immediately after a bar-press while the second group was simply removed from the apparatus following the same response. Care was taken to eliminate all known sources of "secondary reinforcement.

Seward's results indicated that both experimental groups learned to press the bar as measured by latent time and by frequency of response during extinction. The food reward group, however, was clearly superior to the removal group by both measures. The control Ss learned little or nothing.

How is it, from the contiguity viewpoint, that food reward reinforced bar pressing to a greater extent than physical removal from the situation? As a possible explanation Seward noted that the food rewarded Ss limited their activity much more closely to the food pan and bar than did the removal animals. According to the contiguity position the less varied the activity the fewer the new stimuli to be associated with the response on each occasion. Therefore the learning is more rapid. The more varied activity on the part of the hand-removal group seemed to result from the fact that some of the animals displayed ". . . conflict behavior, hesitating before the bar, sniffing

or barely touching it and drawing back as if alarmed" (49, p. 254).

Some Ss, in other words, developed approach-avoidance behavior toward the bar and toward hand-removal. Such behavior reduced the efficiency of this treatment. The avoidance response probably stemmed from the fact that rats have an unconditioned "reluctance" toward being handled which takes many trials to extinguish.

There is another experiment using the bar-pressing response where the bar, instead of the animal, was removed from the Skinner box after the response. In this situation learning also occurred. The experiment was conducted by Perin (46) and he was studying the effect of delayed reinforcement upon the differentiation of bar responses in the white rat. He trained 150 animals to push a bar, food being presented immediately after a bar press in either direction. After this preliminary training, the Ss were divided into six groups and rewarded only after pressing the bar in the "correct direction" (that direction least used by the animal during preliminary training). When the bar was pressed in the correct direction it was withdrawn immediately. The six groups of rats differed only in the length of delay between a correct bar response and food presentation. The intervals were 0, 2, 5, 10, 20, and 30 seconds respectively.

Perin found that the 0-, 2-, and 5-second delay groups acquired the response very rapidly, while the 10- and 20-second delay groups showed poor acquisition, and the 30-second delay group learned very little. Perin concluded that the rate of habit acquisition is an inverse function of the delay-of-reward-interval.

In a significant footnote Perin (46, p. 99) stated that in the original plan of the experiment, provision was made for the bar to withdraw from the box following both correct and incorrect responses. The bar could be pushed right or left and the correct response consisted in pressing the bar in the direction least used by the rat during preliminary training. The only difference resulting between responses was the delivery of food following the correct response. In this experimental set-up Perin found that a differentiation of response was very difficult to produce, some animals making several hundred incorrect responses in succession without receiving any food reward. From the drive reduction point of view the persistence of these incorrect responses is difficult to explain. However, as Voeks (62) has cogently pointed out, such results are in line with the contiguity position. Even though the S is not food-rewarded for making an incorrect response, reinforcement occurs, nonetheless, because removal of the bar changes the stimulus situation and prevents the occurrence of new responses to the bar. Upon being placed again in the situation the animal is expected to do what it did last in that situation, whether pressing the bar in the incorrect, or correct, direction. If the bar is withdrawn following the incorrect response that response is reinforced. Similarly, if the bar is withdrawn following a correct response that response receives reinforcement.

With regard to Perin's conclusion that learning is an inverse function of the length of the delayed food interval, Voeks suggested that a more accurate interpretation would be that learning is a function

of the removal of the animal from the situation following a response. As the delay between the response, withdrawal of the bar, and presentation of food reward increases, the animal is given increased opportunity to emit new behavior in the apparatus. This new behavior supplants bar pressing and becomes associated with the delivery of food.

In an open field situation, using albino rats, Hayward (25) demonstrated that hand-removal following a rearing response is an effective reinforcing agent in producing one-trial learning when cues are held constant. Two kinds of field were used, one with a maximum number of distinctive cues and the other with a minimum. In the acquisition trial the animal was placed in a field and allowed to remain there until he gave one full rear. While still in full rear the animal was lifted, by hand, out of the situation and returned to a restraining cage. Hence, rearing was the postreme response.

Two groups of fourteen rats were used and one group was conditioned in the minimal cue situation while the other was conditioned in the maximal situation. After the acquisition trial the two groups were split into four sub-groups, half of the animals being tested in the same situation and the other half in the different one. The prediction that hand-removal reinforcement would speed up rearing time when cues are held constant but not when they are varied was borne out by the data. Also in line with expectation was the finding that, when conditions are held constant, the large cue change group gained more from the acquisition trial than the small cue change group.

Jenkins (25) employed a rather novel technique to demonstrate that removal from a situation constitutes reinforcement. He exposed a group of pigeons, under two drive conditions, to the experimental situation prior to conditioning. The response to be conditioned was that of pecking at a small circular window and the reinforcement was to be food reward. Since, in the preliminary "training" pecking was not reinforced via presentation of food the animals were largely occupied with the class of behavior of not pecking. The chances are extremely high that the animals were emitting other than pecking responses at the time of removal from the apparatus. According to contiguity theory, these postreme responses were being reinforced, and because of this reinforcement, the animals should take longer to learn the pecking response for food reward than a group of animals not given prior exposure to the situation. The data supported this prediction where, in some cases, the experimental animals took from two and a half to five times as long to condition as the control animals.

In an unpublished study, Roe (48) demonstrated the Skaggs-Robinson hypothesis, using hand-removal as the reinforcing agent.

Bolstering the contiguity interpretation of reinforcement from another angle, Sheffield and associates (52) have shown that learning occurs in situations where primary needs are present, although unreduced, throughout the experimental period. These authors stress the significance of the behavioral change induced by the reinforcing stimulus.

In one experiment Sheffield and Roby (52) ran six hungry rats

in a standard T-maze, the learning task being the acquisition of a simple position habit. The reward consisted of a non-nutritive, sweet-tasting, substance (saccharin). The results--in terms of a decrease in running time and a decrease in number of errors--indicated that saccharin is a very effective reinforcing agent. Apparently there was no need-reduction in this learning situation and the authors suggested that elicitation of the consummatory response (drinking) was a more crucial reinforcing factor in this experiment than any drive reduction subsequently achieved.

In a more extended study of the reinforcing effects of non-nutritive substances, Sheffield et al. (51) placed four groups of rats on a food deprivation schedule and then trained the animals in a runway response, each group receiving differential rewards. One group obtained tap water, another a solution of 1.3 grams per liter of pure saccharin, the third a solution of 20 grams per liter of anhydrous dextrose, and the fourth group received a solution of 1.3 grams of saccharin plus 20 grams of dextrose per liter. The results were that the saccharin reward reinforced running, but the dextrose was reinforcing only if saccharin was added.

More specifically, the authors discovered that if runway performance were plotted as a function of the rate of ingestion of the reward solution in the goal box during runway training, an almost linear relation was found between strength of the consummatory response and the strength of the instrumental response (running-speed in the runway). They concluded that nourishment per se (drive reduction) is an irrelevant

ant aspect of the reinforcing value of sweet substances in hungry rats and that the strength of the consummatory response determines the reward value of the substance. Put another way, they are saying that the more the reinforcing stimulus changes behavior the greater is its strengthening properties. The drinking response to the bottle containing sweet solutions removes the animal from runway cues and thus prevents unlearning of the running response to these cues. Also, the more the drinking the greater the removal.

In another experiment performed by Sheffield et al. (53) the purpose was to determine whether sexual stimulation in male rats without any associated sex drive reduction through ejaculation, and without any past history of ejaculation, would reinforce the responses (running and hurdle-jumping) instrumental in bringing about the stimulation. The occurrence of learning under these conditions would be contrary to the expectation from a drive reduction position. Male albino rats were divided into three groups, one of which received a female lure in the goal box, another which received a male companion, and a third group consisted of those Ss who showed sustained pursuit of a female but never copulated. The third group was further sub-divided into two groups, half of which received male, and half of which received female "lures".

In training trials the S was removed from the goal box after two copulations (or two attempts in the case of male "lures") or after two minutes if two copulations were not achieved in that period.

The authors found that all groups showed indications of acquisit-

ion. However, the experimental copulators who received female lures were superior to both non-copulators and to control copulators who received male "lures". It was further found that the copulator controls performed much better than non-copulators. Sheffield et al. attribute this superiority in learning to the attempted copulation on the part of the copulators who received a male lure. The contiguity position predicts these results because attempted copulation is a greater behavioral change than merely entering the goal box and "seeing" another animal, and, therefore, a more efficient reinforcer for behavior preceding it. The non-copulators gained less of a behavioral change and, thus, learned less.

The authors indicated that the superior acquisition of the copulators was due, not to the intromission that accompanied copulatory responses with females, but rather to the greater frequency with which copulatory responses were elicited by the female. Paralleling the results on non-nutritive reinforcers, there was a linear relationship between strength of the instrumental response—running and hurdle-jumping—and strength of the consummatory response. In other words, the more the reinforcing stimulus in the goal box (either a male or female lure) elicited a radical behavioral change (copulation) with respect to running, the more running to runway cues was reinforced.

There are a number of experiments demonstrating acquisition of a bar-pressing response when the onset of illumination is used as a reinforcer. Since the increase in illumination represents an increase in the intensity of stimulation, learning is taking place under increased

drive, according to Miller (34). Again the drive-reduction position is hard-pressed to explain such phenomena.

A representative experiment involving illumination as a reinforcing stimulus is reported by Kish (27). Kish used sixteen mice in a modified Skinner box, who were at all times satiated for food and water. During the habituation trials the animals were in total darkness and bar touches were recorded but no illumination resulted from the press. After these trials the Ss were divided into two groups of eight animals each, equated with regard to number of operant responses they emitted during habituation. On the eighth day the experimental group received the onset of illumination immediately subsequent to a bar press. The control animals received no such change. On days nine through twelve all Ss were run under the original habituation conditions. These constituted extinction trials. To rule out the possibility that the light flashes were creating increased responding via an increase in general activity, a control was added where Ss were exposed to illumination changes uncorrelated with their behavior.

Kish found that on the acquisition day the experimental group responded more than twice as much to the bar as did the control group. This finding was statistically significant at a high level of confidence. During extinction trials the mean number of responses emitted by the experimental group remained greater than that of the controls but the difference decreased over four days.

Secondary reinforcement, as an explanation of these results is rejected by Kish who points out that no training was given associating

the onset of light with primary reinforcement. He advanced the hypothesis that a perceptible environmental change per se is a reinforcer for behavior preceding it. This, of course, is the contiguity interpretation.

Results similiar to those of Kish have been reported by Marx et al. (31) and by Kling and associates (28). Both of these studies involved the albino rat. However, Moon and Lodahl (41) found that changes in illumination reinforce lever-pressing in monkeys, and Sharpe (50), working with a different sense modality, reported significant increments in the chain-pulling rate of preschool children with the sound of a chime as the reinforcing agent.

In this general area of experimentation, Shrader (54) attempted to demonstrate the contiguity tenet that the greater the cue change following a response the greater the reinforcement. He used three groups of pigeons with the pecking response in a Skinner box being subjected to the experimental treatment. One group of birds was exposed to an appreciable increase in illumination when they pecked, while a second group had this increased stimulation plus the noise of the food magazine turning. The third group was a control which received no increased stimulation following the pecking response. All birds were satiated and none was exposed to food while in the experimental box.

In this experiment all groups showed an increase in their pecking responses over trials but the increased responding of the control Ss, above their initial level, was not statistically significant. The prediction that the two cue change group would show the greatest in-

crease in pecking was not supported. On the contrary, the one cue change Ss were superior to them. Apparently the light-noise combination has a suppressive effect on the pecking response (25).

Horowitz (25), using a different combination of stimuli, obtained results in the predicted direction. In his experiment twelve untamed pigeons had free access to food in their home cages for two weeks prior to training trials. The animals were then split into two groups and tested in a Skinner box containing a pecking window. One group was exposed to the sound of the turning of the food magazine after a pecking reaction. The other group received the sound plus sight of food. No birds had access to food in the apparatus during testing but food was always available in their home cages. A control group was added, which received the same treatment as the other two groups except that they received no cue change when they pecked.

Horowitz found that the responding of the peck-sound group and the peck-sound-sight of food group increased over time while that of the control group decreased. There was some tendency for the two cue change group to reach a higher level of responding than the one cue change group but the difference was never statistically acceptable.

In the Skinner box situation, where an increase in illumination is used as the reinforcer, recent experiments have demonstrated superior acquisition in food-deprived animals when compared to satiated ones.

Forays and Levin (13) studied the reinforcing effect of a light paired with a bar pressing response in satiated and food-deprived albino

rats. Four groups of animals received fifteen-minute trials in a Skinner box for 21 days. Two groups were on a 22-hour food deprivation schedule and two were on an ad lib. feeding schedule. For fourteen days, one hungry and one satiated group received a five-second light following a lever press while the two other groups had no light stimulation following the response. Seven extinction trials were given where no group received the light.

The results were that the lever-light groups responded more frequently than their controls. In fact, the satiated controls showed no evidence of acquisition. Further, the food-deprived animals tended to respond at a higher rate than the food-satiated animals. Across trials the experimental subjects exhibited typical acquisition behavior, and typical response decrements occurred during extinction.

An experiment by Davis (11) adds further evidence that hunger drive in the absence of food reward increases the rate and magnitude of acquisition of a bar pressing response. He used eighteen male albino rats in a Skinner box, placing all animals on a one-hour ad lib. feeding schedule. The animals were then divided into three groups which received their daily food rations at 0, 2, and 23.5 hours before their test periods. Operant levels of responding were determined during three thirty-minute sessions. Following this, three test sessions were run where illumination resulted from a bar press.

Davis found that all three groups revealed indications of learning, with the 23.5-hour group showing the greatest amount of responding, the 0-hour group the least, and the 2-hour group falling between these

extremes. More specifically, the number of responses emitted under light-onset reinforcement was directly related to the level of food deprivation.

Can the contiguity position offer an explanation to account for the differential strengthening effects of illumination onset in the presence of an "irrelevant" drive? Forgays and Levin (13) suggest that deprived animals are more "reactive" to changes in external stimulation than are rats fed on an ad lib. food diet. (Support for this hypothesis comes from studies on rats in activity drums done by Campbell and Sheffield (8) and by Hall (18)). To say that deprived animals are more reactive than satiated ones is another way of saying that a greater behavioral change is induced by the post-response cue. Thus, the greater the behavioral change the greater the reinforcement, and the better the learning. Further research on this differential reactivity hypothesis is needed before it can be accepted as more than a possible explanation of the above results.

