AN ATTEMPT TO DEVELOP A METHOD OF CONDITIONING ALBINO RATS TO RUN

Thesis for the Degree of M. A.

MICHIGAN STATE UNIVERSITY

Richard L. Bartsch

1966

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ALBINO RATS TO RUN

By

Richard L. Bartsch

AN ABSTRACT OF A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

MASTER OF ARTS

Department of Health, Physical Education, and Recreation

1966

Approval William W. Heusner

ABSTRACT

AN ATTEMPT TO DEVELOP A METHOD OF CONDITIONING ALBINO RATS TO RUN

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The purpose of this study was to attempt to establish a satisfactory method of training albino rats to perform a prescribed amount of appropriate work. Light, electrical shock, and water deprivation were used in an apparatus designed to simulate interval and other types of running training.

Albino rats (Sprague-Dawley strain) were used as subjects during four training periods. A different group of animals was used for each of the three-week training sessions.

The lack of previous data necessitated the use of a trial and error testing method to determine the proper rotation of the stimulus parameters. Daily records were kept to evaluate the different combinations and to determine future rotation of the stimulus parameters.

The apparatus, which consisted of eight identical individual running tracks, was controlled by both electrical and mechanical methods. The light and electrical shock were controlled automatically by a timing device and the water source was operated manually by the experimentor. Using

both individual and simultaneous methods, various possible combinations of the stimulus parameters were tested and the results recorded.

Daily records of activity were kept. The reactions included jumping, squealing, urinating, defecating, and finally, by accident, some desired responses. All of the animals, regardless of the amount of improvement, reached a peak and then displayed signs of confusion and frustration.

The subjective evaluation of the records revealed that the various combinations of stimuli were unsuccessful in training the rats to run. However, valuable information for future experimentation was obtained. The light seemed to be the most ineffective stimulus and it should be replaced by some other stimulus in future testing. Low voltage pulsating shock was more favorable than a high voltage continuous shock. There was a definite need for a work time prior to the initiation of the punishing stimulus. The back-and-forth movement pattern proved to be undesirable for training the rats to run. In future training, a movement pattern more natural to the rat may yield more favorable results.

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ACKNOWLEDGMENTS

The author is indebted to Dr. William W. Heusner for his advice, assistance, and cooperation; to Mr. Franklin L. Hartman, Mr. Michael G. Marshall, Mr. Norman K. Mizuguchi, and Mr. Paul D. Robinson whose laboratory assistance made completion of the study possible; to Mr. Francis Y. H. Yap for his aid in the construction of the apparatus; and to Mr. Robert L. Wells for his skillful design and construction of the electrical system of the apparatus.

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CHAPTER I

THE PROBLEM

Introduction

Because there are many areas in physical education that need substantiating research, it is necessary to conduct experimentation to obtain accurate information. It is not feasible to conduct some preliminary experiments on humans. Therefore, in many cases, the researcher must turn to animals.

In a large number of studies, rats have been used in an attempt to determine the specific effects of exercise upon individual organs and systems of organs. This provides clues as to what may take place in the human body as a result of physical activity. Despite the fact that the rat is not directly comparable to the human, it has proven to be a good animal to use in the embryonic stages of research.

Although there have been many valuable experiments conducted with other species, Steinhaus' work with dogs for example, (5) the albino rat has many characteristics that make it an excellent animal for laboratory experimentation. According to Weber, (7, 570) these favorable characteristics are: (a) the small size; (b) the ease of handling; (c) the relative cleanliness; (d) the low initial cost and expense in handling; (e) the ease of housing; (f) the large litters which allow grouping; (g) the short gestation period (21-23 days); (h) the short prepuberty period (60-65 days); and (i) the short life span (2-3½ years). Consequently, the rat has been the most common animal used in the physical education laboratory.

However, the use of the rat as an experimental animal in exercise physiology presents some problems which are as yet unsolved. For example, numerous studies have demonstrated the need for the development of a valuable method of training albino rats to perform a prescribed amount of work of a type which is natural to the species.

Statement of the Problem

This study was undertaken as an attempt to train albino rats to exercise by running them in an apparatus designed to simulate interval and other types of training.

Importance of the Study

Previous efforts have failed to provide a satisfactory means of training the white rat to exercise. Forced swimming (one method that has been proven to be inadequate) involves the placement of the rats in a tank after attaching weights to their tails. The primary problem with this method is that the rat, by nature, is not a "swimming" animal. By forcing it to swim, other factors may enter into the experiment, such as psychic stress. Also, the measurement of the amount and intensity of work performed is difficult to control or even assess. One animal can exert considerably more energy and yet remain in the tank the same amount of time as the other animals. These problems, the complications reported by Updyke which include respiratory ailments--primarily "chronic murine pneumonia, and the extreme sanitary conditions necessary" (6, 2) have made this method much too difficult to be realistically operational.

A treadmill theoretically could provide a satisfactory means of controlling both the amount and intensity of work. Furthermore, the activity involved would seem to be natural for the rat. However, several attempts using a treadmill and forced running have been unsuccessful also. Hardin points out that not all rats will learn to run on a treadmill because of the complex learning task involved. (2, 371) Some animals have a tendency to ride the revolving belt, and even with the introduction of electrical stimulation, these animals continue to ride the belt. In general, the use of a treadmill involves considerable time and effort in order to train a very small number of selected rats to run.

Therefore, there is a definite need for the development of a better means of training albino rats to run under controlled conditions. Progress in the field of exercise physiology is dependent upon the ability of the experimental subjects to perform a prescribed amount of appropriate work. If no better means of training rats is devised many important advances will be impeded.

Limitations of the Study

Size of the sample. The experiment was performed on four groups of albino rats, each containing twenty-four animals. The total sample, therefore, consisted of ninty-six animals.

Time span of the study. The study was conducted over a period of twelve weeks. Each group was trained an average of about three weeks.

Lack of previous methodology. Since this was the initial attempt to use a specially designed running track, there was no actual basis for determining the correct number, type, or rotation of stimulus parameters. The trial and error method of testing the various stimuli was initiated.

