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LEARNING A TRAVERSAL PATTERN IN A SHOCK AVOIDANCE MAZE

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ARMED FORCES RADIOBIOLOGY RESEARCH INSTITUTE
Defense Atomic Support Agency
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LEARNING A TRAVERSAL PATTERN IN A SHOCK AVOIDANCE MAZE

E. M. GRESKO
S. J. KAPLAN
D. W. CONRAD
H. D. COOPER

W. F. Davis, Jr.
W. F. DAVIS, JR.
Acting Chairman
Behavioral Sciences Department

Hugh B. Mitchell
HUGH B. MITCHELL
Colonel, USAF, MC
Director

ARMED FORCES RADIOBIOLOGY RESEARCH INSTITUTE
Defense Atomic Support Agency
Bethesda, Maryland

ACKNOWLEDGMENT

The assistance of the many persons in AFRRI who supported the research efforts presented herein is gratefully acknowledged. Appreciation is proffered to the Design and Fabrication Branch with special recognition of D. R. Gotthardt whose tireless efforts in construction of the X and Y chambers and the KAM made this investigation possible.

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FOREWORD
(Nontechnical summary)

The purpose of this study was to ascertain the most efficient means for training a monkey to make conditioned running responses in an especially constructed shock avoidance apparatus. Three conditions of training required to learn the task were devised in an attempt to establish which of the conditions best met the objectives for studying radiation effects upon performance.

The Armed Forces Radiobiology Research Institute (AFRRI) is studying various effects of sublethal and supralethal whole body doses of pulsed radiations from the AFRRI-TRIGA reactor. Since a need has been established for identifying the motor, as well as the sensory and cognitive skills which may be impaired as a result of these exposures, a maze, which requires that the subject learn by avoiding shock, has been designed and constructed to permit study of motor learning. This maze, known as the Kaplan-AFRRI Maze (KAM),[1] consists of six test compartments and requires that a monkey traverse these clockwise (Figure F-1), making sensory and motor responses in a time frame which will permit avoidance of an aversive electric shock to the floor grid.

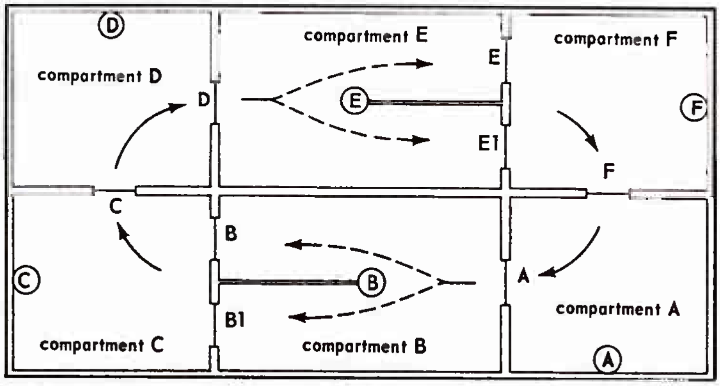
In the present study, the KAM was given its first laboratory tests for the purpose of determining its ultimate usage as a device for measuring radiation effects upon behavior. While earlier versions of this maze have been successfully employed in irradiation work,[2] the current version, which is under automatic control, and which contains more sensitive measuring equipment, had not been tested previously.

Since little is known about the training requirements for the KAM, it is important to ascertain several factors, two of which are:

1. The time required for a monkey to learn a specified task to a pre-established criterion of mastery.

2. The means of measuring the learning of a maze task in terms of (a) latency of response to each stimulus, (b) indices of accuracy of response to each stimulus, and (c) stability of the performance once learned.

MAZE



PROBLEM

Task *	Stimulus	Response **
1	(B) lights, door A lifts	enter door A, press switch (B)
2	(C) lights, door B or B1 lights and unlocks	open lighted door, press switch (C)
1	(D) lights, door C unlocks	open door C, press switch (D)
4	(E) lights, door D lifts	enter door D, press switch (E)
1	(F) lights, door E or E1 lights and unlocks	open lighted door, press switch (F)
6	(A) lights, door F unlocks	open door F, press switch (A)

* Bell sounds at start of each task

** Incorrect response results in shock from grids

Figure F-1. Graphical diagram of the Kaplan-AFRRI Maze (KAM)

Since large numbers of subjects ultimately will be required to obtain an adequate sample for interpreting radiation effects, it is also important to obtain information which will assist in devising logistical plans for the training of animals in substantial numbers. It is expected that results reported herein will lend assistance to this type of logistical requirement.