Within the last ten years research on so-called "exploratory" behavior—conducted largely on food and water satiated animals—has yielded results which are in line with the contiguity position. Hullian-oriented theorists (3) have attempted to cope with this new data by postulating an "exploratory drive" whose reduction increases response strength. As will be shown, however, there are good grounds for believing that the "exploratory drive" (presuming its existence) is either increased or maintained at a constant level during learning trials rather than decreased.

An early experiment in this area (1942) was performed by Finger and Mote (42). They employed a simple runway situation to determine whether learning (measured by a decrease in latency and running time) would occur in the absence of food reward. Two groups of albino rats were placed on a deprivation schedule and given one trial a day on an elevated runway. The animals were simply required to traverse the runway and enter an end-box, at which time a guillotine door was dropped to prevent retracing. After a thirty-second interval the end-box was moved to the starting position, and following a short delay, the door was opened, starting another trial.

For one group of Ss the end-box was similar to one in which they had been fed during preliminary training. The other group of Ss (Group II) never had any experience with the end-box prior to the training trials.

The results were that both groups of animals showed a small and variable decrease in latency and running time, with the first group being somewhat superior to the second one. Finger and Mote interpreted the performance of the first group as learning resulting from the "secondary reinforcement" provided by the familiar goal box. The performance of the second group was not viewed as learning by the authors but, to them, merely reflected behavior being "impelled" by an exploratory drive. Such an interpretation would seem to be quite arbitrary and based mainly on the fact that Finger and Mote believed the Group II animals to be receiving no reinforcement for running. Thus, no reinforcement equals no learning. However, the contiguity position

would maintain that this group was being reinforced since running into a distinctive end-box removes the rat from the runway situation.

Avoiding certain methodological points of confusion in the Mote and Finger study (42), Willingham (25) performed an experiment to show that, in the runway situation, an animal will learn simply by running to a goal box which is distinctively different from the runway. Willingham controlled for all known sources of "secondary reinforcement" and continued training beyond the logical point of extinction of any "exploratory drive" (56 trials). Also investigated was the question as to whether immediate removal from the end-box is more effective in reinforcing behavior than detaining the animal for an extended period of time.

In the first phase of the experiment one group of food-deprived rats ran to a distinctive end-box for 24 trials. They received no food reward but were merely confined in the end-box for fifteen seconds. The Ss were not handled by the experimenter but dumped directly from end-box to restraining cage. They were fed in their home cages one hour after exposure to the experimental treatment. Another group of rats, for comparison purposes, ran to food reward in the same situation.

The results were that both groups showed a significant decrease in running time over trials with the food-reward animals being consistently superior to the non-reward group. The important finding, however, was that the non-reward group revealed definite indications of learning, with the acquisition being much less variable and more enduring than that of the comparable group in the Mote and Finger study.

In the second phase of the experiment, the non-reward animals were sub-divided into three groups. For two groups the only change in treatment, from the first phase, was that of the delay period in the end-box. One group had its delay period changed from fifteen seconds to one second and the other, fifteen seconds to 150 seconds. The third group had its delay period changed from fifteen to 150 seconds, and its end-box changed so as to produce maximum similiarity between it and the runway (an actual runway unit was converted into the end-box).

The results, here, were that the first two sub-groups showed a further significant drop in running time over trials while the maximum similiarity group showed no change in running time. This indicates the crucial nature of cue change in the reinforcement process. The change of delay-time in the end-box had little effect on acquisition.

In an experiment by Myers and Miller (44) it was shown that albino rats, satiated for food and water, will learn a bar-pressing response, the only reward being entrance into, and "exploration" of, a new compartment.

The Ss were placed in a two-compartment Miller learned-drive apparatus. The compartments differed from each other only in regard to color—one was painted black, the other white. The animals could gain access to the second compartment by pressing a small bar which raised a guillotine door. All Ss showed clear evidence of acquisition, running either from the black compartment to the white or vice versa. A control group of animals, which was prevented from seeing or entering the second compartment by a white wooden panel located immediately behind the door,

did not learn. The authors state: "Apparently the fact that pressing the bar is followed by the chance to observe and enter a new compartment is sufficient to produce learning" (44, p. 434). In contiguity terms, bar-pressing was reinforced because it resulted in immediate cue change which changed the animal's behavior from bar-pressing to running forward.

Being oriented toward drive reduction theory, Myers and Miller find it necessary to posit a "boredom drive" aroused by the homogenous or monotonous stimulation of the first compartment which is reduced by the "sensory variety" and freedom of action resulting from moving into the second one. In suggesting that sensory variety (increased stimulation) and freedom of action (increased activity) signify the reduction of drive, Myers and Miller are contradicting the latter's operational criterion of drive reduction (see p. 4) as well as disregarding the customary conceptions of drive operations, i.e., drive increase is usually thought of as "energizing" the organism and raising activity level (5). For this reason, theorists (38, 39) who argue that learning in "exploratory" situations is based on drive increment reinforcement would seem to be more consistent with the general body of psychological lore than proponents of the drive reduction position. Contiguity theory does not have to take any particular stand in this argument, viewing removal via cue change (of which drive change is merely a part) as the significant aspect of reinforcement.

There are several studies, dealing with more complicated habits than simple forward locomotion and bar-pressing, which are relevant to

the present section of this paper. For instance, Montgomery (38) ran rats, satiated for food and water, in a Y-maze where one arm ended in a blind alley and the other opened into a large Dashiell-type maze which offered much stimulation to the animal, i.e., there was a big cue change between the Y-maze and the Dashiell maze. Montgomery found that the Ss learned, with decreased latency, to enter the arm of the Y-maze leading to the Dashiell maze and to avoid the arm ending in a blind alley (minimal cue change). It was further found that the Ss reversed their behavior when the position of the Dashiell maze was reversed.

In an extension of this experiment Montgomery and Segall (39) found that satiated rats could learn a black-white discrimination when reinforcement for a correct choice consisted of a short period (fifteen seconds) of "exploration" in the Dashiell maze. As in the above-mentioned experiment, an incorrect choice in the Y-maze resulted in the animal's being detained in the blind alley for fifteen seconds. As the authors point out, the experimental situation was such ". . . that the novel stimulation following a correct choice is more extensive, both spatially and temporally, than that following an incorrect choice" (36, p. 225).

When an S made an incorrect choice it was detained in a blind alley, the cues of which (blackness or whiteness, depending on the group) were highly similiar to the Y-maze proper. The S in this situation could either sit or twist around, both of the responses being incompatible with forward locomotion. Hence, according to the princi-

ple of postremity, forward locomotion was not reinforced in the presence of the discriminative color cue. Instead, sitting or twisting responses were reinforced. In making a "correct" choice and entering the Dashiell maze forward locomotion was not impeded, and so it was reinforced in the presence of both Y-maze and D-maze cues. Hence, the selective learning to run to the side containing the Dashiell maze.

The reinforcing properties of simple cue change in a discriminative learning situation have been demonstrated in other organisms than the albino rat. Thus, in an experiment using adult rhesus monkeys, Butler (7) found that he could establish a strong visual discrimination habit, the only reinforcement for which was allowing the S, when making a correct response, to push open a small door in the enclosed experimental cage and "look" at novel stimuli for thirty seconds. The strength of the habit is revealed by the fact that efficient performance was maintained during long daily sessions with little or no evidence of satiation.

In an experiment using kittens on a 23-hour food deprivation schedule, Miles (32) found that the Ss would quickly learn a non-spatial discrimination habit in a single unit Y-maze where reinforcement for a correct choice consisted simply of a fifteen-second detention period in a goal box which contained such objects as a rubber ball, crumpled paper, and a piece of torn towel. The goal box of the incorrect arm was empty. When all objects were removed from the correct goal box all animals showed a typical extinction trend.

Here, again, it was demonstrated that animals learn to choose the

arm of a Y-maze which offers the greatest amount of removal (reinforcement). Or, stated another way, the goal box containing various objects which can be manipulated by the kittens offers a greater cue change than an empty box.

In a continuation of this experiment, the kittens were placed on a four-hour food deprivation schedule and trained as follows: An escape hatch was opened in the right goal box so that the Ss could jump out of the maze and explore the experimental room for fifteen seconds. The left goal box contained a familiar porcelain dish from which the Ss received their daily food ration (a secondary reinforcer in Hullian theory). If they entered this goal box the Ss were detained for fifteen seconds. The results were that the kittens rapidly learned to choose the arm of the Y-maze whose goal box permitted escape into the room. This would appear to be a clear case of an experiment where "secondary reinforcement" cannot account for the observed learning and where the concept of differential cue change (removal) is patently applicable.

With regard to the performance of satiated versus food-deprived animals in the "exploratory" situation there appears to be only one experiment in the literature to date. In this study Chapman and Levy (9) investigated the reinforcing effects of "novel" cue change in the end-box of a uniform black, straight alley. Wall and floor inserts with varying designs were used as novel stimuli and running time was used as the measure of acquisition. Sixty female albino rats were given one trial daily in the straight alley. In the first part of the experiment

the Ss were divided into a food-satiated and a 22-hour food-deprived group. These animals were run for nine trials to one set of inserts (A). Following these trials a new set of inserts (B) was installed and the animals given five more trials. After trial fifteen all Ss were placed on a 22-hour deprivation schedule and run to food in the end-box containing inserts B for eight more trials. Following this the food was removed and the animals were given thirteen extinction trials.

With regard to the first phase of the experiment, Chapman and Levy found that both hungry and satiated Ss showed a decrease in running time over trials but that the satiated animals ran significantly faster than the hungry ones. Introducing an end-box change after trial nine further widened the gap between the groups. When both groups were then run on a deprivation schedule the formerly satiated animals showed a relative increase in running time so that the difference between the two groups disappeared. During extinction, however, the original ad lib. group exhibited greater resistance to extinction and a smoother extinction curve than the drive group.

The authors concluded that novel stimuli reinforce a behavior sequence but that food deprivation decreases the reinforcement value of such stimuli. The results of this experiment contradict the findings of other studies on learning in deprived Ss and replication is clearly needed.

#### Summary of Experimental Evidence

Experimental research, covering various learning situations, has been presented to demonstrate the contiguity tenet that removal via

cue change is the necessary and sufficient condition in the reinforcement process. Thus, physical removal of the organism from a situation, as well as removal of an important aspect of the stimulus (cue) compound, following a given response, was shown to increase the strength of that response. Further, experiments on consummatory behavior (drinking and copulation) demonstrated that the more the behavior is altered by the post-response cue change (bottle containing non-nutritive sweet substances, sexual lure in the goal box) the greater is the reinforcement of that response.

Studies on the reinforcing effect of simple sensory changes (illumination, noise level) following a response were seen to be directly relevant to the contiguity position. Finally, research on exploratory behavior demonstrated that simple running, or more complex discrimination habits could be created by having the animal remove himself (via forward locomotion) from one distinctive situation to another.

In all of these experiments there would seem to be little evidence for believing that drive reduction entered into the learning process. Indeed, in many cases, drive was apparently either maintained at a constant level or increased. In several experiments all known "primary drives" were satiated (unless one posits a "primary exploratory drive"). In addition, most of the investigators cited made careful controls to rule out possible sources of "secondary reinforcement."

In studies comparing the acquisition of behavior in deprived versus satiated animals, the evidence to date suggests that deprived

animals learn faster, although at least one experiment (9) found the opposite result.

### Purpose of the Present Study

Although contiguity theory predicts that the greater the cue change following a response, the greater will be the reinforcement of that response, there have been few experiments designed systematically to test this prediction. Two studies using pigeons in a Skinner box where one group received no change following a pecking response, while another group received one cue change and a third group received two cue changes, yielded only partial confirmation of the contiguity hypothesis (see pp. 19-20). Apparently the removal capacity of simple illumination and auditory changes rapidly reaches a maximum.

One purpose of the present experiment was to test the reinforcing effects of systematically varied cue change in the "exploratory" situation. Thus, three conditions were created, each differing with regard to amount of cue change received by the subject as he locomoted from one region of the apparatus to the other. One group received minimal cue change, a second received a moderate amount of cue change and a third received a large cue change. It was predicted that the degree of learning would be directly related to amount of cue change, i.e., the greater the change, the better the learning.

A second purpose of this study was to investigate further the deprived-satiated variable in each of these conditions. Therefore, half of the Ss were run under a 23-hour food deprivation schedule while the

other half ran under conditions of ad lib. feeding.

A final purpose was to investigate the effects of cue change on performance after the asymptote of acquisition had been established. Reducing the amount of cue change in a group formerly exposed to a large change should produce typical extinction effects. Similiarly, increasing the amount of change in a group formerly exposed to minimal cue differences should result in further acquisition.

## CHAPTER II

### METHOD AND PROCEDURE

#### Background Research

In preparing for the final experiment several pilot studies were performed, only one of which is directly relevant to the present investigation. The purpose of this pilot study was to compare the rate and magnitude of acquisition of a simple running response to small and large cue changes following forward locomotion in a runway situation. The small change animals were simply hand-removed from the end-arm of the runway after either a five-second or a four-minute delay period. The large change Ss were allowed to run out of the end-arm onto an open table where they were then removed by the experimenter after the same delay periods. A control group of Ss was removed only in the starting arm of the runway following a five-minute period of "free" exploration. In line with the contiguity position, it was predicted that the large change Ss would show the best acquisition, the small change Ss would show some acquisition, and the control group would show little change in running behavior.

#### Subjects

The subjects consisted of thirteen male albino rats of the Budd Mountain strain. All animals were experimentally naive and, at the beginning of the study, they were between 55 and 75 days old. None of the

Ss had ever undergone food or water deprivation. During the entire course of the experiment, they had ad lib. access to food and water (except during the actual trials). The Ss were given five days of taming by handling prior to the experiment.

### Apparatus

The apparatus consisted of a four-foot runway and two arms, measuring one foot in length, placed at right angles to the runway. These arms were made as similiar to each other as possible, the major difference being that the starting arm opened into the runway on the right whereas the end-arm opened into the runway on the left. Thus, the apparatus resembled an inverted "U" with an elongated base. At the entrance to the end-arm of the apparatus was a metallic guillotine door (A) which could be manually raised and lowered by the experimenter. The far wall of the end-arm was also made into a guillotine door (B) and, when raised, permitted the S access to a flat, open table which measured approximately 4 by 4 feet. The entire apparatus, the top of which was covered with wire mesh, was painted a uniform dull grey.