Evaluative technique. Because of the nature of this study, the evaluative techniques were limited to observation, recording, and subjective judgment of the apparent success or failure of the various stimulus combinations used.

Definition of Terms

The following terms appear in the study.

Unconditioned stimulus. Any stimulus which, on the outset of an experiment, regularly produces a response.

Unconditioned response. Any response evoked by the unconditioned stimulus.

Conditioned stimulus. Any stimulus which is paired with a given unconditioned stimulus and which at the outset of an experiment, does not produce the response elicited by that unconditioned stimulus.

Conditioned response. A response elicited by the conditioned stimulus which is similar to the unconditioned response.

Work time (interval). The period of time between an anticipatory stimulus and a punishing stimulus during which the animals were to perform a prescribed running pattern.

Rest time (interval). The period of time between the change in sequence of the stimulus parameters. If the animal made the desired movement during the work interval, it would be free from the punishing stimulus.

CHAPTER II

RELATED LITERATURE

The purpose of this study was to establish a satisfactory method of training albino rats to perform a prescribed amount of appropriate exercise. The problem was to design an apparatus in which a basic stimulus-response sequence for the desired movement pattern could be established.

Literature Related to Learning

The phenomenon of learning is often described as merely a "permanent change in behavior." However, Kimble (3, 192) states that this oversimplified statement must be supplemented, since several other factors are also involved in the learning process. In the first place, improvement in behavior is vital because the implied value judgment is an important criterion of useful learning. Secondly, the processes of fatigue and adaptation, which are short lived, must be considered before conclusive statements can be made. Excluding these latter two factors will eliminate the "behavioral change which depends upon physiological development." (3, 192)

Learning and training are in most cases considered synonomous, and both involve a stimulus-response situation. Guthrie (1, 22) explains that in order for future association to occur, there must be more than just the immediate association of ideas or cues with the initial stimulus. It is necessary that some rewarding effect be present. According to the Hull-Spence theory, this effect is called reinforcement. In the simple learning situation a series of stimuli induce some particular movement; and when they reoccur, the same or similar movement should appear.

Guthrie continues (1, 28) by stating that is is almost impossible to follow or record a movement in its totality. The obvious characteristic of the movement is observed; and from this then, future movements can be predicted.

There are many stimuli that can effect a movement, and many of these are divorced from the original stimuli. Also, other secondary movements, such as posture, are influential but often are not considered in the analysis of the primary movement pattern. Because of all these external influences, the exact duplication of the original movement is impossible. It is sufficient that each repetition be similar enough to the "original behavior" so that the prediction of future movements is possible.

Guthrie (1, 31-33) makes several generalizations regarding the stimulus-response sequence.

1. The simple conditioned reflex is most readily established when the substitute stimulus is given shortly before the original stimulus.

2. Temporary extinction may disappear after a period of rest, or after disturbance from a new irrelevant stimulus.
3. A response involving widespread bodily action is more readily conditioned than a response confined to a few local effectors.
4. The certainty of conditioning seems to depend upon the number of pairings of substitute stimuli and responses.
5. Negative or inhibitive conditioning is possible to achieve by presenting a stimulus and not insuring the response, or by distracting the response, or by inhibiting the response; or by presenting the substitute stimulus after the original stimulus. The signal has a positive inhibiting effect on the response. In many cases such inhibition is clearly accompanied by conflicting response.
6. There seems to be evidence that among children, conditioned responses are formed more readily as age advances and more readily in the more intelligent.
7. When a substitute stimulus has been conditioned, other stimuli to the same class of sense organs may be found to elicit the response. This is called generalization.
8. If the substitute stimulus is presented some time before the original stimulus, this delay interval finally characterizes the conditioned response.
9. A stimulus acting separately, and the same stimulus acting as an element of a pattern, may have radically different effects; the combination may act as conditioner and the element as an inhibitor, or the element may act as the conditioner and the combination as the indifferent. (1, 31-33)

Ratner and Denny (4, 523) discuss the conditioning of animals in terms of the stimulus-response theory. Conditioning, often referred to as "classical conditioning," is the establishment of a stimulus-response sequence which is new to the subject. The stimulus may be familiar to the subject in some manner and the response similar to a previous movement, but the association of the stimulus with the response may be entirely new and different.

In order for conditioning to occur, a stimulus which does not elicit the response desired must be paired with another stimulus which consistently, or unconditionally, elicits the response. The first stimulus is the conditioned stimulus and the second the unconditioned stimulus.

The authors (4, 524) continue that in the actual establishment of the pattern or sequence, the conditioned response occurs first and is, therefore, called the "anticipatory response." It often acts as a preparatory signal for the subsequent behavior. The two responses are never identically the same since the conditioned response usually has a greater latency period, occurs less consistently, has less amplification, is usually more incomplete, and generally has different characteristics than the unconditioned response. It is possible to eliminate the unconditioned response by frequent omission of the unconditioned stimulus. The unconditioned response becomes progressively weaker and eventually can be considered to be totally diminished. Response patterns that can be conditioned most readily are those which are most anticipatory and those which do not interfere with other ongoing behavior.

According to the afore mentioned authors, (4, 529) there are two methods to administer the conditioned stimulus in relationship to the unconditioned stimulus. The first method employs the conditioned stimulus as a "momentary stimulus" for the duration of a second or two prior to the initiation of the unconditioned stimulus. This particular type of conditioning is commonly classified as "trace conditioning" because the two stimuli do not overlap in any manner.

The second method also introduces the conditioned stimulus before the unconditioned stimulus, but it is of an adequate duration so that it will overlap the unconditioned stimulus. This type of situation is referred to as "simulataneous conditioning" because both stimuli are operative at the same time. There are other methods but most are merely variations of these two schemes.

Whatever the method employed by the experimentor, it must be realized that any stimulus can be used as a conditioned stimulus as long as it is "over the threshold and not too intense." (4, 529) The numerous proprioceptors, chemoreceptors, and pressoreceptors can be utilized, as well as the more commonly used visual and auditory receptors, to institute the stimulus.