Six male monkeys (Macaca mulatta), naive to psychological testing, were given training on a traversal pattern in a shock avoidance maze. Three training conditions were employed to determine the most efficient means for training subjects to master a problem in the shortest possible time. Performance was under automatic control and permitted stimuli to be presented every 10 seconds over a period of 8 minutes. Latencies ranged between approximately 1.5 and 3.5 seconds for conditioned stimulus-conditioned response intervals. Results indicated that these animals could learn the maze problem to a stable and high level of performance in 20 to 27 days. The training condition wherein the animals were first trained in a two-chambered box and then transferred to the six-compartmented maze was deemed the most practical.

ABSTRACT

Six male monkeys (Macaca mulatta), naive to psychological testing, were given training on a traversal pattern in a shock avoidance maze. Three training conditions were employed to determine the most efficient means for training subjects to master a problem in the shortest possible time. Performance was under automatic control and permitted stimuli to be presented every 10 seconds over a period of 8 minutes. Latencies ranged between approximately 1.5 and 3.5 seconds for conditioned stimulus-conditioned response intervals. The tasks required of the subjects entailed an involvement of the auditory, visual, and pain senses and also some form of temporal sense. In addition, the tasks involved a capacity for motor dexterity as demonstrated by the use of muscles required in the performance. Results indicated that these animals could learn the maze problem to a stable and high level of performance in 20 to 27 days. The training condition using the two-chambered box was chosen for subsequent studies because the subjects trained by this method performed to a degree deemed more efficient in comparison to the other methods.

I. INTRODUCTION

Identification of the muscular as well as the sensory and cognitive skills which may be impaired as a result of exposure to ionizing radiations is essential in the studies being conducted at the Armed Forces Radiobiology Research Institute (AFRRI). The occurrence of muscular aberration following irradiation of the monkey has been established by Seigneur and Brennan.[3] Since these investigators observed their subjects in a large cage and were not concerned with discrete muscular activity, they reported only ataxia and convulsions as signs of gross muscle disorder.

To provide additional information, the Kaplan-AFRRI Maze (KAM)[1] has been constructed to permit the study of animal learning which involves a running activity. The KAM consists of six test compartments and requires that a monkey traverse these clockwise making various muscular responses to visual and auditory stimuli in a time frame which will permit avoidance of an electric shock to the floor grid. The KAM offers a means for studying specific finger, hand, arm and leg action with the facility for measuring speed of traversal through portions of the instrument. Thus, a more refined statement of radiation effects upon motor action will become possible.

While earlier versions of this maze have been successfully employed in experiments on radiation effects,[2] the latest version, which is under automatic control and contains more sensitive measuring equipment, had not been tested previously.

In the present study the KAM has been given its first laboratory tests for the purpose of establishing the most effective means for its employment in training monkeys to learn the required responses. Three conditions of training were examined to determine the one most appropriate for behavioral performance testing.

II. PROCEDURES

Six male monkeys (Macaca mulatta), naive to psychological testing at the beginning of the experiment, were employed. The subjects were maintained in the animal colony and were fed on a daily schedule at 8:00 a.m. and 3:00 p.m. Their diet consisted of fruit (one-half orange or apple) and twelve biscuits of Purina Monkey Chow at the scheduled times. Two subjects, matched as closely as possible for age and weight prior to the commencement of the experiment, were trained under each of three different training conditions described below.