### Procedure

All Ss were given one trial a day for sixteen days. The small change animals were simply placed in the starting arm of the apparatus and allowed to "explore" until they made a full body entry into the end-arm whereupon door A was closed to prevent retracing. One group of these animals was detained in the end-arm for five seconds, the other

for four minutes. Door B was never opened to these groups.

The procedure was the same for the large change groups except that both doors A and B were raised at the outset of each trial permitting the Ss to run out of the apparatus and onto the table. After gaining access to the table, door B was closed to prevent re-entry. One group of animals was allowed to remain on the table for five seconds, the other for four minutes.

Animals in the control group were placed in the starting arm facing away from the entrance to the runway ( in contrast to the other groups ). Door A remained open during the entire trial permitting the Ss to wander unimpeded in the apparatus. Door B was always closed. The animals were left in the apparatus for an average of five minutes and removed only in the starting arm while facing away from the runway.

A final group consisted of those Ss who did not run into the end-arm of the apparatus after a five-minute period on the first trial. On succeeding trials these animals were placed in the starting arm and allowed to remain there five minutes or until they ran into the end-arm whereupon they were detained there for four minutes before removal.

### Results and Discussion

No statistical analysis was performed on the data because of the small number of Ss involved and because of the wide variability in performance in some of the groups. Out of five animals in the large change group, two developed marked approach-avoidance behavior toward the cues of the open table. One of these Ss ran onto the table only six times in sixteen trials while the other ran three times. The

presence of much defecation and squealing when picked up by the experimenter indicated the presence of strong "fearfulness". Similarly, in the small change groups both five-second delay animals developed strong approach-avoidance behavior toward the end-arm. Apparently being removed immediately after entry into the end-arm was the significant factor in producing avoidant responses since neither of the four-minute delay animals developed such responses.

In taking only those Ss not showing significant avoidant tendencies and plotting running-time over trials (running-time being defined as time interval between placement of the S in the start-arm and a full body entry into the end-arm) it was found that the large change group (LC) ran faster than the small change group (MC) in twelve out of sixteen trials, and the latter group ran faster than the control group in fourteen out of sixteen trials. Further, running time progressively decreased in the experimental groups whereas no orderly changes occurred in the control group (C) (see Table I).

Thus, this pilot study tended to support the contiguity position regarding the differential reinforcing effects of small versus large cue changes although the results were confounded by avoidance behavior. Such behavior in the presence of novel or radical cue changes has been found by several experimenters (14, 36). Montgomery (37) hypothesizes that novel stimuli elicit both "fear" and the "exploratory drive", the former accounting for avoidant tendencies, the latter motivating approach behavior. In any case, novel stimulus cues appear to be unconditioned (or at least pre-experimentally established) elicitors of

TABLE I

MEAN RUNNING-TIME IN SECONDS  
FOR NON-AVOIDING ANIMALS  
TWO SS PER GROUP

| Trials | LC   | Group | C    |
|--------|------|-------|------|
|        |      | MC    |      |
| 1      | 40.0 | 25.0  | 28.5 |
| 2      | 29.0 | 41.0  | 81.5 |
| 3      | 19.5 | 8.5   | 6.0  |
| 4      | 10.5 | 24.0  | 4.5  |
| 5      | 4.5  | 18.0  | 27.0 |
| 6      | 4.0  | 12.5  | 21.5 |
| 7      | 4.5  | 8.5   | 10.0 |
| 8      | 4.5  | 6.5   | 24.5 |
| 9      | 3.0  | 8.0   | 27.0 |
| 10     | 8.5  | 4.5   | 25.5 |
| 11     | 8.5  | 6.0   | 17.5 |
| 12     | 3.0  | 8.5   | 13.0 |
| 13     | 3.0  | 5.5   | 7.5  |
| 14     | 3.5  | 5.0   | 30.0 |
| 15     | 3.0  | 17.0  | 20.0 |
| 16     | 3.5  | 7.0   | 11.0 |

both approach and avoidance responses. Whether approach, avoidance, or a combination of the two will occur on any trial is undoubtedly some function of the degree of novelty of the situation and of the internal state of the organism. And, according to contiguity theory, the last response made to the situation is the one most likely to recur on the next trial. Thus in some Ss avoidance responses become strengthened while in others approach is strengthened.

With regard to the internal state of the organism it will be noted that all animals in the pilot study were run on a 0-hour deprivation schedule as were the Ss in Montgomery's studies (33, 34). The question presents itself as to whether avoidant responses to novel stimuli would be reduced if Ss were run under conditions of food deprivation. The final experiment was designed to answer this question as well as to further assess the effect of differential cue change following a response.

### The Final Experiment

In this experiment it was decided to reduce the apparatus to a simpler form from that of the pilot study. A straight alley, separated by a door into two compartments, was used. The measure of acquisition employed was the speed of entering the second compartment. Following the procedure of Zimbardo and Miller (65) all Ss were detained in the first compartment for ninety seconds to reduce any "conflict" between tendencies to explore the immediate environment thoroughly and to move on to explore the next unit. Three apparatuses were con-

structed so that one group of Ss received minimal cue change by locomoting from one unit to the next, while a second group received a moderate amount of change, and a third group obtained a large change. Half of the Ss were run satiated and half food-deprived. It was predicted that increased cue change would elicit both approach and avoidance behavior but that the deprived animals would show less avoidance than the satiated ones. It was further predicted that with avoidance responses extinguished or inhibited, Ss receiving the largest cue change would show the best learning and those receiving little change would show the poorest, with the moderate change Ss falling between the extremes.

After the deprived Ss in the maximum change condition, and the satiated Ss in the minimal change condition, had reached their asymptote they were interchanged and given further trials with the prediction that the former would show a decrement in responding while the latter would reveal an increment.

### Subjects

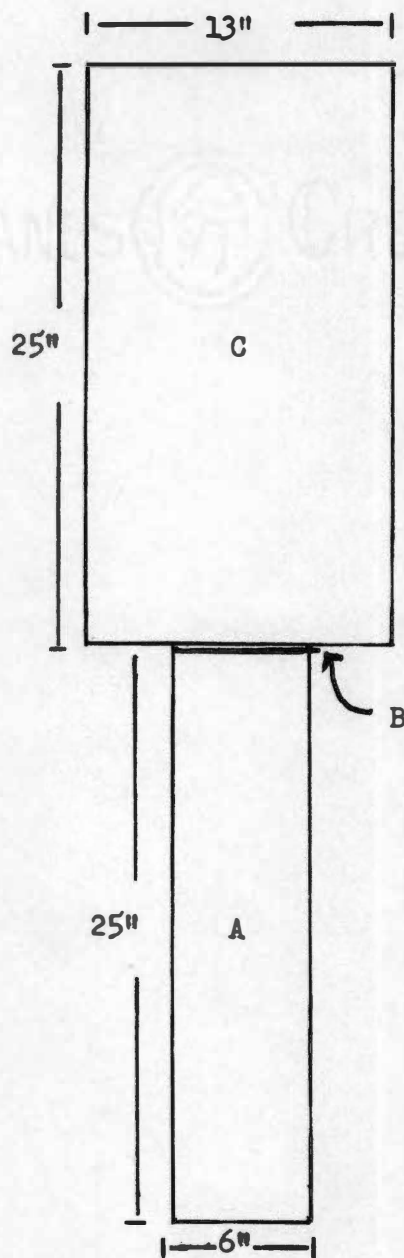
The Ss were thirty male albino rats from the Budd Mountain Rodent Farm. All animals were between seventy and eighty days old at the outset of the experiment. Prior to the experiment they were maintained on an ad lib. diet of water and Purina Lab Checkers. The Ss were housed in individual cages and were tamed by handling for five days prior to the experiment.

### Apparatuses

The Ss were divided into three groups and tested in three different apparatuses. The basic structure of these apparatuses was the same, consisting of two compartments separated by a wooden guillotine door. The first compartment of each apparatus was made as similar to the others as possible. They measured 25 by 6 by 7.5 inches with walls and floor made of wood. These compartments were painted a flat grey as were the doors. The doors were attached to a string by which they could be manually raised and lowered by E. The doors rested on a one inch block which served as a hurdle for the Ss to surmount.

The second compartment of the first apparatus (Condition 1) was made as similar as possible to the first compartment, thus providing a minimal cue change situation. The second compartment of the next apparatus (Condition 2) measured 25 by 13 by 7.5 inches and was unpainted raw wood. Thus, in this condition, the S was confronted with two major cue changes when locomoting from one compartment to the next—increased space and increased brightness level. This constituted the moderate cue change situation. (See Figure 1.)

The second compartment of the last apparatus (Condition 3) measured 24 by 22 by 7.5 inches. It, also, was unpainted and contained several novel objects. The objects consisted of a crumpled piece of white paper, a vinegar bottle, a nut and bolt, and a small block of black wood measuring 4 by 4 inches. These objects were arbitrarily arranged in the compartment and remained in place throughout the ex-



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Figure 1. Diagram of the apparatus for Condition 2 showing the first compartment (A), the guillotine door (B), and the second compartment (C).

periment. This constituted the maximal change situation, representing a large increase in space (relative to the first compartment), an increase in brightness, and the inclusion of five objects.

The entire experimental room was painted black and contained no windows. The only source of illumination was a 7.5-watt bulb, filtered through two thicknesses of ordinary white paper, suspended three feet above the center of the apparatus. An air-conditioner ran continuously to maintain constant temperature and to provide a rather unvarying noise level.

A separate apparatus was used for habituating the Ss to the sight and sound of a moving guillotine door and from going to one compartment to another. It consisted of an unpainted T-maze, the alley of which measured four inches in width and four inches in height. The leg of the T was separated from the cross-member by a guillotine door which was manually operated by E. Each S was allowed to "explore" in the cross-member for sixty seconds after entering it.

### Procedure

Five preliminary trials in the T-maze, at the rate of one trial a day, were given to all Ss. A trial consisted of allowing the S to explore the leg of the T for sixty seconds before opening the guillotine door which permitted passage into the cross-member. The time lapsing between opening of the door and a full body entry into the cross-member (running-speed) was recorded by means of a stop-watch. After sixty seconds in this section of the T the Ss were returned to their home

cages.

On the basis of running-speed scores of the first trial, the animals were divided into six approximately equated groups of five Ss each, which were randomly pre-assigned to the three experimental conditions. Further, immediately after the first trial, half of the animals were placed on a 23-hour food deprivation schedule while the other half remained on an ad lib. feeding schedule. All Ss had ad lib. access to water.

The remaining four trials in the habituation apparatus were run to accustom the Ss to a moving door and to the presentation of a novel situation, i.e., the second compartment to be explored. These trials also permitted the deprived animals to become habituated to a one-hour feeding schedule and to "exploring" under conditions of deprivation.

In the experimental test trials proper, the groups were assigned to their respective conditions and given one trial a day. Each condition contained a satiated and a deprived group, making a simple 2x3 factorial design.

The procedure was the same for the Ss in all three conditions. They were placed in the far end of the first compartment and allowed to explore it for ninety seconds, at which time the guillotine door barring them from the second compartment was raised. After the S entered into the second compartment the door was lowered preventing re-entry into the first compartment. Each S was then allowed to explore the second compartment for sixty seconds. If an animal did not run into the second compartment within a period of two minutes after the door had been raised,

it was placed in that compartment by E and removed after sixty seconds. Following each trial the S was immediately returned to its home cage. Food was available to the satiated groups and the deprived Ss were fed thirty to sixty minutes after testing.

To control for any systematic position effects the order of trial presentation was reversed every other day.

By the eighteenth trial the deprived Ss in the three conditions (Groups  $D_1$ ,  $D_2$ ,  $D_3$ ) appeared to reach asymptote. No further trials were given to Groups  $D_1$  and  $D_2$ . To investigate further the effects of cue change, the  $D_3$  animals were placed on an ad lib. feeding schedule immediately after the eighteenth trial and switched to Condition 1 following a four-day adjustment period to the new feeding schedule. At the same time, the satiated Ss in Condition 1 ( $S_1$ ) were placed on a 23-hour deprivation schedule and switched to Condition 3. Under these conditions the groups were run for twelve more trials.

The satiated Ss in Conditions 2 and 3 ( $S_2$ ,  $S_3$ ) were run for the entire thirty trials as their performance remained erratic and variable.

Records were kept of: (a) the latency from door-opening to entry into the second compartment (running-speed), (b) the amount of time, during the ninety-second delay interval, spent by each S in that half of the first compartment nearest the door (unit 2), (c) the number of reversals in direction made by each S during the ninety-second delay interval, (d) the number of approach-avoidance responses emitted after door-opening and before S entered the second compartment, and (e) the number of fecal boli dropped during testing. An approach-avoidance

response was scored whenever an S approached to within three inches of the door and either turned around or backed away from the point of furthest progression. Stretching part of the body forward into the second compartment and then withdrawing was also scored as approach-avoidance. A reversal in direction was scored only when S made a full one hundred and eighty degree turn from the long axis of the compartment. This constituted a rough measure of amount of activity elicited from each S during the ninety-second delay period.

## CHAPTER III

### RESULTS

Because of the small number of subjects used, the skewedness of the distribution, and the heterogeneity of variance existing among some of the groups, non-parametric statistics were employed in the analysis of most of the data in this chapter. The 2x3 factorial design made it possible to analyze scores by group, by condition, and by drive (satiated versus deprived). For group and condition comparisons the Kruskal-Wallis rank analysis of variance ( $\chi^2_H$ ) was used. Comparisons on the drive variable were made with either  $\chi^2_H$  or the Wilcoxon-Mann-Whitney T-test. For a discussion of these statistics see Siegel (55) and Jenkins (25).

#### Data on Preliminary Trials

The only datum recorded on the five preliminary trials was the time taken by Ss to run from the leg of the T-maze into its cross-member after E raised the guillotine door (running-speed). Because of rather large intra-individual variability across trials it was decided to use the combined running-speed scores (in seconds) on trials 4 and 5 to compare the relative performance of the six groups. These scores, for each S, arranged by group, are presented in Table II. An analysis of variance on this data yielded a  $\chi^2_H$  of 1.91 with  $P = .86$ , indicating that there were no significant differences in running-speed among the six groups at the end of preliminary training. Similarly, an analysis



of variance by condition to which Ss were to be exposed on the test trials proper, was non-significant ( $X^2_H = .692$ ,  $P = .74$ ), as was a T-test on the satiated versus deprived variable ( $X^2_H = .469$ ,  $P = .50$ ).