The number of stimuli that can be used as unconditioned stimuli is much more limited because of the restriction that such a stimulus must consistently elicit a predictable response. This means that an unconditioned stimulus must be more powerful than any surrounding element that may serve as a stimulus. However, there must not be any sudden or great adaptation to the stimulus. Also, it must create a broad response pattern including a variation of response components. If the stimulus elicits a simple and single response, it will be too specific, and learning or conditioning will be difficult to achieve.

The most vital procedure in the training or conditioning process is the establishment of the proper stimulus-response sequence. The researcher must discriminate, test, and choose the most appropriate stimulus from all those which will elicit the desired response pattern.

CHAPTER III

METHODOLOGY

As stated in the introductory chapter, there has not yet been discovered a satisfactory method of training albino rats to perform a prescribed amount of appropriate exercise. This study explored the use of light, electrical shock, and water deprivation in an apparatus designed to simulate interval and other types of running training.

The Sample

The subjects used in the study were albino rats (Sprague-Dawley strain) obtained at an age of twenty-five days. There were four groups of twenty-four animals each used at different times throughout the duration of the experiment. For specific stimulus combinations tried during the testing periods, the animals were subdivided into smaller units, the number of which depended upon the number of variations to be tested that period. The animals were numbered for identification and housed in individual spontaneous exercise cages.

Design of the Apparatus

The apparatus basically consisted of eight individual running tracks of stainless steel rods enclosed in a rectangular box. At each end of the tracks there were glass windows behind which were light bulbs that could be seen by the rats in the tracks. Under the tracks were paper-covered galvanized trays for sanitary purposes. As illustrated in Figures 1 and 2, each track was identical in size and had plywood walls and a plexi-glass top. In addition to a light bulb, there was a water source at each end of each track. At each end of the top of the eight tracks, there were hinged plexi-glass doors through which the animals were placed into and removed from the apparatus. Next to each end wall there were plexi-glass walls hinged to one of the floor rods and connected to an arm outside of the apparatus. These were used to make the water source available or unavailable.

This apparatus was built in two sections that, when joined, formed four-foot long tracks. The original idea was to gradually increase the number of sections and build the tracks to a maximum length of sixty feet.

The exposure of the stimuli was controlled by both electrical and mechanical means. The light and electrical shock were controlled by a master control unit and a volt box and the water source was operated mechanically by the experimentors. It was necessary to have two men working with the apparatus because it was too long for one man to operate both water sources and maintain the proper timing sequence.

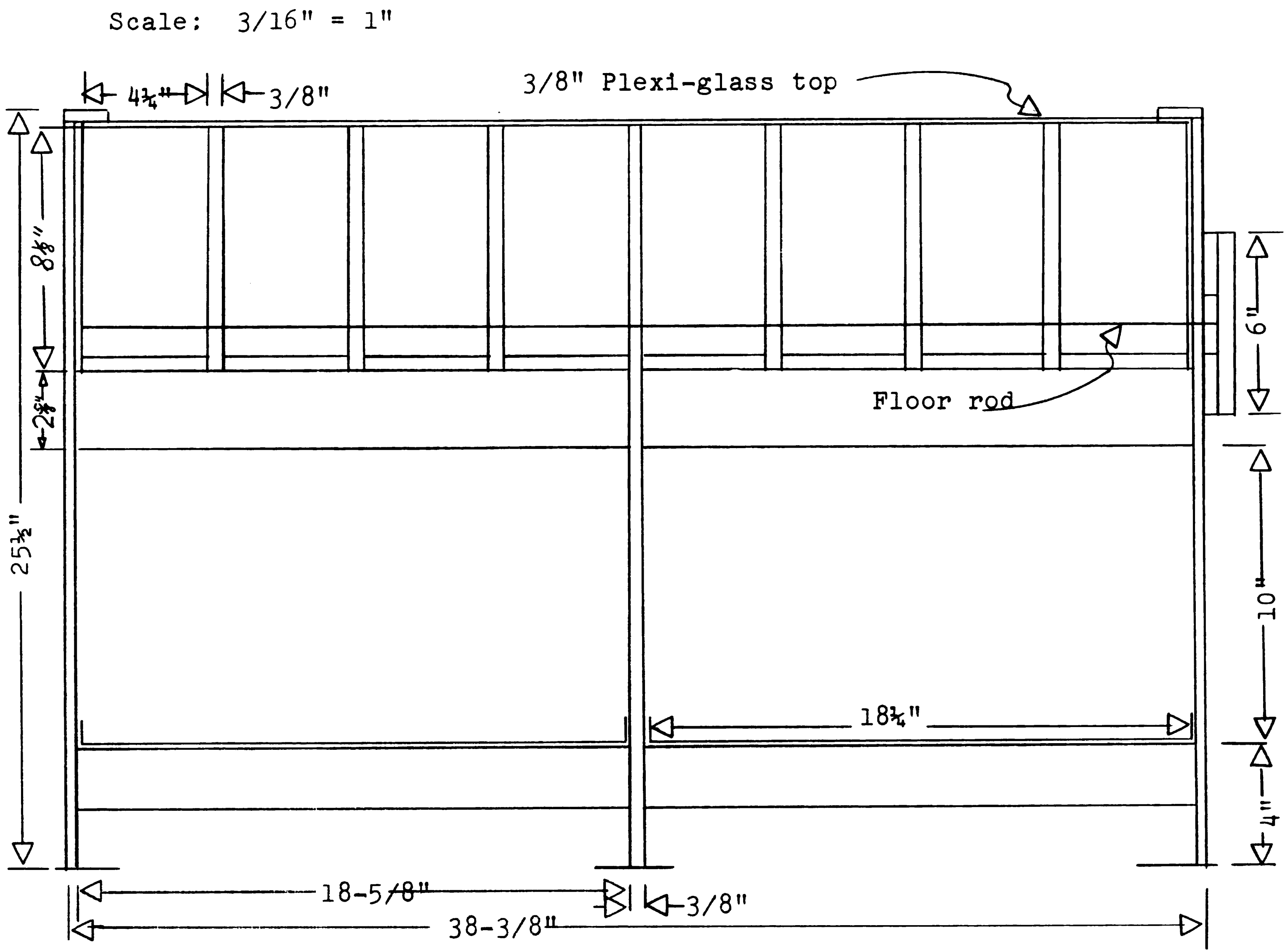

Figure 1.--Cross Section of the Apparatus from the End.