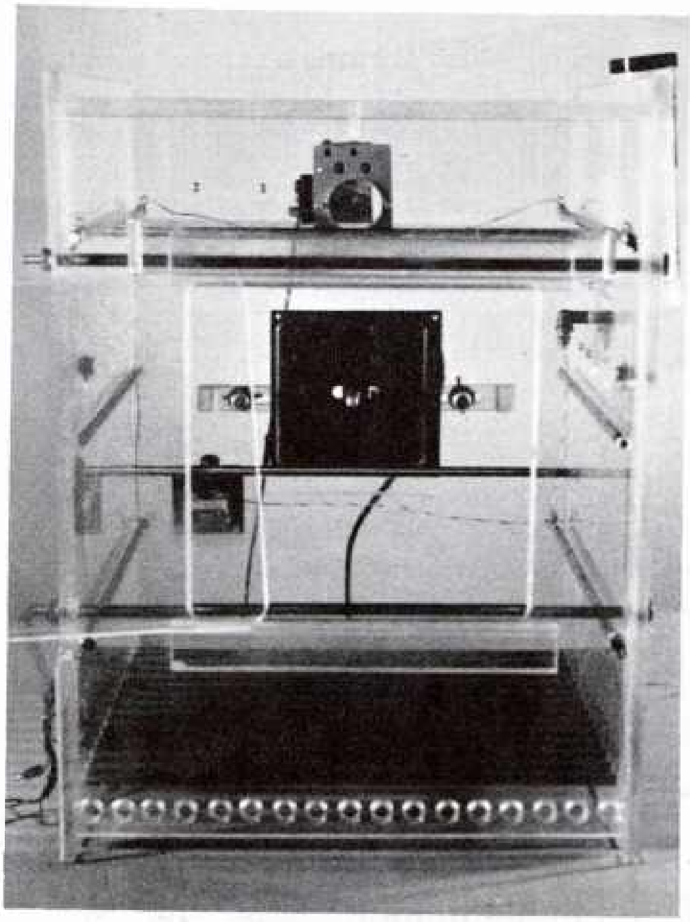


Figure 1. The X Chamber

Three training devices were used in experimental condition I. The subjects were trained first in a Plexiglas box designated as the X chamber (Figure 1), then graduated to a device called the Y chamber (Figure 2), and finally transferred to the KAM (Figure 3). The subjects trained under experimental condition II began in the Y chamber and transferred to the KAM while the subjects of experimental condition III began their training directly in the KAM.