To determine whether any significant changes in running-speed occurred across the preliminary trials, the combined running-speed scores for each S on trials 1 and 2 versus 4 and 5 were calculated and a parametric t-test for correlated data applied. Twenty-two out of thirty Ss ran faster on the last two trials than on the first two. The mean running-speed for trials 1 and 2 was 69.4 seconds; that for trials 4 and 5 was 39.3 seconds. A mean difference of 30.3 seconds was found to be significant at the .01 level of confidence ( $t = 2.68$ ,  $df = 29$ ).

The five preliminary trials, then, resulted in a significant increase in running-speed for the Ss as a whole without differentially affecting any of the six groups.

#### Running-Speed Data on Test Trials

Table III presents, for each group, the grand medians of groups of three consecutive running-speed medians across the eighteen test trials and the twelve post-test trials. On these latter trials,  $S_1$  and  $D_3$  were interchanged with respect to condition and drive. Groups  $S_2$  and  $S_3$  were maintained on the same conditions, with 0-hours deprivation, throughout the entire thirty trials. Inspection of the table indicates that all groups tended to reach a median asymptotic running-speed by the ninth trial. Deprived groups seemed to show better learning than satiated ones, and among the former groups,  $D_2$  and  $D_3$  appeared to be

TABLE III

THE GRAND MEDIAN OF GROUPS OF THREE CONSECUTIVE  
 MEDIAN. RUNNING-SPEED IN SECONDS

| Trials | Groups         |                |                |                |                |                |
|--------|----------------|----------------|----------------|----------------|----------------|----------------|
|        | S <sub>1</sub> | D <sub>1</sub> | S <sub>2</sub> | D <sub>2</sub> | S <sub>3</sub> | D <sub>3</sub> |
| 1-3    | 12             | 15             | 29             | 29             | 13             | 16             |
| 4-6    | 22             | 6              | 14             | 14             | 20             | 7              |
| 7-9    | 12             | 6              | 7              | 7              | 26             | 6              |
| 10-12  | 12             | 6              | 8              | 6              | 13             | 3              |
| 13-15  | 12             | 9              | 6              | 5              | 8              | 3              |
| 16-18  | 11             | 6              | 6              | 3              | 11             | 3              |
| 19-21  | 7              |                | 9              |                | 6              | 4              |
| 22-24  | 7              |                | 7              |                | 4              | 7              |
| 25-27  | 3              |                | 9              |                | 10             | 11             |
| 28-30  | 3              |                | 14             |                | 5              | 8              |

superior to  $D_1$ . Following the interchange of conditions on the nineteenth trial it can be seen that  $S_1$  showed a definite increase in running-speed whereas  $D_3$  evidenced a decrease. The satiated groups (especially  $S_2$  and  $S_3$ ) evidenced so much intra-group variability that the medians in Table III do not reflect the performance of the  $\underline{Ss}$ . For instance, the ranges of the combined running-speed scores, for the last three test trials (16-18), were 97 seconds for  $S_1$ , 118 seconds for  $S_2$ , and 118 seconds for  $S_3$ . In contrast, the respective ranges for the D groups were 5, 40, and 4 seconds. Applying the Hartley  $F_{\max}$  test for homogeneity of variance to these scores the following results were obtained: For within-satiated groups  $F_{\max} = 3.1$  which indicated that the variances were homogeneous; for within-deprived groups  $F_{\max} = 137.05$  which indicated significant heterogeneity, due entirely, however, to one extremely deviant score. The variance of the combined satiated groups was 16676.2 and that for the deprived groups was 737.0. A variance ratio of 22.6 is significant beyond the .01 level, revealing marked heterogeneity of variance between the two groups, with satiated  $\underline{Ss}$  being much more variable in performance than deprived  $\underline{Ss}$ .

Because both intra-group and intra-individual variability appeared to be an important measure in this experiment, it was decided to use the combined running-speed scores of three consecutive trials as the unit of analysis. Table IV presents the combined running-speed scores (in seconds) for all  $\underline{Ss}$ , by group, on the first three trials of the test proper. It can be seen by inspection of the sum of ranks that, except for group  $D_1$ , there was little difference in performance among



the groups. A rank anova on this data, yielding a  $\chi^2_H$  of 4.3 ( $P = .50$ ) confirmed this observation. Separating all Ss by condition, and running another rank anova on the resulting data, a  $\chi^2_H$  of 2.44 was obtained with  $P = .34$ . Although this  $P$  indicates a significant lack of differential responding among the three conditions taken together, inspection suggested that  $C_1$  and  $C_3$ , the two extreme groups, might diverge from each other to a significant degree. Therefore, a Wilcoxon-Mann-Whitney T-test was applied to these two groups whose median running-speeds, for the three trials combined, were 38.5 seconds for  $C_1$  and 64.0 seconds for  $C_3$ . A  $P = .105$  was obtained, and it might be concluded that, at the outset of testing, a large cue change tended to delay progression from one compartment to the other more than did a minimal change. This result, however, was largely based on the superior performance of group  $D_1$  and the relatively poor performance of group  $D_3$ . There was no overlap in scores between  $D_1$  and  $D_3$  and a Fisher-Yates Exact Test on a 5-0, 0-5 split yielded a  $P = .004$  which is highly significant. The other four groups did not differ significantly among themselves or with  $D_1$  and  $D_3$ . Thus, the relationship between cue change condition and running-speed, at the onset of training, is obscure and it would be hazardous to make generalizations on the basis of the present data.

To assess the effects of the drive variable on the first three trials a Kruskal-Wallis test was applied to the combined scores of all satiated versus all deprived Ss. Median running-speed (for three trials) was 65.0 seconds for the satiated group and 48.0 seconds for the de-

prived group. A  $\chi^2_H$  of .172 with  $P = .70$  indicated the absence of significant differences between these medians.

The next step was to determine whether the groups showed a progressive and orderly increase in running-speed across training trials. For each S the combined running-speed was calculated for trials 1-3, 8-10, and 16-18. A Friedman single classification rank analysis of variance for correlated measures was then performed on each of the six groups. As shown in Table V, none of the satiated groups reached the acceptable levels of significance while all of the deprived groups were highly significant. These results point up the across-trial, intra-individual variability existing within satiated groups and the relative absence of such variability among the deprived groups.

Since the increase in running-speed (across trials) of the satiated groups, separately, lacked statistical significance it was decided to run a Friedman  $\chi^2_H$  on the three groups combined. Such an analysis yielded a  $\chi^2_H$  of 9.7 with  $P > .01$ . The satiated Ss as a whole, then, showed a definite trend toward a progressive increase in running-speed (learning) although much less so than the deprived Ss.

To assess the amount of improvement in performance among the six groups, at the end of the test trials, the raw score differences between the combined running-speed scores of trials 1-3 versus 16-18 were subjected to a Kruskal-Wallis anova (see Table VI). A resulting  $\chi^2_H$  of 12.4 with  $P = .031$  indicated the presence of significant differences among groups. Inspection of the medians and sums of ranks suggested that the deprived groups tended to show marked improvement in running-

TABLE V

RANK ANALYSIS OF VARIANCE FOR CORRELATED MEASURES  
ON ALL SIX GROUPS TO ASSESS  
TRENDS IN RUNNING SPEED

| Group          | $\chi^2_R$ | df | P    |
|----------------|------------|----|------|
| S <sub>1</sub> | 3.6        | 2  | .182 |
| S <sub>2</sub> | 3.6        | 2  | .182 |
| S <sub>3</sub> | 3.9        | 2  | .160 |
| D <sub>1</sub> | 6.4        | 2  | .042 |
| D <sub>2</sub> | 10.0       | 2  | .007 |
| D <sub>3</sub> | 7.6        | 2  | .023 |

TABLE VI

RANK ANOVA ON RAW DIFFERENCE SCORES BETWEEN THE COMBINED  
 RUNNING-SPEED SCORES OF TRIALS 1-3  
 VERSUS 16-18 (IN SECONDS)

| Groups            |                |                |                |                |                |
|-------------------|----------------|----------------|----------------|----------------|----------------|
| S <sub>1</sub>    | D <sub>1</sub> | S <sub>2</sub> | D <sub>2</sub> | S <sub>3</sub> | D <sub>3</sub> |
| 19                | 5              | 58             | 91             | 29             | 58             |
| 15                | 22             | -13            | 152            | 2              | 40             |
| 200               | 23             | 14             | 242            | -54            | 218            |
| -114              | 33             | 15             | 29             | 41             | 296            |
| 19                | 24             | 10             | 20             | 8              | 47             |
| Mdn.              | 19             | 14             | 91             | 8              | 58             |
| Sum R             | 92.5           | 86.0           | 104.0          | 104.5          | 31.5           |
| $\chi^2_H = 12.4$ |                |                |                |                |                |
| $P = .031$        |                |                |                |                |                |

speed compared to satiated ones. Further there was an indication that the deprived groups differed among themselves ( $D_2$  and  $D_3$  showing more improvement than  $D_1$ ), whereas the satiated groups revealed no such differences.

To check these observations statistically, a Wilcoxon-Mann-Whitney T-test was run on the difference scores of all satiated versus all deprived groups. The median difference score was 15.0 seconds for the satiated groups and 40.0 seconds for the deprived groups with  $P > .01$ . On the basis of the medians, then, the latter groups showed almost three times as much improvement as the former.

Next, the deprived Ss were separated by condition and a rank anova applied to the resulting data (see Table VII). A  $\chi^2_H$  of 6.5 with  $P = .04$  indicated that the cue change variable had a significant effect on these animals.  $C_1$  and  $C_3$  groups showed no overlap in scores, a result which is significant at the .004 level of confidence by the Fisher-Yates Exact test. The greater the cue change, then, the greater the improvement in running-speed of the deprived Ss.

A comparable anova on the satiated groups proved to be statistically non-significant ( $\chi^2_H = .483$ ,  $P < .75$ ). Amount of cue change apparently had no differential effect with regard to improvement in running-speed.

In addition to amount of improvement shown by the six groups, over trials, there was the question of absolute level of learning attained by each group. Using asymptotic running-speed as a measure of this level was ruled out because many of the satiated Ss did not

TABLE VII

RANK ANALYSIS OF VARIANCE ON RAW  
DIFFERENCE SCORES AMONG  
DEPRIVED GROUPS

|               | Condition      |                |                |
|---------------|----------------|----------------|----------------|
|               | C <sub>1</sub> | C <sub>2</sub> | C <sub>3</sub> |
|               | 5              | 91             | 58             |
|               | 22             | 152            | 40             |
|               | 23             | 242            | 218            |
|               | 33             | 29             | 296            |
|               | 24             | 20             | 47             |
| Mean.         | 23             | 91             | 58             |
| Sum R         | 60             | 35             | 25             |
| $X_H^2 = 6.5$ |                |                |                |
| P = .04       |                |                |                |

asymptote even after thirty trials. By the eighteenth trial fourteen out of fifteen deprived Ss had reached the criterion of asymptotic performance (four out of five trials where individual trial running-speeds did not depart from each other by more than five seconds).

For comparison purposes the combined running-speed scores of trials 16-18 were used as estimates of the level of learning attained during testing. Table VIII presents these scores for each S separated by group. A Kruskal-Wallis anova on this data yielded a  $\chi^2_H = 7.19$  with  $P < .20$ . Thus, there were no significant differences in running-speed among the six groups at the end of training. A rank anova on Ss separated by condition was also significant ( $\chi^2_H = 1.6$ ,  $P < .25$ ). A Wilcoxon-Mann-Whitney T-test on the drive variable, with conditions held constant, resulted in a  $P = .02$  (the median running-speed for the last three trials being 28.0 seconds for satiated Ss and 10.0 seconds for deprived Ss). Deprivation would seem to be a more important variable than amount of cue change (within the limits of this experiment) in determining the level of performance attained. This conclusion was supported by analyses of variance on within-satiated and deprived groups, both of which were statistically non-significant. As seen in Table IX, the trend, within deprived groups, is toward greater running-speed as amount of cue change increases although  $P$  is greater than .25. A rank T-test on  $C_1$  versus  $C_3$  yielded a  $P$  of .10 which approaches significance.

### TABLE VIII

### RANK ANALYSIS OF VARIANCE ON COMBINED RUNNING-SPEED SCORES FOR TRIALS 16-18 (IN SECONDS)

|                   | S <sub>1</sub> | D <sub>1</sub> | Group<br>S <sub>2</sub> | D <sub>2</sub> | S <sub>3</sub> | D <sub>3</sub> |
|-------------------|----------------|----------------|-------------------------|----------------|----------------|----------------|
|                   | 24             | 25             | 17                      | 22             | 36             | 5              |
|                   | 28             | 16             | 295                     | 117            | 163            | 8              |
|                   | 74             | 19             | 7                       | 9              | 310            | 10             |
|                   | 248            | 13             | 7                       | 5              | 11             | 10             |
|                   | 16             | 9              | 350                     | 4              | 7              | 16             |
| Mdn.              | 28             | 16             | 17                      | 9              | 36             | 10             |
| Sum R             | 47.0           | 79.5           | 70.0                    | 99.0           | 60.0           | 109.5          |
| $\chi^2_H = 7.19$ |                |                |                         |                |                |                |
| P = <.20          |                |                |                         |                |                |                |

TABLE IX

RANK ANALYSIS OF VARIANCE WITHIN THE DEPRIVED GROUPS  
ON COMBINED RUNNING-SPEED SCORES OF TRIALS 16-18

|                   | Condition |     |    |
|-------------------|-----------|-----|----|
|                   | 1         | 2   | 3  |
|                   | 25        | 22  | 5  |
|                   | 16        | 117 | 8  |
|                   | 19        | 9   | 10 |
|                   | 13        | 5   | 10 |
|                   | 9         | 4   | 16 |
| Mdn.              | 16        | 9   | 10 |
| Sum R             | 29        | 43  | 48 |
| $\chi^2_H = 1.94$ |           |     |    |
| $P = < .25$       |           |     |    |

### Running-Speed Data on Post-test Trials

Table X presents the combined running-speed scores of groups  $S_1$  and  $D_3$  at the end of testing (trials 16-18) as compared to scores on the last three relearning trials (28-30) where drive and cue condition had been interchanged. It had been predicted that  $S_1$  animals would show an improvement, and  $D_3$  a decrement, in running performance as a result of such an interchange. Inspection of Table X revealed that all five  $S_s$  in the  $S_1$  group showed an increase in running-speed from trials 16-18 to 28-30 whereas all  $S_s$  in  $D_3$  showed a decrease. By the binomial test (26) ten events in the predicted direction with no reversals yields a  $P = .001$ . As both external cues and drive were varied simultaneously there was no way to assess the effect of either variable separately. However, the results in the analysis of the test trials proper suggested that the drive variable had a more powerful effect on running-speed than amount of cue change. The post-test trials essentially replicated the results of the testing phase of this experiment.