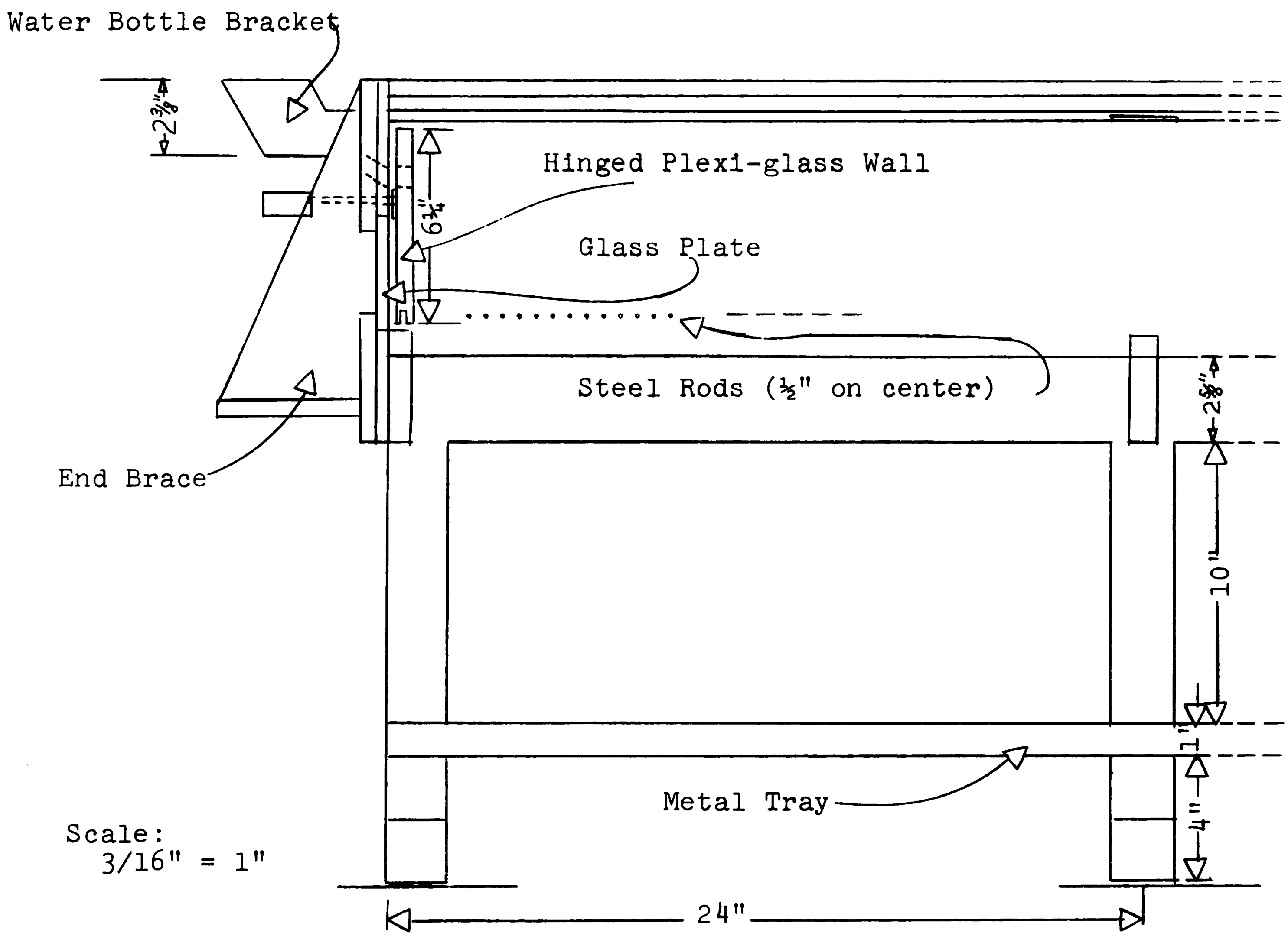

Figure 2.--Cross Section of the Apparatus from the Side.

Simultaneous Method of Operation

The wiring system (Figure 3) enabled the eight tracks to be operated simultaneously, that is, the light and shock sequences were identical for each track at any given time during the experiment.

The order of events most frequently used was as follows: (a) The room lights were turned off to increase the effect of the subsequent light stimuli. (b) The training period was started by activating the apparatus which turned on the lights at end A. These lights were supposed to serve as a conditioned stimulus for the rats to work (run to the dark end B where the lights remained off throughout the work and rest intervals of the first sequence). (c) The animals were allowed a predetermined amount of time (work interval), during which they were supposed to run to end B. (d) At the conclusion of the first work interval, the floor of the entire track, except for a 12-inch "safe" section at the dark end B, became charged. Supposedly, this electrical shock acted as an unconditioned stimulus for the rats to finish running to the dark end and rest there (if they had not already done so). Simultaneously, the appropriate lights above the track went on illuminating the entire charged area of the track but leaving the "safe" section at end B dark (these lights remained on throughout the rest interval of the first sequence). (e) The animals were allowed a predetermined amount of time (rest interval), during which they were supposed to stay at end B. (f) At