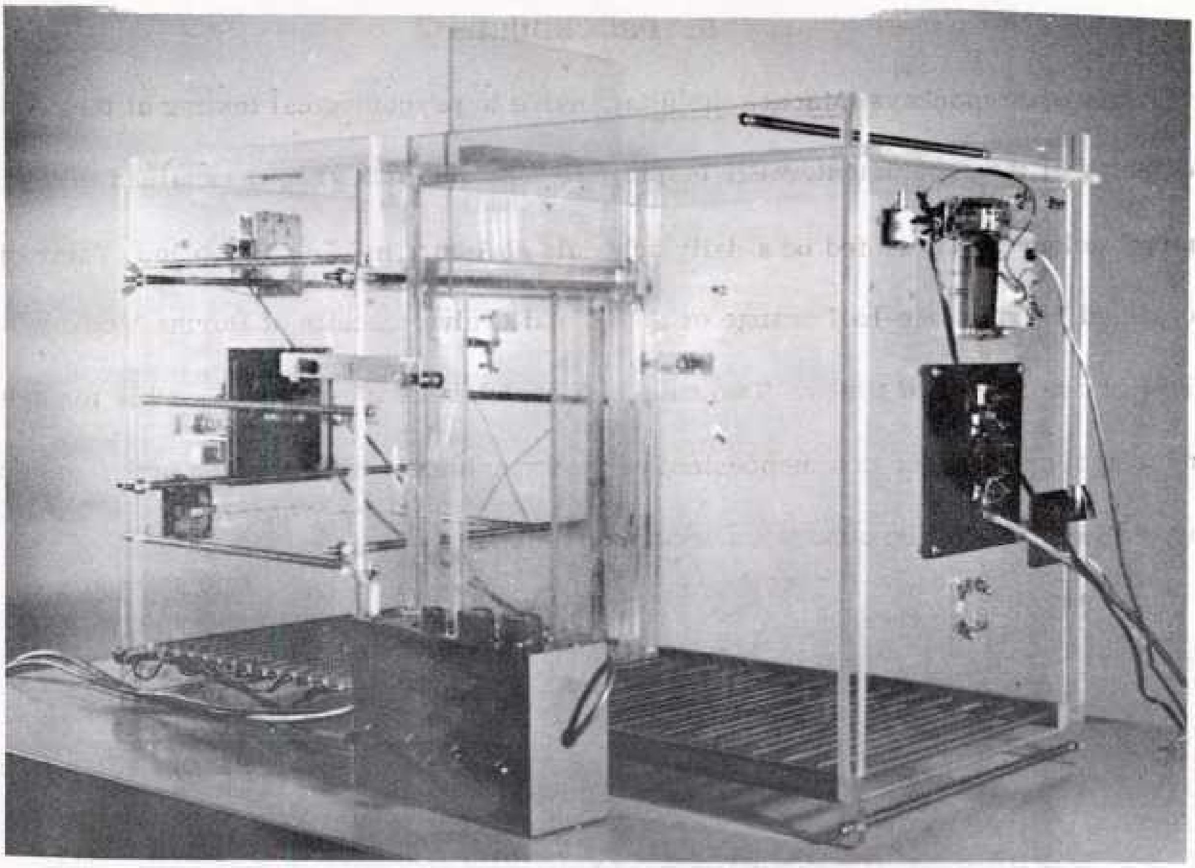


Figure 2. The Y Chamber

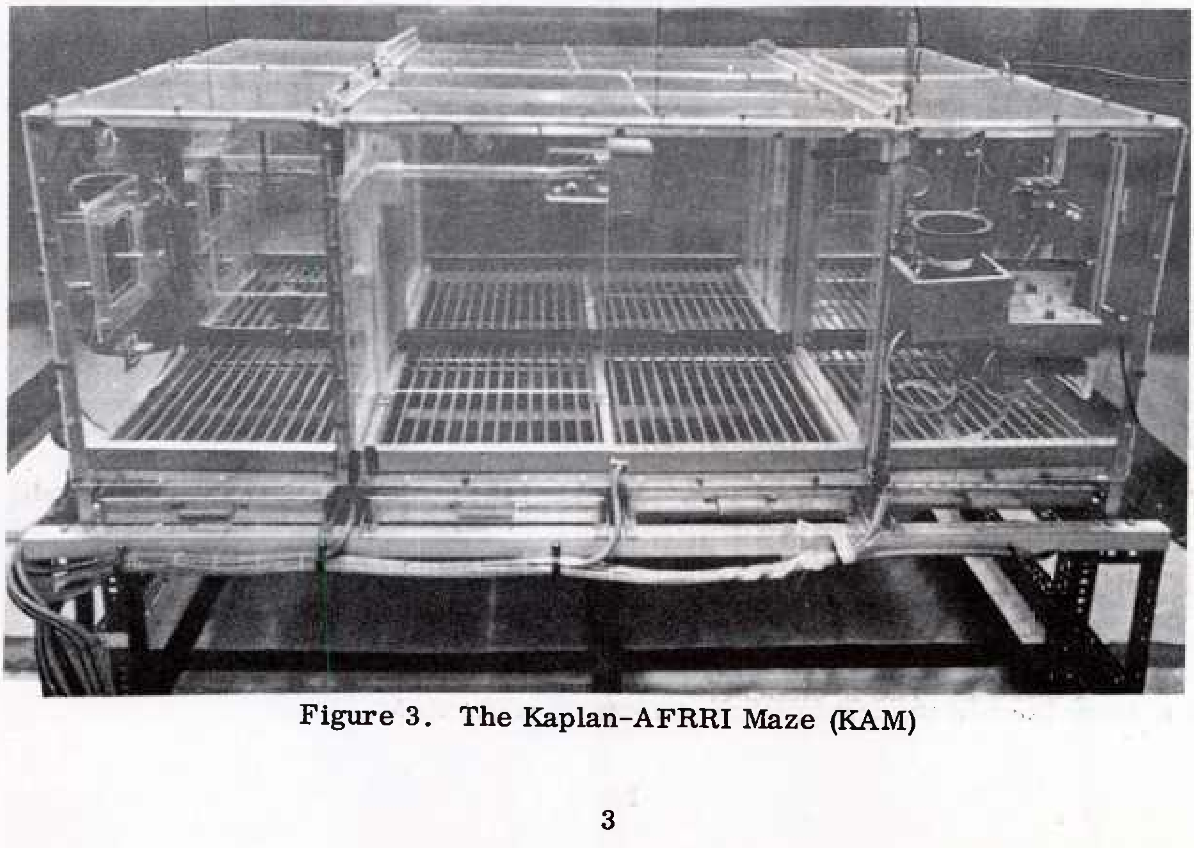


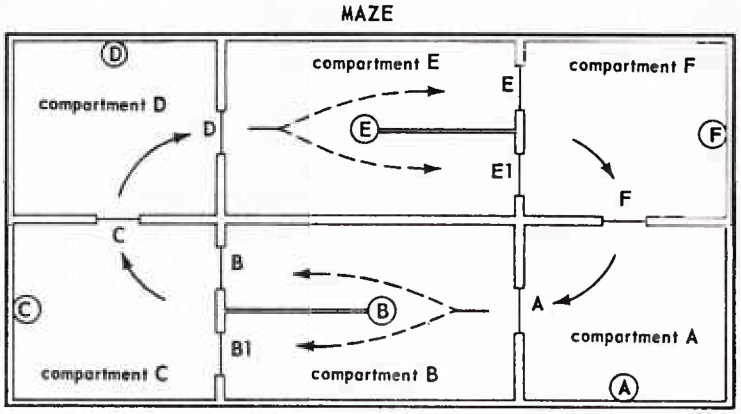
Figure 3. The Kaplan-AFRRI Maze (KAM)

The X chamber consists of a box constructed of 1/2-inch thick Plexiglas with dimensions of 17-5/8 inches x 17 inches x 24 inches. The floor of the box consists of aluminum rods, 3/8 inch in diameter, mounted 1-1/16 inches apart to form a shock grid. A checkback switch and a removable lever manipulandum are situated on the wall opposite a sliding door entrance. The lever manipulandum can be replaced by devices requiring linear, rotary, push and pull responses. The box is reinforced with two aluminum rods of 3/8-inch thickness.

The Y chamber consists of a second X-type chamber being latched to the first X-chamber by means of two 1/2-inch metal bars. The dimensions of the second X-type chamber are 16 inches x 21-1/2 inches x 24 inches and this chamber is also equipped with a shock grid. Space for a door is provided between the two chambers and one of the two types of doors is used separately in training a subject to traverse a type of door it will encounter during maze training. One door is a guillotine-type door which slides vertically and another is a swinging-type door. Both doors are operated manually by the experimenter.