Table XI presents the combined running-speed scores of groups  $S_2$  and  $S_3$  for trials 16-18 versus 28-30. By the end of the test phase (trial 18) the intra-group variability (with respect to running-speed) of  $S_2$  and  $S_3$  was so large that it was decided to give them twelve additional trials to see if learning would progress further. As Table XI indicates, Group  $S_2$  showed little improvement in performance, the median raw difference score being 2.0 seconds, with two  $S_s$  actually showing a worsening in performance. In group  $S_3$  all animals revealed improve-

TABLE X

COMBINED RUNNING-SPEED SCORES FOR GROUPS  
 $S_1$  AND  $D_3$  BEFORE AND AFTER INTERCHANGE  
 OF CONDITION AND DRIVE

| Group | Trials |       |
|-------|--------|-------|
|       | 16-18  | 28-30 |
| $S_1$ | 24     | 10    |
|       | 28     | 9     |
|       | 74     | 27    |
|       | 248    | 19    |
|       | 16     | 6     |
|       | Mdn.   | 28    |
| $D_3$ | 5      | 12    |
|       | 8      | 20    |
|       | 10     | 52    |
|       | 10     | 47    |
|       | 16     | 160   |
|       | Mdn.   | 10    |

TABLE XI

COMBINED RUNNING SPEED SCORES FOR  
GROUPS  $S_2$  AND  $S_3$  ON TRIALS 16-18  
AND 28-30

| Group | Trials      |       | Difference |
|-------|-------------|-------|------------|
|       | 16-18       | 28-30 |            |
| $S_2$ | 17          | 42    | -25        |
|       | 295         | 245   | 50         |
|       | 7           | 5     | 2          |
|       | 7           | 9     | -2         |
|       | 350         | 321   | 39         |
|       | <b>Mdn.</b> |       |            |
|       | 17          | 42    | 2          |
| $S_3$ | 36          | 19    | 17         |
|       | 163         | 84    | 79         |
|       | 310         | 93    | 227        |
|       | 11          | 3     | 8          |
|       | 7           | 3     | 4          |
|       | <b>Mdn.</b> |       |            |
|       | 36          | 19    | 17         |

ment from trials 16-18 to 28-30. The median raw difference score was 17.0 seconds and the binomial test, on five events in the same direction, yielded a P of .031.

With such a small number of Ss it is hazardous to make any generalizations from this data except to suggest the possibility that the large cue change situation ( $S_3$ ) tended to result in further learning with extended trials whereas the moderate change situation ( $S_2$ ) did not.

#### Data on Approach-Avoidance Responding

Table XII presents the total number of approach-avoidance responses emitted, and the number of boli dropped, by each S during the eighteen trials of training. It can be seen from inspection of the scores that Ss tended to show either little or much avoidance and defecation. Further, of those Ss that showed much of these behaviors, the satiated groups seemed to be more extreme than the deprived. To test this inspectional observation, the median number of avoidance responses for all Ss was calculated. This measure turned out to be 7.0, and all Ss emitting more than seven avoidance responses were arbitrarily designated as "avoiders". The "avoiders" were then separated on the drive variable (satiated versus deprived) and a Wilcoxon-Mann-Whitney T-test run on the resulting data. There were nine "avoiders" in the satiated group and six in the deprived. The medians were 40.0 and 16.0 avoidance responses, respectively, with P significant at the .01 level. Thus, the satiated group contained both more avoiders and a higher level

TABLE XII

TOTAL NUMBER OF APPROACH AVOIDANCE (AA) RESPONSES  
AND NUMBER OF BOLI (B) FOR EACH S  
DURING THE EIGHTEEN  
TEST TRIALS

| Group          |     |                |   |                |    |                |    |                |    |                |    |
|----------------|-----|----------------|---|----------------|----|----------------|----|----------------|----|----------------|----|
| S <sub>1</sub> |     | D <sub>1</sub> |   | S <sub>2</sub> |    | D <sub>2</sub> |    | S <sub>3</sub> |    | D <sub>3</sub> |    |
| AA             | B   | AA             | B | AA             | B  | AA             | B  | AA             | B  | AA             | B  |
| 1              | 0   | 0              | 0 | 3              | 0  | 14             | 16 | 16             | 1  | 5              | 0  |
| 32             | 92  | 0              | 0 | 108            | 35 | 63             | 10 | 108            | 12 | 4              | 0  |
| 51             | 53  | 18             | 1 | 1              | 0  | 13             | 0  | 105            | 10 | 9              | 2  |
| 24             | 3   | 1              | 0 | 0              | 0  | 0              | 0  | 9              | 0  | 38             | 23 |
| 0              | 0   | 0              | 0 | 40             | 58 | 0              | 0  | 0              | 0  | 2              | 0  |
| Total 108      | 148 | 19             | 1 | 152            | 93 | 90             | 26 | 238            | 23 | 58             | 25 |

of avoidance than the deprived group.

Further, there seemed to be some association between amount of approach-avoidance responding and amount of defecation. To check this trend statistically, the median number of boli excreted for all Ss was calculated. This figure turned out to be zero, and every S excreting more than zero boli was arbitrarily designated as "fearful." Applying the  $\phi/\phi_{\max}$  test of correlation, an  $r$  of .74 was found to exist between "avoiders" and "fearfulness."

The question presented itself as to whether any differences in running-speed would exist, at the end of training (trials 16-18), between deprived and satiated Ss who gave no avoidance responses. Only animals in Conditions 2 and 3 were used in this comparison. There were five satiated and nine deprived Ss giving no avoidance responses on the last three trials. The median running-speed for the former group was 7.0 seconds; that for the latter group was 9.0 seconds. A Wilcoxon-Mann-Whitney T-test on these differences was non-significant. Thus, with "avoiders" ruled out, there were no differences in running-speed between satiated and deprived animals in Conditions 2 and 3. This result suggested that the over-all superiority in running-speed of the deprived groups was due to the fact that deprivation reduced tendencies to avoid entering the second compartment of the apparatus.

To obtain a "purer" measure of the effects of cue change alone, a rank anova on the combined running-speed scores was performed, using only non-avoiding Ss (see Table XXVI in Appendix B). The median running-speed score (trials 16-18) for  $C_1$  was 16.0 seconds, while that for  $C_2$

and  $C_3$  was 7.0 seconds and 10.0 seconds, respectively. The obtained  $X_H^2$  of 6.7 was significant at the .03 level. With avoiding  $S_s$  ruled out, then,  $C_2$  and  $C_3$  animals ran significantly faster than  $C_1$ . As all of the non-avoiding animals had reached the criterion of asymptote by the eighteenth trial it can be concluded that moderate and large cue change conditions resulted in better learning than minimal cue change.

#### Data on Reversals in Direction (Activity)

It will be remembered that all  $S_s$  were detained in the first compartment of the apparatuses for ninety seconds before the guillotine door was raised, permitting entry into the second compartment. Table XIII presents the total number of reversals in direction emitted by each  $S$  during this delay period, from trials one through eighteen. These reversals in direction were used as an estimate of amount of gross bodily activity. A Kruskal-Wallis anova on the six groups yielded a  $X_H^2$  of 3.38 with  $P$  greater than .50. Thus, there were no significant differences among groups with regard to amount of gross bodily activity evidenced during the eighteen test trials. Analysis of variance by condition also proved to be statistically non-significant ( $X_H^2 = 2.71$ ,  $P = .25$ ). A Kruskal-Wallis test on the drive variable revealed a lack of significant differences in activity between satiated and deprived groups. This last finding is not in line with results obtained in activity drums, where deprived rats are found to be more active than satiated ones, especially under conditions of increased environmental stimulation (18).



## Data on Time Spent in Unit 2

As will be recalled, the first compartment of each apparatus was marked off into two equal units. During the ninety-second delay period of each trial, the amount of time spent by S in that unit nearest the guillotine door (designated Unit 2), was recorded. Inspection of the medians and sums of ranks in Table XIV indicated that, with the notable exception of  $S_2$ , the amount of time spent in Unit 2 tended to increase from  $S_1$  to  $D_3$ . A  $X_H^2$  on this data resulted in a P of .079 which approaches statistical significance. Another  $X_H^2$ , performed on Ss separated by conditions, yielded a P of .077 which suggested that the cue change variable, independent of drive, had a significant effect on the amount of time spent near the door. The median amount of time was 849.5 seconds for Condition 1, 814.5 seconds for Condition 2, and 944.0 seconds for Condition 3. Kruskal-Wallis tests revealed no significant difference between  $C_1$  and  $C_2$  ( $P < .50$ ), a moderate difference between  $C_1$  and  $C_3$  ( $P = .146$ ), and a statistically acceptable difference between  $C_2$  and  $C_3$  ( $P = .04$ ).

Table XIV also suggested that deprived Ss spent more time in Unit 2 than satiated ones. A Kruskal-Wallis test on the drive variable, independent of cue change, confirmed this observation ( $P = .05$ ), with satiated groups having a median-time of 819 seconds and deprived groups a median-time of 905 seconds.

A parametric analysis of variance run on the time-in-Unit 2 data (see Table XXVII in Appendix B) yielded essentially the same results as the  $X_H^2$  tests. Both drive and cue change variables were significant



at the .06 level or better and the interaction of Drive x Condition was statistically non-significant.

These results might be interpreted to mean that deprived Ss and those satiated Ss exposed to large cue change learned to stay nearer the guillotine door than did other Ss. This hypothesis was supported by a comparison of the time scores for groups  $S_1$  and  $D_3$  before and after interchange of drive and condition. This comparison is presented in Table XV. The table presents the total amount of time spent in Unit 2 for trials 1-18 and 19-30. It can be seen that, for the eighteen test trials, the median difference between groups was 135 seconds in favor of  $D_3$ . On the twelve trials following interchange of drive and condition the median difference was 169 seconds in favor of  $S_1$ .

Since those Ss spending more time in Unit 2 would tend to be closer to the guillotine door when it opened, one might predict a direct relationship between time-in-Unit 2 and running-speed. No such a relationship was found. Rank-order correlation by group ranged from -.80 to .90. The possibility that avoidance responding might account for this lack of a relationship was ruled out by a rank-order correlation using only non-avoiding Ss. A resulting  $r = .01$  revealed a complete absence of any co-variation between time-in-Unit 2 and running-speed.

TABLE XV

TOTAL AMOUNT OF TIME SPENT IN UNIT 2  
OF THE FIRST COMPARTMENT FOR GROUPS  
 $S_1$  AND  $D_3$  BEFORE AND AFTER  
INTERCHANGE OF CONDITION  
AND DRIVE

| Group | Trials |       |       |       |
|-------|--------|-------|-------|-------|
|       | $S_1$  | $D_3$ | $S_1$ | $D_3$ |
|       | 1-18   |       | 19-30 |       |
|       | 880    | 858   | 769   | 503   |
|       | 674    | 940   | 702   | 497   |
|       | 577    | 957   | 630   | 597   |
|       | 837    | 1040  | 672   | 697   |
|       | 805    | 865   | 565   | 393   |
| Mdn.  | 805    | 940   | 672   | 503   |

## CHAPTER IV

### DISCUSSION

The results of this experiment would appear to support the contiguity stand on reinforcement as opposed to the drive reduction position. There were no primary drive reducers such as food or water in the apparatuses during the preliminary, test, or post-test trials, in spite of which all six groups of Ss showed signs of acquisition (increased running-speed over trials). Reduction in "fear" of the first compartments could not have served as "secondary" reinforcement for leaving it since the Ss (especially in Conditions 2 and 3) tended to evidence greater "fearfulness" (in terms of defecation and avoidance responses) of the second compartment. It is difficult to conceive of being returned to the home cage as a source of either primary or secondary reinforcement. A full sixty seconds elapsed between running into the second compartment and being removed to the home cage. Further, the deprived Ss were not fed for at least thirty minutes after they had been returned to the cage. The research of Perin (46) and others (58) demonstrated (for the albino rat) that the strength of a response does not increase if reinforcement is delayed more than twenty seconds.

It might be argued a la Hullian tradition that the Ss learned to run more and more rapidly into the second compartment because they obtained reduction in a primary exploratory, or curiosity, drive for doing so. This argument has already been discussed in Chapter I. The second compartment, in Conditions 2 and 3 at least, confronted the Ss

with increased stimulation and, by Miller's definition (see p. 4), this is equivalent to increasing drive rather than the opposite. Furthermore, research on exploration per se (3, 7) indicates that tendencies to explore novel objects suffer a permanent decrement after the first experience with the objects. In the present experiment, all groups of Ss revealed a significant increment, over trials, in speed-of-running into the second compartment. By the eighteenth trial most of the deprived Ss had reached an asymptote and, while many of the satiated Ss remained variable in performance, there was no trend toward a permanent decrement in running-speed.

Contiguity theory views the cue change, from one compartment to the other, as the essential factor in reinforcement. The learning process in the present experiment, according to this theory, can be described thus: When the guillotine door, separating the two compartments, is raised, the S is confronted with new stimuli (second compartment) which elicit various kinds of responses. Among these responses is that of movement toward the new stimulation. After the S has entered the second compartment, the guillotine door is lowered, preventing retracing. Movement into the second compartment, thus, becomes the postreme response to the pattern of cues presented by the raised door and the visual stimulation beyond. As more and more sub-sets of this complex cue pattern become associated with forward movement response strength increases. Reinforcement consists simply in preserving the postreme response by lowering the guillotine door after S has entered the second compartment, and by making the second compartment discriminably

different from the first. If the second compartment is not discriminably different, the postreme response will tend to become that response emitted just before S was removed from the compartment to the home cage. This is often a response which is incompatible with forward locomotion (sitting, crouching, rearing, etc.). Thus, if the second compartment is highly similar to the first (minimal cue change), learning to run into the second compartment will tend to be retarded. It was shown in Chapter III that minimal change groups (Condition 1) ran significantly slower than moderate or large change groups (Conditions 2 and 3), especially when non-avoiding Ss were discarded from the analysis.