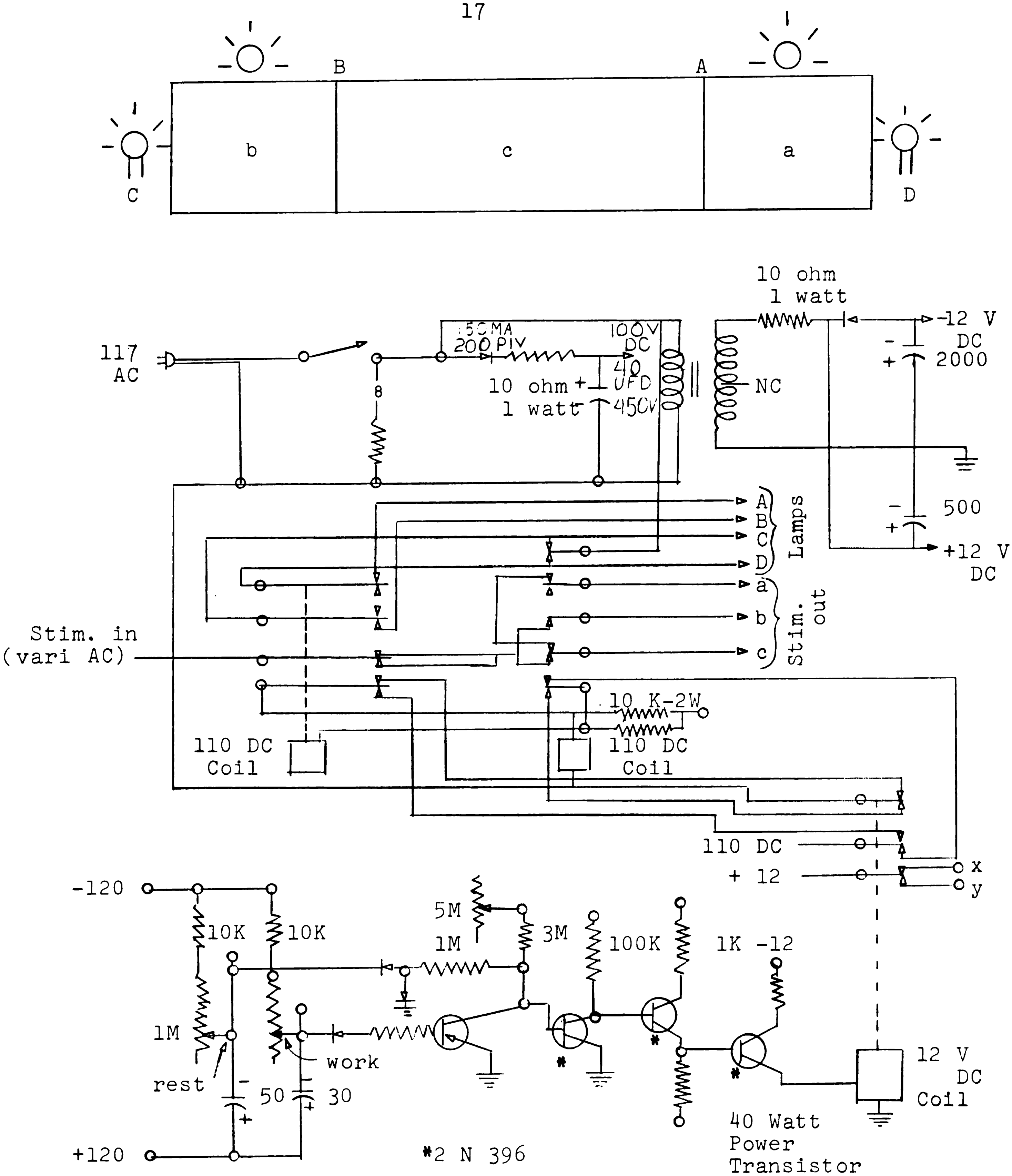

Figure 3.--Wiring Scheme of Master Control Unit for Automatic Light and Shock Control.

Note: All lamps have common ground to low side of 117v. AC.

the conclusion of the first rest interval, the lights at end A, the overhead lights, and the electrical shock were turned off. Simultaneously, the lights at end B were turned on. This initiated the second work-rest sequence which was identical to the first, except that the stimuli were reversed with respect to ends A and B. (g) The sequences continued, with the rats supposedly running back and forth between ends A and B, until the apparatus was turned off and the room lights turned on.

The master control unit controlled the duration of the work and rest intervals by regulating the amount of time the lights and the electrical stimulus were on. The intensity of the shock was determined by the volt box which was connected through the master unit. The experimentor could vary these stimuli and thus test numerous variations and combinations of time and intensity.

The mechanical operation of the water source involved an arm that extended the width of the eight running tracks across the outside of the end of the rectangular box. The plexi-glass walls inside the tracks were attached to the outside arm. There was a hole in each wall through which the nipples of the water bottles could protrude. To expose the water, the experimentor pulled the arm away from the end wall which exposed the nipple of the bottles inside the tracks. The arm was pushed toward the end wall to remove the water. The nipples were exposed at the dark end of the tracks for the duration of each work and rest sequence. Water availability was changed in sequence with the lights.

Individual Method of Operation

It was also possible to operate each track individually rather than simultaneously by changing the lights from a common circuit to eight independent circuits. This change in connections cut out the timing device and each track was operated independently of the other tracks (see Figure 4). In conjunction with the change in the lighting, it was possible to operate each water source separately so that it would work with the individual tracks. This method did eliminate the use of the shock stimulus because the tracks were not wired independently for this stimulus. The steel rod floor was continuous across all tracks, and if the shock was used it could not maintain the proper stimulus sequence for the individual tracks.

Preparation Procedures

Each rat was marked for identification and housed in its own spontaneous exercise cage for the duration of the experimental period. The first two days consisted of a period of familiarization with the apparatus. On each of these two days, the animals were placed in the dormant apparatus for not less than one-half hour.