The devices in the X and Y chambers as well as in the KAM are controlled manually during the initial stages of training. The manual controls permit the experimenter to present a subject with simultaneous visual and auditory stimuli and to transmit a shock to the grid floor as required. The visual stimulus is a blue light located behind the checkback switch which is made of translucent Plexiglas. The auditory stimulus consists of the sound of a bell.

The KAM[1] is a six-compartmented maze with overall dimensions of 48 inches x 72 inches x 24-1/2 inches. The device is shown graphically in Figure 4 together with a description of the traversal requirements of the KAM.



PROBLEM

Task*	Stimulus	Response**
1	Ⓑ lights, door A lifts	enter door A, press switch Ⓑ
2	Ⓒ lights, door B or B1 lights and unlocks	open lighted door, press switch Ⓒ
1	Ⓓ lights, door C unlocks	open door C, press switch Ⓓ
4	Ⓔ lights, door D lifts	enter door D, press switch Ⓔ
5	Ⓕ lights, door E or E1 lights and unlocks	open lighted door, press switch Ⓕ
6	Ⓐ lights, door F unlocks	open door F, press switch Ⓐ

* Bell sounds at start of each task

** Incorrect response results in shock from grids

Figure 4. Graphical diagram of the Kaplan-AFRRI Maze (KAM)

Two views of a checkback switch are shown in Figure 5. The location of these switches is indicated by the letters enclosed in circles on Figure 4.