In this experiment, as well as in the pilot experiment discussed in Chapter II, avoidance, in addition to approach, responses were elicited by the novel stimuli of the second compartment. It was found that total avoidance responding was greater among satiated Ss than among deprived Ss, and that such responding tended to be associated with "fearfulness" (for lack of a better term). That no difference in amount of avoidance between satiated and deprived groups existed at the outset of testing (trials 1-3) is evident from the fact that the two groups did not differ with respect to running-speed. By the end of testing, however, the deprived Ss were running significantly faster than the satiated ones. That this result was not due to any difference in activity level among the two groups was seen in the analysis of the reversal-in-direction data.

It is suggested that continued deprivation may, in some way,

directly reduce the occurrence of responses which compete with forward locomotion. Such an hypothesis is supported by the research of Cotton (10) who studied the simple running response of rats in a straight alley. He used four groups of Ss, under different schedules of deprivation (0, 6, 16, and 22 hours), who ran to food reward. Cotton found that the major effect of increased deprivation was to reduce the number of competing responses rather than to increase the speed of forward locomotion per se.

It should be remembered, however, that the satiated Ss in our experiment evidenced large intra-group variability, with approximately half of the animals emitting few if any, avoidance responses during the course of testing. The only difference between the satiated and deprived groups was that the avoiders in the latter group stopped avoiding as testing progressed whereas those in the former did not. At the end of training, and with conditions held constant, non-avoiding satiated Ss were running as fast as the comparable deprived Ss.

Since the deprived groups spent significantly more time in Unit 2 than the satiated groups (and thus would tend to be closer to the guillotine door when it was raised) it might have been expected that the deprived Ss would be superior in running-speed. However, time-in-Unit 2 also varied with the cue change condition and the two factors had differential, although independent, effects on the groups. Drive tended to separate groups in Conditions 1 and 2 but not in 3; cue change effected performance in Condition 3 much more than in Conditions 1 and 2. Furthermore, there did not appear to be any definite relation-

ship between running-speed and amount of time spent near the door. The two habits seemed to be independent of each other. A possibility that avoidance responding accounted for the lack of co-variance was ruled out by a test of correlation on non-avoiders. The only other possibility is that the individual Ss differed, on a genetic basis, with respect to optimal speed of forward locomotion.

Why some Ss should show more avoidance of novel situations than others, and why satiated Ss tended to retain their avoidance responses longer than deprived Ss, remain experimental questions. We have already reviewed the work of Montgomery (36, 37) who posits that the "exploratory drive" evokes approach responses whereas "fear" evokes avoidance. If amount of defecation is an index of fear, then the present research lends support to at least the latter part of Montgomery's formulation. Following this line of theorizing it could be hypothesized that hunger has a suppressing effect on fear and, thus, on the consequent avoidance responses. This suppression would allow approach behavior to predominate and to be reinforced. Hence the superiority in learning of the initially avoiding, deprived Ss over the comparable satiated Ss. The basic difficulty with Montgomery's formulation is that there are no adequate measures of the strength of the so-called exploratory drive. Without such measures prediction of what an organism will do in novel situations is made impossible.

A more adequate solution to the problem would seem to be an experimental investigation of the effects of early experience on later behavior in novel situations. Recently, work in this area has been given

impetus by D. O. Hebb (20, 21). Hebb has postulated that sensory events may attract or repel an organism, depending upon the amount of excitation these events arouse in the "nonspecific or diffuse projection system of the brain stem." This arousal is identified with a "general drive state." Hebb further conjectures that there is an optimal level of arousal which the organism seeks to maintain. If a stimulus event induces excitation below the optimal level the organism will increase contact with it; if the optimal level is exceeded, however, the organism will retreat, thereby lowering the amount of excitation. Thus, the same stimulation in mild degree may result in approach and in strong degree produce avoidance.

The major contribution of Hebb is not necessarily his neurophysiological concepts, but rather the fact that he emphasized, and provided a rationale for, a genetic perspective to the problems of learning. He suggests that approach and avoidance tendencies (or the level of optimal arousal) for the individual adult organism may be closely related to the kind and, especially, to the intensity of stimulation received in infancy. Infants reared in an environment that offered little sensory stimulation, for instance, might develop a low optimal level of arousal and thus avoid many novel situations in adulthood. In support of this hypothesis Luchins and Forgas (30) found that rats reared in a large, diversified environment were more active in a novel situation than rats reared under conditions of sensory deprivation. Young (64) found indications to suggest that rats exposed to various kinds of intense stimulation arousing avoidance responses tend, later,

to generalize their avoidant behavior to any novel situation. However, research in the area of early experience is still scanty and often contradictory, so that no definite conclusions can be drawn at the present time (2).

The fact that avoidance behavior seems to be much more difficult to eliminate in satiated than in deprived Ss may have some bearing on the Skinner box studies of Forgays and Levin (13), and of Davis (see pp. 20-22). These studies found that deprived Ss gave more bar presses to light-onset reinforcement than did satiated Ss. It is possible that the illumination changes aroused some avoidance, as well as approach, to the bar, but that food-deprivation reduced the avoidant tendencies in the one group. This would automatically result in greater bar pressing for the deprived animals. Unfortunately, the studies did not include any statements regarding the animals' behavior in the Skinner box so that the avoidance hypothesis must remain speculative.

In returning to the present experiment, it was found that the results on differences in running-speed, due to amount of cue change (condition) following the response-to-be reinforced, were less clear-cut than the results on the drive variable. The conditions, up to the end of the testing phase, had no differential effect on the running-speed of the satiated Ss as a whole. This was true both with regard to amount of improvement in running-speed and with level of performance attained at the end of testing (trial 18). However, additional training trials given to the moderate-change and large-change groups (S<sub>2</sub> and S<sub>3</sub>) indicated a tendency for the latter to show more improvement in

running-speed than the former. This result is in line with our prediction although the number of Ss in the groups was too small to produce adequate statistical significance.

Within the deprived groups there was a significant trend for large cue change Ss to show more improvement in running-speed than moderate or minimal change Ss. The same trend was found in level of running-speed attained at the end of testing although the results were not statistically significant. Again, it was only when avoidant Ss were discarded from the analysis, that significant differences emerged with regard to asymptotic running-speed. Here, moderate-change and large-change groups ran significantly faster than the minimal-change group. This is in line with our prediction that minimal-change between compartments would tend to interfere with the reinforcement of forward locomotion.

The prediction regarding interchange of drive and condition was clearly borne out. When deprived Ss in the maximal-change condition were placed on an ad lib. feeding schedule and switched to the minimal-change condition, extinction-like effects occurred in running-speed, i.e., running-speed decreased over trials. When satiated Ss were placed on a 23-hour deprivation schedule and switched to the maximal-change condition, running-speed increased. As stated in Chapter III, it was not possible to separate the effects of drive and cue change in producing these results since both were varied simultaneously. To achieve such a separation it would be necessary to divide each group in half, and run one of each sub-group deprived and the other satiated.

Aside from the problem of avoidance behavior, it is probable that the learning task in this experiment was too simple to provide an adequate test of the effect of cue changes on running-speed. The Ss had to traverse a ~~maximum~~ distance of only 25 inches to go from one compartment to the other. Such a short distance might not have permitted greater running-speed differences among conditions to emerge. A better test would be to lengthen the first compartment by several feet and to do away with the 90-second delay interval. This would make the learning problem more difficult because more opportunities for responses competing with forward locomotion would be present.

There are other directions which research in this area might take. The present experiment investigated the effect of cue change on running-speed by increasing the amount of cues (and the amount of space) in the second compartment over that in the first. This procedure might be reversed in order to determine whether the direction of change is an important factor in this learning situation. Also worthy of investigation is the kind and intensity of cues used for experimental treatment. It is possible that spatial cues have different effects on the organism than visual or auditory cues. In the present experiment increased space and increased visual stimulation were confounded.

## CHAPTER V

### SUMMARY

This study was concerned with the effect of hunger drive and cue change upon the running response of the albino rat. This response was strengthened according to Guthrie's principle of reinforcement in the absence of any primary need reducers. The learning situation was a simple one, involving two compartments separated by a guillotine door. The measure of learning was the time (running-speed) taken by Ss to approach and enter into the second compartment after the door had been raised. Three apparatuses were constructed which differed from each other in the amount of cue change existing between the first and second compartments. In one condition there was a minimal amount of change, in the second condition a moderate amount of change, and in the third condition a large change, between compartments. It was predicted, on the basis of the contiguity principle, that the degree of learning would be directly related to the amount of cue change existing between compartments. Specifically, the prediction was that the large-change group would be superior to the moderate-change group and the latter, in turn, would be superior to minimal-change Ss.

Pilot studies with satiated Ss indicated a high operant level of avoidance, as well as approach, responding to conditions of moderate and large cue change. In the final experiment, half of the Ss in each condition were run on a 23-hour food deprivation schedule and half were run on an ad lib. schedule with the prediction that food deprivation

would reduce the amount of avoidance responding.

On each trial the Ss were detained in the first compartment of the apparatuses for ninety seconds. During this interval, the amount of gross bodily activity and the amount of time spent in the region of the guillotine door were recorded for each S.

The major findings are as follows: 1) All groups of Ss showed signs of acquisition although satiated groups were significantly more variable in performance than deprived groups. 2) Within the satiated groups no differences in running-speed emerged as a result of the cue change variable. This seemed to stem from the fact that avoidance responses tended not to extinguish during testing. 3) Within the deprived groups, the predicted relationship between degree of learning and amount of cue change emerged although the trend was not highly significant statistically. 4) When avoiding Ss were discarded from the analysis and non-avoiding satiated and deprived Ss were combined by condition, the predicted relationship between degree of learning and amount of cue change was obtained to a statistically significant degree. 5) Satiated groups contained more avoiders and a higher level of avoidance than deprived groups. Further, there was a definite relationship between amount of avoidance and amount of defecation. 6) There were no differences among groups with regard to total amount of gross bodily activity evidenced during the delay periods. 7) Deprived Ss and Ss in the large cue change condition spent more time near the guillotine door during the delay period, than did other Ss. 8) There was no definite relationship between time spent near the guillotine door and running-speed. 9) After the

asymptote of learning had been reached, satiated Ss in the minimal-change condition and deprived Ss in the large-change condition were interchanged. In line with contiguity theory, the former group showed further acquisition while the latter group underwent extinction-like effects.

Methods were suggested whereby this experiment might be elaborated and areas for future research were delineated.

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**▲PPENDIX ▲**



TABLE XVI

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RUNNING-SPEED SCORES IN SECONDS FOR ALL SS,  
BY GROUP, IN FIVE PRELIMINARY TRIALS

| Group          | Subject<br>Number | 1    | 2    | Trials<br>3 | 4    | 5    |
|----------------|-------------------|------|------|-------------|------|------|
| S <sub>1</sub> | 1                 | 17   | 17   | 20          | 17   | 80   |
|                | 2                 | 2    | 11   | 5           | 7    | 6    |
|                | 3                 | 24   | 70   | 28          | 51   | 14   |
|                | 4                 | 120  | 120  | 120         | 6    | 10   |
|                | 5                 | 4    | 35   | 4           | 7    | 7    |
| D <sub>1</sub> | 6                 | 4    | 4    | 10          | 8    | 15   |
|                | 7                 | 35   | 7    | 7           | 14   | 19   |
|                | 8                 | 6    | 15   | 8           | 6    | 5    |
|                | 9                 | 15   | 8    | 16          | 5    | 11   |
|                | 10                | 85   | 21   | 11          | 21   | 8    |
| S <sub>2</sub> | 11                | 9    | 111  | 6           | 9    | 13   |
|                | 12                | 40   | 52   | 12          | 6    | 7    |
|                | 13                | 7    | 11   | 11          | 22   | 7    |
|                | 14                | 22   | 34   | 29          | 16   | 11   |
|                | 15                | 32   | 120  | 120         | 120  | 120  |
| D <sub>2</sub> | 16                | 9    | 22   | 7           | 16   | 22   |
|                | 17                | 8    | 44   | 12          | 9    | 7    |
|                | 18                | 101  | 35   | 36          | 41   | 14   |
|                | 19                | 14   | 13   | 26          | 23   | 14   |
|                | 20                | 63   | 14   | 15          | 8    | 8    |
| S <sub>3</sub> | 21                | 10   | 41   | 18          | 46   | 38   |
|                | 22                | 6    | 22   | 21          | 8    | 9    |
|                | 23                | 86   | 120  | 120         | 14   | 65   |
|                | 24                | 8    | 16   | 32          | 36   | 17   |
|                | 25                | 47   | 17   | 14          | 7    | 6    |
| D <sub>3</sub> | 26                | 11   | 19   | 6           | 5    | 9    |
|                | 27                | 6    | 9    | 9           | 7    | 7    |
|                | 28                | 62   | 12   | 20          | 13   | 6    |
|                | 29                | 120  | 60   | 79          | 17   | 36   |
|                | 30                | 17   | 11   | 13          | 9    | 13   |
| Total          |                   | 990  | 1091 | 835         | 574  | 604  |
| $\bar{X}$      |                   | 33.0 | 36.4 | 27.8        | 19.1 | 20.1 |