The animals were fed and watered ad libitum during the first two days. Once the actual experiment commenced,

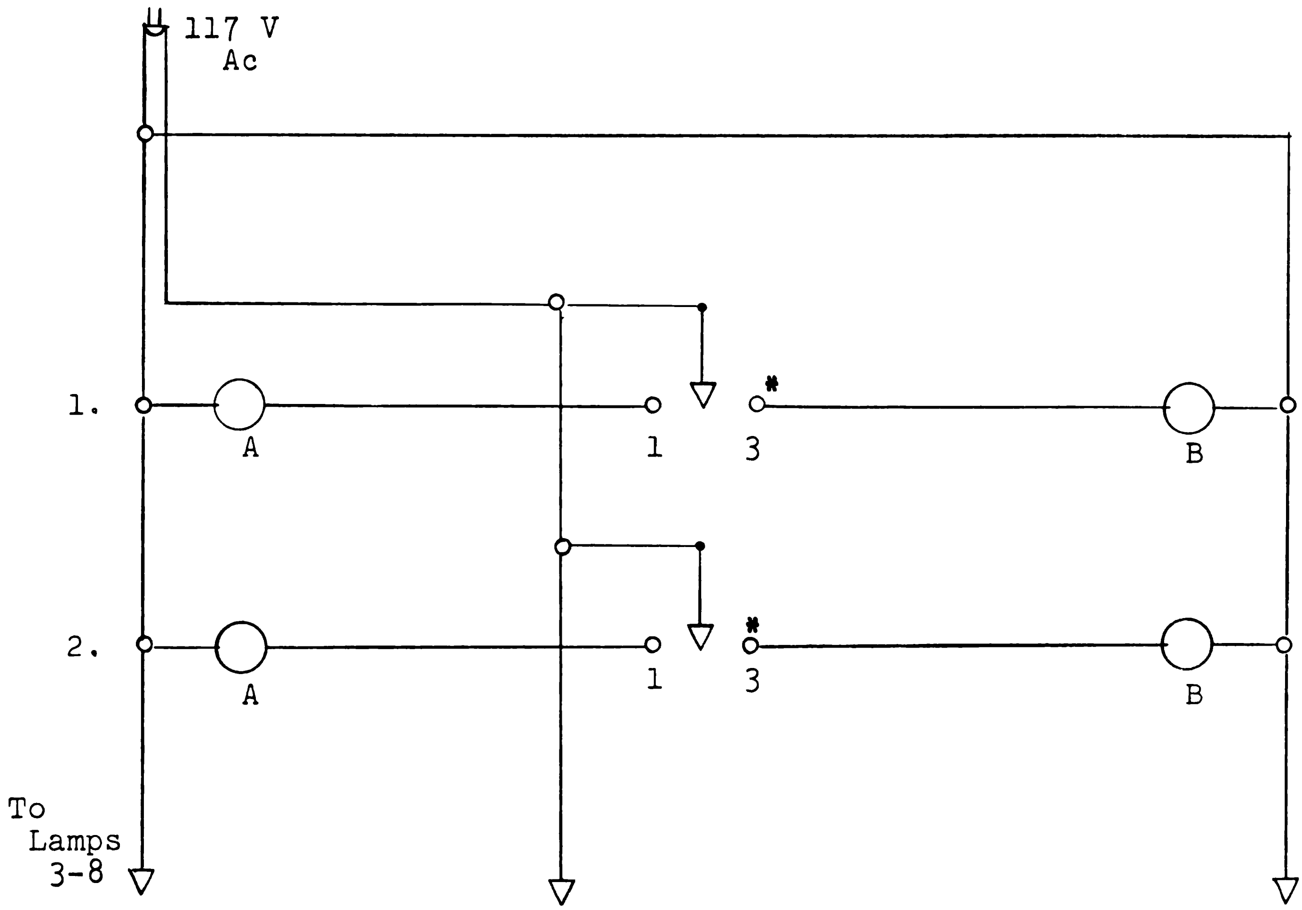

Figure 4.--Wiring Scheme for Manual Light Control.

*All switches: Position 1 = Lamp A; Center Position = Off; Position 3 = Lamp B.

ad libitum food was maintained, but the water was taken away at a regular time each day. The pattern was to deprive them of water for approximately twelve hours prior to testing in the apparatus. After testing, water was again available ad libitum in their housing cages.

Special attention was given to the fact that the animals were numbered and kept in separate cages. For the entire experiment, each day each animal was trained in the same track to avoid contamination of a large number of animals if one rat were to become infected with some contagious disease.

In addition to these procedures, records were kept of the daily number of spontaneous revolutions run by each rat. The most convenient time was prior to experimentation each day, therefore, establishing a consistent time of recording.

Test Procedures

The apparatus, with the multiple wiring system, provided numerous combinations of the light and electrical stimuli to be used in conjunction with the water source. The electrical stimulus could be connected so that the "safe" area was at either the lighted or the darkened end of the apparatus. The work and rest intervals could be varied within a range of zero to thirty seconds. Having no basis for the proper combination of these stimuli, the trial and error method was employed to test various combinations.

Observations were made and recorded daily. This information was used to establish procedures for later testing.

Group I. Eight adult male animals were used in a pilot study to test the animal's reactions to the activated apparatus and to perfect operational procedures. The wiring scheme was set initially so that the rats had to run towards the light to reach the "safe" area and the water. After four days, this group of animals were subjected to a change in direction. The light scheme was altered so that the rats had to run to the darkened area to obtain safety.

At the end of the first week, the sixteen other adult rats were divided into equal groups, and the three groups were used for the first round of testing. The light scheme remained the same as noted above for these and for the remainder of the experiment. Sweetened milk was also introduced at this time as the reward instead of the water.

Subgroup C was run with the individual method for four days and then placed under the simultaneous method used with the other animals. Table 1 lists the specific details for the stimulus parameters used with group I.

Group II. Young male rats were used during this experimental period. The light scheme was the same as for the previous testing period, but there were changes in the intensity of the shock and the duration of the rest intervals. Water was used, instead of the milk, as the reward. Subgroup C was run individually for four days and then simultaneously in the same manner as the others (see Table 2).

TABLE 1

STIMULUS PARAMETERS FOR GROUP I

Subgroup	Method	Work Time (sec.)	Rest Time (sec.)	Voltage (volts)	Reward
A	Sim.	0	30	25	water
B	Sim.	0	30	30	milk
C	Ind./ Sim.	not set/5	30	0/15	milk

Sim. - Simultaneous
Ind. - Individual

TABLE 2

STIMULUS PARAMETERS FOR GROUP II

Subgroup	Method	Work Time (sec.)	Rest Time (sec.)	Voltage (volts)	Reward
A	Sim.	0	15	15	water
B	Sim.	5	15	15	water
C	Ind./ Sim.	not set/5	15	0/15	water

Sim. - Simultaneous
Ind. - Individual

Group III. This group of young male rats was run in the same manner as the other groups except that the individual running for subgroup C was reduced to only two days. The overhead center lights were not activated for subgroups B and C. At the conclusion of the test period, a pulsating shock was tested on subgroup A (see Table 3).