TABLE XVII

RUNNING-SPEED IN SECONDS FOR SATIATED SS.  
TRIALS ONE THROUGH EIGHTEEN

| Trial | Subject<br>Number | Condition |     |     |     |    |    |     |    |    |     |    |     |     |    |    |
|-------|-------------------|-----------|-----|-----|-----|----|----|-----|----|----|-----|----|-----|-----|----|----|
|       |                   | 1         | 2   | 3   | 4   | 5  | 11 | 12  | 13 | 14 | 15  | 21 | 22  | 23  | 24 | 25 |
| 1     |                   | 12        | 23  | 34  | 41  | 3  | 29 | 58  | 10 | 7  | 120 | 42 | 13  | 120 | 13 | 7  |
| 2     |                   | 12        | 8   | 120 | 72  | 11 | 14 | 111 | 8  | 10 | 120 | 11 | 77  | 26  | 26 | 4  |
| 3     |                   | 10        | 12  | 120 | 21  | 21 | 32 | 113 | 6  | 5  | 120 | 12 | 75  | 110 | 13 | 4  |
| 4     |                   | 7         | 13  | 61  | 15  | 10 | 15 | 67  | 13 | 3  | 120 | 20 | 77  | 87  | 60 | 3  |
| 5     |                   | 22        | 22  | 92  | 44  | 6  | 14 | 83  | 7  | 4  | 120 | 8  | 120 | 71  | 11 | 4  |
| 6     |                   | 6         | 47  | 15  | 28  | 8  | 12 | 120 | 8  | 4  | 120 | 24 | 120 | 28  | 7  | 3  |
| 7     |                   | 8         | 36  | 19  | 12  | 8  | 7  | 120 | 5  | 3  | 120 | 26 | 120 | 60  | 8  | 2  |
| 8     |                   | 9         | 42  | 65  | 50  | 8  | 6  | 120 | 3  | 5  | 97  | 26 | 74  | 99  | 10 | 4  |
| 9     |                   | 22        | 76  | 12  | 8   | 6  | 14 | 102 | 3  | 3  | 83  | 64 | 93  | 104 | 11 | 2  |
| 10    |                   | 5         | 120 | 12  | 23  | 5  | 8  | 120 | 2  | 4  | 120 | 18 | 99  | 120 | 8  | 1  |
| 11    |                   | 9         | 120 | 12  | 12  | 18 | 10 | 12  | 2  | 5  | 120 | 13 | 120 | 44  | 8  | 1  |
| 12    |                   | 6         | 6   | 26  | 18  | 4  | 8  | 120 | 2  | 4  | 120 | 11 | 76  | 54  | 7  | 1  |
| 13    |                   | 7         | 70  | 16  | 12  | 4  | 6  | 94  | 2  | 7  | 120 | 8  | 65  | 11  | 5  | 2  |
| 14    |                   | 8         | 8   | 10  | 4   | 4  | 5  | 120 | 4  | 3  | 120 | 16 | 85  | 15  | 3  | 1  |
| 15    |                   | 6         | 12  | 9   | 120 | 3  | 6  | 120 | 2  | 2  | 120 | 7  | 120 | 39  | 3  | 1  |
| 16    |                   | 7         | 11  | 23  | 102 | 5  | 5  | 55  | 3  | 2  | 120 | 11 | 28  | 120 | 3  | 2  |
| 17    |                   | 7         | 6   | 27  | 120 | 4  | 6  | 120 | 2  | 3  | 120 | 22 | 28  | 120 | 5  | 2  |
| 18    |                   | 10        | 11  | 24  | 26  | 7  | 6  | 120 | 2  | 2  | 110 | 3  | 107 | 70  | 3  | 5  |

TABLE XVIII

RUNNING SPEED IN SECONDS FOR DEPRIVED SS.  
 TRIALS ONE THROUGH EIGHTEEN

|       |                | Condition |    |    |    |    |    |     |     |    |    |     |     |     |     |    |
|-------|----------------|-----------|----|----|----|----|----|-----|-----|----|----|-----|-----|-----|-----|----|
|       |                | 1         |    |    |    |    | 2  |     |     |    |    | 3   |     |     |     |    |
| Trial | Subject Number | 6         | 7  | 8  | 9  | 10 | 16 | 17  | 18  | 19 | 20 | 26  | 27  | 28  | 29  | 30 |
| 1     |                | 8         | 16 | 3  | 15 | 19 | 22 | 29  | 52  | 19 | 13 | 12  | 16  | 19  | 120 | 34 |
| 2     |                | 17        | 6  | 15 | 26 | 6  | 29 | 120 | 93  | 7  | 7  | 8   | 16  | 120 | 120 | 15 |
| 3     |                | 5         | 16 | 24 | 5  | 9  | 62 | 120 | 106 | 8  | 4  | 43  | 16  | 89  | 66  | 14 |
| 4     |                | 29        | 8  | 6  | 27 | 6  | 46 | 112 | 11  | 5  | 4  | 7   | 4   | 13  | 86  | 6  |
| 5     |                | 13        | 6  | 4  | 7  | 5  | 44 | 46  | 16  | 4  | 3  | 11  | 3   | 6   | 36  | 9  |
| 6     |                | 13        | 5  | 14 | 6  | 3  | 23 | 102 | 14  | 4  | 3  | 4   | 12  | 7   | 105 | 6  |
| 7     |                | 18        | 5  | 3  | 18 | 14 | 13 | 76  | 5   | 8  | 3  | 6   | 3   | 11  | 25  | 6  |
| 8     |                | 4         | 8  | 4  | 3  | 6  | 11 | 90  | 3   | 3  | 3  | 7   | 2   | 9   | 72  | 5  |
| 9     |                | 14        | 6  | 12 | 4  | 4  | 10 | 16  | 7   | 2  | 2  | 2   | 2   | 7   | 18  | 5  |
| 10    |                | 13        | 5  | 7  | 5  | 2  | 3  | 44  | 7   | 3  | 3  | 2   | 1.5 | 3   | 12  | 4  |
| 11    |                | 6         | 6  | 6  | 7  | 3  | 7  | 59  | 8   | 2  | 2  | 2   | 2   | 3   | 15  | 6  |
| 12    |                | 31        | 11 | 12 | 4  | 3  | 6  | 64  | 3   | 2  | 2  | 3   | 2   | 2   | 10  | 7  |
| 13    |                | 3         | 4  | 12 | 8  | 16 | 5  | 76  | 5   | 2  | 3  | 2   | 3   | 3   | 11  | 5  |
| 14    |                | 12        | 4  | 7  | 2  | 2  | 9  | 36  | 2   | 2  | 2  | 2   | 3   | 4   | 7   | 4  |
| 15    |                | 10        | 5  | 9  | 2  | 13 | 6  | 17  | 7   | 2  | 1  | 4   | 2   | 2   | 5   | 3  |
| 16    |                | 9         | 5  | 4  | 2  | 2  | 14 | 41  | 14  | 2  | 2  | 2   | 3   | 2   | 4   | 5  |
| 17    |                | 8         | 5  | 6  | 3  | 4  | 3  | 67  | 3   | 2  | 1  | 1.5 | 2   | 4   | 3   | 3  |
| 18    |                | 8         | 6  | 9  | 8  | 3  | 5  | 9   | 4   | 1  | 1  | 1.5 | 3   | 4   | 3   | 8  |

TABLE XIX

RUNNING-SPEED IN SECONDS FOR GROUPS  
 $S_2$  AND  $S_3$ . TRIALS NINETEEN  
 THROUGH THIRTY

| Trial | Subject<br>Number | Group |     |    |    |     |       |     |     |     |    |
|-------|-------------------|-------|-----|----|----|-----|-------|-----|-----|-----|----|
|       |                   | $S_2$ |     |    |    |     | $S_3$ |     |     |     |    |
|       |                   | 11    | 12  | 13 | 14 | 15  | 21    | 22  | 23  | 24  | 25 |
| 19    |                   | 9     | 120 | 2  | 2  | 81  | 6     | 62  | 12  | 5   | 1  |
| 20    |                   | 7     | 120 | 2  | 2  | 120 | 5     | 119 | 38  | 2   | 1  |
| 21    |                   | 9     | 52  | 2  | 1  | 120 | 9     | 66  | 39  | 5   | 2  |
| 22    |                   | 7     | 120 | 1  | 2  | 109 | 5     | 93  | 35  | 2   | 1  |
| 23    |                   | 8     | 32  | 2  | 2  | 120 | 2     | 23  | 12  | 1   | 1  |
| 24    |                   | 3     | 120 | 1  | 1  | 120 | 4     | 26  | 14  | 1   | 1  |
| 25    |                   | 3.5   | 120 | 1  | 2  | 81  | 10    | 18  | 11  | 1.5 | 1  |
| 26    |                   | 9     | 120 | 2  | 3  | 96  | 2     | 54  | 120 | 2   | 1  |
| 27    |                   | 10    | 5   | 4  | 2  | 37  | 17    | 90  | 47  | 2   | 1  |
| 28    |                   | 14    | 120 | 2  | 3  | 120 | 11    | 22  | 60  | 1   | 1  |
| 29    |                   | 22    | 120 | 1  | 2  | 120 | 5     | 43  | 18  | 1   | 1  |
| 30    |                   | 6     | 5   | 2  | 4  | 81  | 3     | 19  | 15  | 1   | 1  |

TABLE XX

RUNNING-SPEED IN SECONDS FOR GROUPS  
 $S_1$  AND  $D_3$ . TRIALS NINETEEN  
 THROUGH THIRTY

| Trial | Subject<br>Number | 1   | 2   | 3  | 4  | 5 | 26  | 27  | 28 | 29 | 30  |
|-------|-------------------|-----|-----|----|----|---|-----|-----|----|----|-----|
| 19    |                   | 23  | 27  | 87 | 38 | 8 | 3   | 2   | 7  | 31 | 8   |
| 20    |                   | 11  | 6   | 28 | 7  | 3 | 1.5 | 3.5 | 4  | 36 | 18  |
| 21    |                   | 16  | 7   | 13 | 6  | 4 | 1   | 1   | 4  | 11 | 12  |
| 22    |                   | 7   | 6   | 12 | 7  | 2 | 3   | 2   | 3  | 38 | 7   |
| 23    |                   | 7   | 3   | 17 | 10 | 4 | 2   | 7   | 7  | 9  | 12  |
| 24    |                   | 3   | 2.5 | 86 | 6  | 2 | 6   | 11  | 7  | 46 | 17  |
| 25    |                   | 3   | 5   | 34 | 7  | 1 | 2   | 22  | 30 | 15 | 11  |
| 26    |                   | 2.5 | 3.5 | 86 | 7  | 1 | 3   | 18  | 6  | 15 | 5   |
| 27    |                   | 4   | 3   | 19 | 4  | 2 | 3   | 8   | 11 | 34 | 13  |
| 28    |                   | 4   | 3   | 10 | 5  | 2 | 2   | 7   | 11 | 7  | 120 |
| 29    |                   | 3   | 3   | 9  | 10 | 2 | 5   | 6   | 27 | 8  | 16  |
| 30    |                   | 3   | 3   | 8  | 4  | 2 | 5   | 7   | 14 | 32 | 24  |

TABLE XXI

TOTAL NUMBER OF REVERSALS FOR SATIATED SS.  
TRIALS ONE THROUGH EIGHTEEN

|       |                | Condition |     |     |     |     |     |     |     |     |    |     |     |     |     |     |
|-------|----------------|-----------|-----|-----|-----|-----|-----|-----|-----|-----|----|-----|-----|-----|-----|-----|
|       |                | 1         |     |     |     |     | 2   |     |     |     |    | 3   |     |     |     |     |
| Trial | Subject Number | 1         | 2   | 3   | 4   | 5   | 11  | 12  | 13  | 14  | 15 | 21  | 22  | 23  | 24  | 25  |
| 1     |                | 12        | 10  | 10  | 14  | 10  | 29  | 14  | 8   | 10  | 6  | 12  | 12  | 10  | 12  | 10  |
| 2     |                | 14        | 10  | 8   | 8   | 8   | 14  | 12  | 8   | 16  | 4  | 10  | 6   | 8   | 10  | 12  |
| 3     |                | 14        | 6   | 8   | 6   | 16  | 32  | 16  | 12  | 14  | 2  | 12  | 10  | 10  | 10  | 12  |
| 4     |                | 12        | 4   | 6   | 8   | 12  | 15  | 12  | 10  | 18  | 2  | 14  | 6   | 8   | 12  | 16  |
| 5     |                | 12        | 2   | 8   | 6   | 12  | 14  | 12  | 14  | 16  | 4  | 10  | 10  | 8   | 14  | 18  |
| 6     |                | 14        | 6   | 10  | 8   | 12  | 12  | 16  | 12  | 16  | 4  | 12  | 8   | 8   | 14  | 14  |
| 7     |                | 16        | 8   | 10  | 14  | 14  | 7   | 16  | 18  | 20  | 4  | 14  | 10  | 8   | 12  | 20  |
| 8     |                | 26        | 8   | 6   | 12  | 14  | 6   | 16  | 20  | 24  | 4  | 12  | 10  | 10  | 16  | 26  |
| 9     |                | 20        | 2   | 10  | 10  | 18  | 14  | 14  | 22  | 20  | 4  | 10  | 12  | 10  | 14  | 22  |
| 10    |                | 22        | 6   | 12  | 10  | 20  | 8   | 10  | 20  | 20  | 4  | 14  | 6   | 10  | 18  | 24  |
| 11    |                | 16        | 4   | 12  | 8   | 18  | 10  | 12  | 30  | 24  | 2  | 10  | 8   | 12  | 12  | 22  |
| 12    |                | 14        | 8   | 8   | 6   | 20  | 8   | 12  | 16  | 32  | 4  | 12  | 10  | 14  | 16  | 22  |
| 13    |                | 16        | 4   | 10  | 10  | 14  | 6   | 14  | 14  | 24  | 4  | 16  | 12  | 18  | 12  | 22  |
| 14    |                | 10        | 6   | 8   | 10  | 16  | 5   | 10  | 24  | 30  | 4  | 10  | 12  | 14  | 14  | 20  |
| 15    |                | 14        | 8   | 12  | 12  | 18  | 6   | 12  | 22  | 20  | 4  | 14  | 10  | 10  | 14  | 24  |
| 16    |                | 10        | 8   | 8   | 10  | 20  | 5   | 8   | 20  | 21  | 2  | 12  | 12  | 8   | 16  | 24  |
| 17    |                | 12        | 6   | 16  | 14  | 18  | 6   | 12  | 22  | 20  | 4  | 14  | 12  | 12  | 10  | 20  |
| 18    |                | 16        | 10  | 12  | 10  | 16  | 6   | 12  | 16  | 26  | 2  | 10  | 14  | 10  | 12  | 20  |
| Total |                | 270       | 116 | 174 | 176 | 276 | 272 | 230 | 308 | 371 | 64 | 218 | 180 | 188 | 238 | 348 |