TABLE 3

STIMULUS PARAMETERS FOR GROUP III

Subgroup	Method	Work Time (sec.)	Rest Time (sec.)	Voltage (volts)	Reward
A	Sim.	0	15	15	water
B	Sim.	5	15	15	water
C	Ind./ Sim.	not set/5	15	0/15	water

Sim. - Simultaneous
Ind. - Individual

Group IV. Young female rats were divided into four subgroups and were introduced to pulsating shock. The stimulator was set to give the following shock characteristics: a .01 second delay, a duration of 100 ms., and a biphasic pulse. The voltage was consistent for all groups; the overhead lights were out; and each group was trained for twenty-minute periods. Group D was used to test a slowly decreasing work time, beginning with five seconds and reducing it one second every two days until it was zero.

TABLE 4

STIMULUS PARAMETERS FOR GROUP IV

Subgroup	Method	Work Time (sec.)	Rest Time (sec.)	Voltage (volts)	Shock Every
A	Sim.	5	15	75	2 sec.
B	Sim.	5	15	75	1 sec.
C	Sim.	5	15	75	3 sec.
D	Sim.	5-0	15	75	2 sec.

Sim. - Simultaneous

Collection of Data

A daily log was kept for each group of animals for the entire training period. Subjective statements describing the responses each day were recorded.

Because there was no previously collected data with which to compare the results, no statistical analysis could be made. The data collected was analyzed subjectively to determine the apparent success or failure of the particular stimulus combinations used. This information was useful for establishing future combinations of the stimulus parameters.

CHAPTER IV

PRESENTATION AND ANALYSIS OF DATA

The purpose of this study was to attempt to establish a satisfactory method of training albino rats to perform a prescribed amount of appropriate exercise. Light, electrical shock, and water deprivation were used in an apparatus designed to simulate interval and other types of running training.

As described in previous chapters, the lack of previous methodology and data using this type of apparatus has placed limitations upon the presentation and analysis of the data. The method of presentation is, by necessity, limited to subjective statements describing the activity of the rats. Similarly, the analysis is limited to a subjective discussion of the activity in terms of relative success or failure of the different techniques.

Group I

Subgroup A. The animals of the pilot group exemplified varied reactions to the stimuli. Initially, the most common responses were jumping, squealing, urinating, defecating; and finally, by accident, some made the desired response. As time progressed, the animals climbed the walls, sat and absorbed the shock, and bit the steel rod floor. Those that bit the floor rods immediately became paralyzed in a state of shock but appeared to recover fully after removal from the apparatus.

The rats did not respond positively to the original stimulus sequence and when the light scheme was changed, the results were even less favorable. The animals became confused, and many sat at one end, usually the end in which they were placed, and absorbed the shock. This tendency remained for the duration of the training period with this group.

Subgroup B. The reaction patterns were similar to those of the pilot group. There was some improvement in their reactions to the simuli, but not until the animals were in the apparatus for at least twenty minutes. Milk produced no better results than the water which was used as a reward in the pilot study. There was some progress in training because the rats did begin to react positively.

Subgroup C. Individual running produced the best results although for only a short period of time. The initial movement was slow, but as training increased the reactions became more positive. The rats ran, at their individual rates, until their thirst was satisfied. Some of the animals merely remained in the middle of the track for the duration of each experimental period.

When placed in the simultaneous situation, these rats displayed movement patterns which were similar to those of the first two subgroups. However, when these animals finally responded, they did so in less time than the other groups. That is, they moved faster from one end to the other for a longer period of time.

Discussion. The first group of animals was important in determining the various reactions of the rats to the stimuli in the apparatus. Although no conclusions were drawn as to the success or failure of the method, vital information was learned which guided future rotation of the stimulus parameters.

Because the twenty-five volt shock caused confusion, frustration, and near death of several animals, future training was attempted with a reduced stimulation of fifteen volts. The presence of a work time seemed to be more favorable than immediate shock, but the same pattern was kept for the next group which had the reduced voltage.

The water, which was the original reward, was continued because there were no differences in reactions when the water or the sweetened milk was used. The water was much more effectively handled. Fresh water was given every day with much less work, mess, and expense involved than with the sweetened milk. Since the results were similar, the water was retained as the reward throughout the rest of the experiment.

The change in the light scheme completely confused the pilot group, but it was much more realistic to have the rats run to the darkened end of the tracks than to the lighted end. It was logical because the rat is, by nature, a nocturnal animal and engages in most of its activity at night. This light scheme was continued for the remainder of the experiment.

Group II

Subgroup A. This group, although the voltage and the rest time were reduced, still showed signs of confusion and frustration. The positive reaction was erratic and not long in duration. When the rats did not run, they attempted to climb the walls, jumped frantically, or sat and absorbed the shock.

Subgroup B. There was some improvement with this subgroup as the rats reacted more favorably. The reactions came sooner than in the first group, but again the running did not last for any extended period of time.

Subgroup C. The reaction to the individual running was similar to that of the first group. There seemed to be movement as a reaction to the noise of changing the walls rather than to the light. On several occasions the animals did not move until the water was removed.

When placed in the simultaneous situation, the rats had difficulty adjusting to the electrical shock. The patterns of confusion and frustration were obvious and many rats did not continue to run. Those animals which began to run did not exercise for more than five minutes.

Discussion. This group displayed some favorable behavior because more animals began to learn the desired movement pattern. This number was not significant, however, and no definite conclusions were made concerning the success or failure of the method of training.

The reduced voltage was definitely an improvement because the animals did not bite the steel rods and the predominant escape behavior was reduced. This group illustrated that the inclusion of a work time in the sequence was better than immediate shock.