TABLE XXII

TOTAL NUMBER OF REVERSALS FOR DEPRIVED SS.  
TRIALS ONE THROUGH EIGHTEEN

| Trial | Subject<br>Number | Condition |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
|-------|-------------------|-----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
|       |                   | 1         |     |     |     |     | 2   |     |     |     |     | 3   |     |     |     |     |
|       |                   | 6         | 7   | 8   | 9   | 10  | 16  | 17  | 18  | 19  | 20  | 26  | 27  | 28  | 29  | 30  |
| 1     |                   | 8         | 14  | 10  | 8   | 10  | 14  | 14  | 6   | 10  | 10  | 14  | 10  | 10  | 10  | 12  |
| 2     |                   | 8         | 6   | 6   | 8   | 8   | 10  | 10  | 10  | 10  | 10  | 10  | 10  | 8   | 8   | 10  |
| 3     |                   | 8         | 14  | 8   | 12  | 12  | 12  | 8   | 10  | 12  | 10  | 8   | 10  | 10  | 6   | 10  |
| 4     |                   | 6         | 12  | 8   | 12  | 8   | 10  | 8   | 8   | 16  | 16  | 8   | 18  | 12  | 10  | 12  |
| 5     |                   | 4         | 18  | 10  | 10  | 16  | 10  | 8   | 6   | 16  | 20  | 16  | 14  | 12  | 10  | 10  |
| 6     |                   | 2         | 14  | 8   | 10  | 12  | 10  | 10  | 8   | 22  | 14  | 12  | 10  | 16  | 10  | 10  |
| 7     |                   | 2         | 12  | 8   | 10  | 12  | 14  | 10  | 8   | 16  | 14  | 12  | 10  | 12  | 10  | 14  |
| 8     |                   | 4         | 4   | 16  | 12  | 18  | 10  | 8   | 6   | 18  | 14  | 14  | 10  | 8   | 8   | 14  |
| 9     |                   | 8         | 18  | 18  | 10  | 16  | 16  | 10  | 10  | 22  | 12  | 18  | 12  | 12  | 6   | 12  |
| 10    |                   | 2         | 14  | 14  | 8   | 14  | 10  | 8   | 8   | 18  | 10  | 18  | 16  | 12  | 6   | 12  |
| 11    |                   | 6         | 16  | 14  | 14  | 14  | 16  | 10  | 10  | 18  | 14  | 16  | 10  | 14  | 10  | 12  |
| 12    |                   | 2         | 4   | 14  | 10  | 8   | 14  | 10  | 8   | 14  | 16  | 18  | 8   | 16  | 8   | 12  |
| 13    |                   | 8         | 6   | 12  | 8   | 8   | 18  | 10  | 12  | 18  | 14  | 22  | 14  | 16  | 8   | 10  |
| 14    |                   | 4         | 14  | 14  | 12  | 14  | 14  | 10  | 12  | 16  | 18  | 14  | 12  | 10  | 10  | 18  |
| 15    |                   | 4         | 12  | 14  | 10  | 8   | 18  | 12  | 12  | 20  | 12  | 18  | 14  | 14  | 8   | 14  |
| 16    |                   | 6         | 10  | 12  | 14  | 16  | 14  | 14  | 12  | 20  | 14  | 18  | 10  | 10  | 8   | 12  |
| 17    |                   | 4         | 8   | 12  | 10  | 14  | 18  | 8   | 10  | 14  | 16  | 20  | 10  | 10  | 8   | 14  |
| 18    |                   | 4         | 6   | 10  | 10  | 16  | 12  | 12  | 10  | 16  | 16  | 20  | 8   | 10  | 12  | 10  |
| Total |                   | 90        | 202 | 208 | 188 | 224 | 240 | 180 | 166 | 296 | 250 | 276 | 206 | 212 | 156 | 218 |

TABLE XXIII

AMOUNT OF TIME, DURING A 90-SECOND DELAY PERIOD, SPENT  
IN UNIT 2 BY SATIATED SS. TRIALS  
ONE THROUGH EIGHTEEN

| Trials | Subject<br>Number | Condition |     |     |     |     |     |     |     |     |     |     |      |     |     |     |
|--------|-------------------|-----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|-----|-----|-----|
|        |                   | 1         |     |     |     |     | 2   |     |     |     |     | 3   |      |     |     |     |
|        |                   | 1         | 2   | 3   | 4   | 5   | 11  | 12  | 13  | 14  | 15  | 21  | 22   | 23  | 24  | 25  |
| 1      |                   | 44        | 62  | 37  | 31  | 46  | 47  | 21  | 47  | 42  | 28  | 28  | 42   | 42  | 44  | 58  |
| 2      |                   | 47        | 31  | 26  | 47  | 43  | 52  | 13  | 57  | 54  | 22  | 47  | 44   | 31  | 59  | 57  |
| 3      |                   | 32        | 28  | 25  | 24  | 50  | 39  | 15  | 67  | 43  | 73  | 53  | 69   | 38  | 42  | 57  |
| 4      |                   | 49        | 89  | 51  | 22  | 37  | 56  | 34  | 49  | 37  | 3   | 47  | 54   | 87  | 56  | 48  |
| 5      |                   | 49        | 6   | 69  | 18  | 56  | 39  | 34  | 45  | 54  | 5   | 33  | 55   | 45  | 37  | 60  |
| 6      |                   | 51        | 48  | 61  | 31  | 63  | 45  | 33  | 52  | 44  | 3   | 59  | 58   | 50  | 49  | 52  |
| 7      |                   | 28        | 27  | 43  | 36  | 53  | 45  | 41  | 62  | 40  | 15  | 26  | 28   | 54  | 44  | 45  |
| 8      |                   | 43        | 53  | 41  | 34  | 49  | 33  | 44  | 39  | 34  | 11  | 65  | 76   | 68  | 44  | 31  |
| 9      |                   | 43        | 14  | 48  | 26  | 32  | 38  | 48  | 47  | 52  | 45  | 54  | 67   | 48  | 45  | 32  |
| 10     |                   | 50        | 8   | 62  | 30  | 55  | 41  | 41  | 46  | 43  | 11  | 59  | 58   | 50  | 43  | 38  |
| 11     |                   | 47        | 40  | 48  | 42  | 41  | 39  | 49  | 36  | 39  | 4   | 58  | 80   | 44  | 45  | 34  |
| 12     |                   | 76        | 16  | 54  | 25  | 45  | 29  | 45  | 35  | 49  | 16  | 66  | 68   | 39  | 41  | 45  |
| 13     |                   | 49        | 49  | 47  | 34  | 40  | 42  | 46  | 56  | 42  | 14  | 50  | 73   | 43  | 44  | 41  |
| 14     |                   | 52        | 46  | 45  | 28  | 51  | 63  | 56  | 32  | 49  | 21  | 69  | 40   | 56  | 50  | 33  |
| 15     |                   | 52        | 46  | 47  | 39  | 23  | 45  | 55  | 44  | 53  | 34  | 76  | 66   | 63  | 49  | 37  |
| 16     |                   | 57        | 13  | 45  | 30  | 43  | 63  | 59  | 59  | 44  | 11  | 60  | 71   | 49  | 43  | 55  |
| 17     |                   | 57        | 58  | 32  | 34  | 35  | 55  | 44  | 31  | 49  | 20  | 59  | 63   | 70  | 50  | 38  |
| 18     |                   | 54        | 40  | 56  | 46  | 43  | 48  | 57  | 69  | 41  | 9   | 68  | 62   | 71  | 42  | 47  |
| Total  |                   | 880       | 674 | 837 | 577 | 805 | 819 | 735 | 873 | 809 | 345 | 975 | 1074 | 948 | 827 | 808 |

TABLE XXIV

AMOUNT OF TIME, DURING A 90-SECOND DELAY PERIOD,  
SPENT IN UNIT 2 BY DEPRIVED SS. TRIALS  
ONE THROUGH EIGHTEEN

| Trial | Subject<br>Number | 6    | 7   | 8   | 9   | 10  | 16  | 17  | 18  | 19  | 20  | 26  | 27  | 28  | 29   | 30  |
|-------|-------------------|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|-----|
| 1     |                   | 47   | 31  | 34  | 50  | 49  | 29  | 19  | 17  | 43  | 47  | 39  | 41  | 32  | 25   | 41  |
| 2     |                   | 62   | 62  | 58  | 51  | 39  | 33  | 20  | 50  | 58  | 55  | 49  | 46  | 51  | 54   | 52  |
| 3     |                   | 49   | 52  | 55  | 47  | 64  | 37  | 28  | 49  | 57  | 54  | 58  | 54  | 59  | 31   | 36  |
| 4     |                   | 39   | 77  | 47  | 43  | 55  | 33  | 39  | 45  | 59  | 54  | 65  | 30  | 71  | 59   | 55  |
| 5     |                   | 53   | 36  | 50  | 53  | 36  | 56  | 52  | 53  | 42  | 33  | 52  | 46  | 68  | 51   | 64  |
| 6     |                   | 76   | 37  | 54  | 48  | 41  | 66  | 40  | 59  | 48  | 47  | 70  | 47  | 53  | 50   | 57  |
| 7     |                   | 82   | 43  | 54  | 41  | 44  | 59  | 50  | 51  | 53  | 54  | 64  | 46  | 49  | 63   | 49  |
| 8     |                   | 51   | 69  | 63  | 47  | 45  | 68  | 44  | 70  | 45  | 57  | 53  | 66  | 82  | 76   | 42  |
| 9     |                   | 57   | 34  | 72  | 48  | 26  | 51  | 58  | 60  | 50  | 51  | 33  | 65  | 56  | 49   | 53  |
| 10    |                   | 85   | 38  | 35  | 30  | 39  | 68  | 41  | 59  | 37  | 63  | 53  | 55  | 45  | 53   | 61  |
| 11    |                   | 68   | 49  | 31  | 42  | 31  | 79  | 57  | 39  | 45  | 41  | 52  | 35  | 39  | 77   | 40  |
| 12    |                   | 17   | 66  | 47  | 32  | 38  | 61  | 35  | 52  | 42  | 53  | 14  | 63  | 28  | 65   | 43  |
| 13    |                   | 61   | 58  | 53  | 48  | 57  | 60  | 54  | 50  | 46  | 55  | 38  | 43  | 33  | 52   | 39  |
| 14    |                   | 32   | 66  | 39  | 60  | 38  | 73  | 32  | 49  | 37  | 47  | 46  | 60  | 31  | 81   | 29  |
| 15    |                   | 81   | 67  | 43  | 64  | 24  | 35  | 46  | 56  | 47  | 41  | 39  | 56  | 56  | 70   | 47  |
| 16    |                   | 52   | 69  | 37  | 59  | 54  | 43  | 51  | 57  | 29  | 48  | 45  | 57  | 63  | 58   | 49  |
| 17    |                   | 61   | 64  | 56  | 57  | 44  | 50  | 44  | 63  | 19  | 51  | 48  | 67  | 81  | 76   | 49  |
| 18    |                   | 30   | 68  | 39  | 47  | 38  | 55  | 56  | 53  | 53  | 54  | 40  | 63  | 60  | 50   | 59  |
| Total |                   | 1003 | 976 | 867 | 867 | 762 | 936 | 766 | 932 | 810 | 905 | 858 | 940 | 957 | 1040 | 865 |

TABLE XXV

AMOUNT OF TIME, DURING A 90-SECOND DELAY  
PERIOD, SPENT IN UNIT 2 BY SS IN GROUP  
S<sub>1</sub> AND D<sub>3</sub>. TRIALS NINETEEN  
THROUGH THIRTY

| Trial | Subject<br>Number | Group          |     |     |     |     |                |     |     |     |     |
|-------|-------------------|----------------|-----|-----|-----|-----|----------------|-----|-----|-----|-----|
|       |                   | S <sub>1</sub> |     |     |     |     | D <sub>3</sub> |     |     |     |     |
|       |                   | 1              | 2   | 3   | 4   | 5   | 26             | 27  | 28  | 29  | 30  |
| 19    |                   | 47             | 53  | 45  | 33  | 36  | 58             | 52  | 57  | 55  | 40  |
| 20    |                   | 50             | 58  | 60  | 63  | 44  | 28             | 51  | 61  | 60  | 38  |
| 21    |                   | 74             | 61  | 51  | 67  | 63  | 60             | 39  | 56  | 62  | 32  |
| 22    |                   | 61             | 53  | 70  | 54  | 61  | 49             | 35  | 54  | 69  | 31  |
| 23    |                   | 64             | 61  | 55  | 71  | 60  | 37             | 35  | 33  | 65  | 21  |
| 24    |                   | 80             | 54  | 59  | 68  | 53  | 48             | 38  | 44  | 51  | 38  |
| 25    |                   | 72             | 71  | 42  | 23  | 42  | 29             | 48  | 60  | 61  | 34  |
| 26    |                   | 64             | 56  | 49  | 66  | 54  | 31             | 51  | 44  | 57  | 30  |
| 27    |                   | 63             | 66  | 42  | 59  | 44  | 26             | 30  | 44  | 55  | 30  |
| 28    |                   | 65             | 51  | 51  | 49  | 47  | 68             | 41  | 56  | 51  | 14  |
| 29    |                   | 79             | 57  | 38  | 59  | 25  | 29             | 42  | 55  | 51  | 48  |
| 30    |                   | 50             | 61  | 68  | 67  | 36  | 40             | 35  | 33  | 60  | 37  |
| Total |                   | 769            | 702 | 630 | 672 | 565 | 503            | 497 | 597 | 697 | 393 |

**APPENDIX B**

TABLE XXVI

RANK ANALYSIS OF VARIANCE ON THE COMBINED  
 RUNNING-SPEED SCORES OF NON-AVOIDING SS  
 AT THE END OF TESTING (TRIALS 16-18)

|                  | Condition |      |      |
|------------------|-----------|------|------|
|                  | 1         | 2    | 3    |
|                  | 24        | 17   | 11   |
|                  | 28        | 7    | 7    |
|                  | 16        | 7    | 5    |
|                  | 25        | 9    | 8    |
|                  | 16        | 5    | 10   |
|                  | 13        | 4    | 10   |
|                  | 9         | 22   | 16   |
| Mdn.             | 16        | 7    | 10   |
| Sum R            | 42.5      | 97.0 | 91.5 |
| $\chi^2_H = 6.7$ |           |      |      |
| P = .03          |           |      |      |

TABLE XXVII

ANALYSIS OF VARIANCE ON TOTAL TIME (IN SECONDS)  
 SPENT IN UNIT 2 OF THE FIRST COMPARTMENT  
 THROUGH EIGHTEEN TEST TRIALS

| Sources of Variation | Sum of Squares | df | Mean Square | F    | P   |
|----------------------|----------------|----|-------------|------|-----|
| Between Groups       | 209,878        | 5  | 41,976      | 2.67 | .05 |
| Within Groups        | 377,156        | 24 | 15,715      |      |     |
| Drive                | 74,800         | 1  | 74,800      | 4.76 | .04 |
| Condition            | 101,537        | 2  | 50,769      | 3.23 | .06 |
| Drive X Condition    | 33,541         | 2  | 16,771      | 1.07 | NS  |