Another important observation was made regarding the placement and removal of the animals into and out of the apparatus. The animals that were placed into and retrieved from the same end of the tracks tended to remain at that end when they did not run. It was decided to alternate this procedure day to day to avoid the establishment of a false sense of security.

The reduced rest time was also beneficial because the animals did not drink as much water during each sequence. This prolonged the satisfaction of the animal's thirst and increased the running time of the animals that ran. This increase was most appreciable in subgroup B which showed some signs of learning the desired movement pattern. The reduced rest time was maintained for the duration of the experimental period.

Group III

Subgroup A. These rats displayed signs of confusion. They began to react positively, but in most cases the animals moved for one or two sequences and then ceased to move. One or two of the animals ran for a longer period of time but eventually followed the pattern of the other animals that sat and absorbed the shock. The rats tended to remain at the end of the track in which they were placed.

Subgroup B. There was some reaction to the light changes and a larger number of animals reacted in a positive manner. These animals were more calm than the others in the group and ran to the water for a longer period of time than did those in subgroups A and C. These animals did, however, cease running prior to the termination of the training periods.

Subgroup C. The same pattern of movement existed with this subgroup as the corresponding subgroup in Group II. The animals displayed positive reactions under the individual situation, but exhibited difficulty adjusting to the electrical stimulus under the simultaneous method.

Discussion. This test group confirmed the definite need for a work time when training rats. The animals that were exposed immediately to the shock were consistently confused and never adjusted adequately to the electrical stimulation. Those animals which were trained with a work time were more calm and reacted more positively than the others.

The individual method of training prior to the simultaneous training was useless in preparing the animals for the type of running desired. Although the animals responded in a positive manner while running on the individual basis, there was no way of controlling the amount or intensity of the work they performed. Furthermore, the individual method did not include the electrical stimulus which was a part of the eventual test stimuli. The animals that had learned to run first with the individual method had a difficult time adjusting to the shock when they were placed in the simultaneous situation. Because of these facts, the individual method was abandoned in future training.

The responses were more favorable with the center lights inactive. The apparatus was darker at the "safe" end with these lights out and the animals seemed to react in a more positive manner. This change was used for the remainder of the experimental period.

An important observation was made regarding the electrical stimulation. Once the shock was initiated, the rats did not have any safe place to run because the entire floor immediately around them was charged with electrical current. Every direction the animals turned the floor was shocked and this could have been the source of their confusion and eventual frustration. The use of a pulsating shock was introduced and tested on some of the animals in Group III. The results were not inhibitory and this form of stimulation was used on the future groups of animals. With this method of stimulation, the rats had some safe area on which to run, and the method still maintained the use of the electrical shock.

Group IV

Subgroups A, B, and C. These three subgroups were exposed to the same stimuli except that they were shocked at different intervals of pulsation. The increased voltage did not have any detrimental effects on the animals because it was not a constant charge of electricity. The animals reacted positively in less time than the other groups, but after four days of training, the progress ceased. As was demonstrated by the previous groups, these subgroups reached a point of improvement and then became confused and frustrated. Once the rats reached this stage, they never improved again during the remainder of the training period.

Subgroup D. This subgroup ran best of the four in this group. The initial advance was slow but as time passed, the animals reacted more positively. The rate of improvement was slow, but lasted longer than in the other three groups. The running never reached the point where the rats ran for the duration of the training period each day. After eight days, this group seemed to reach a peak and progress ceased.

Discussion. The animals seemed to respond more positively at the onset of experimentation. During the training period, these animals were more clam than any of the other groups and a fewer number were stationary. Initially, this method seemed to be better than the constant shock or stimulation. However, in terms of overall improvement and progress, this method did not yield any significant increases in positive behavior. The animals still responded for a certain period of time and then displayed signs of confusion and frustration.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The purpose of this study was to attempt to establish a satisfactory method of training albino rats to perform a prescribed amount of appropriate work using light, electrical shock, and water deprivation in an apparatus designed to simulate interval and other types of running training.

Albino rats of the Sprague-Dawley strain were used as subjects during four training periods. A different group of animals was used for each of the three-week training sessions.

Since this was the initial study employing this method, there was no previous data from which to determine the proper rotation of the stimulus parameters. The trial and error method was used to test the various possible combinations of the stimuli. Daily records were kept describing the activity of the animals. These records were used to determine future rotation of the stimulus parameters.

The apparatus consisted of eight identical running tracks each with a light and water source at both ends and a steel rod floor that was electrically stimulated. The stimuli were controlled by both electrical and mechanical methods. The light and electrical shock were automatically regulated by a timing device and the water source was controlled manually by the experimentors. The apparatus was wired so that a change of connections made it possible to convert the apparatus from a simultaneous to an individual situation.

Daily records were kept of the activity, and the reactions included jumping, squealing, urinating, defecating, and finally, by accident, some desired responses. The animals were more successful in the individual situation, but then became confused and frustrated when placed in the simultaneous situation. Throughout all of the training periods, the animals either experienced immediate confusion and frustration or they showed some positive action and then experienced this period of confusion and frustration.

The data, in the form of subjective statements, was analyzed after each group was trained and the necessary changes were made for the next group.

Conclusions

Light, electrical stimulation, and water deprivation used in the apparatus designed to simulate interval training did not provide a satisfactory method of training albino rats to perform a prescribed amount of exercise.

Light seemed to be confusing and much too difficult for the rats to react to as compared with sound or electrical shock.

There was a definite need for a work time to allow the animals to adjust before the initiation of the electrical stimulation.

The pulsating shock was less confusing to the rats and did not cause the characteristic escape behavior seen with the constant stimulation.

With the simultaneous situation, the lower voltage was best because the animals did not bite the steel rod floor. However, a higher voltage was suitable for the pulsating shock.

The back and forth running pattern seemed to be confusing to the animals and was detrimental to the progress of the learning pattern.

There were no differences in reactions using sweetened milk rather than water.

Recommendations

Further study should be conducted using some stimulus other than the light with the electrical stimulation and the water deprivation.

The back-and-forth running pattern should be replaced with some other pattern or method that would be less confusing.

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