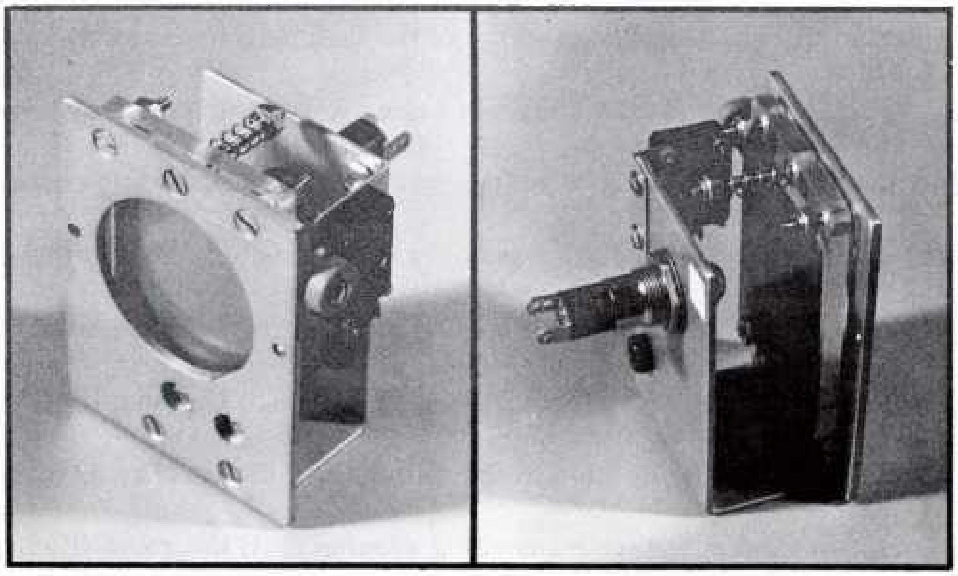


Figure 5. The checkback switch

Table I shows the details of the subjects.

Table I. Subjects and Experimental Conditions

Subject	Experimental Condition	Age	Weight (kilograms) Before Experiment	Weight (kilograms) After Experiment
B-22	I	3 yrs. 11 mos.	5.00	5.60
B-36	I	3 yrs. 2 mos.	4.00	4.30
B-42	II	3 yrs. 4 mos.	4.80	5.30
B-38	II	3 yrs. 2 mos.	4.60	4.90
B-30	III	4 yrs. 11 mos.	5.00	5.00
B-40	III	3 yrs. 2 mos.	5.30	5.80

All subjects were given two training sessions daily during the early portion of their training and one session only during the later stages. In general, the session length was determined by the experimenter and was based on the attention span and fatigue signs in a subject. As training progressed, the session length was determined by numbers of trials with the standard number per session being 30. All monkeys were trained daily, 5 days per week. On the 1st day each subject was allowed an adjustment period of 1 to 2-1/2 hours prior to the commencement of training. The lights in the room were kept at their highest intensity while the monkey explored the new surroundings with the experimenter observing through a one-way observation window. The lights were gradually lowered every 30 minutes to a point where the blue light of the checkback switch under surveillance by the monkey, would be clearly visible to the monkey above the ambient light in the room. This contrast was calculated to attract the subject's attention to the switch. As the training progressed, the lights were brightened during each succeeding session until the room illumination was at its highest intensity.

After the initial adjustment period, training the subject to operate the checkback switch was begun. The task was that of requiring the monkey to press the switch in response to the conditioned stimulus which consisted of a simultaneous presentation of the bell and the blue light behind the translucent plate of the checkback switch.

The subject was rewarded for making responses in the vicinity of the switch until correct response was made to a majority of conditioned stimuli presentations. The unconditioned aversive stimulus was a 0.1-second shock pulse delivered through the grid floor at the discretion of the experimenter. Manual control continued with time sequences variable until the responses became stable and accurate. When the subject's performance stabilized, the time interval between the conditioned stimuli presentations was 10 seconds.

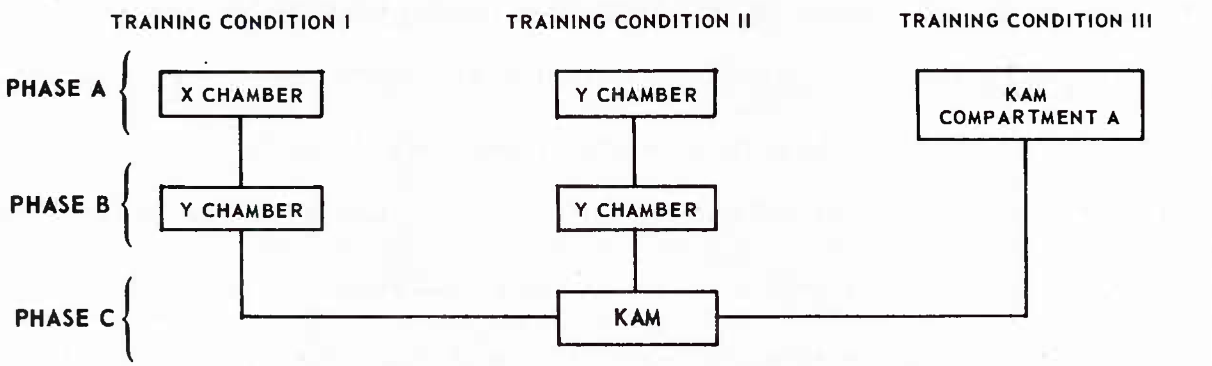
Training Under Condition I. The subjects trained under condition I were required to learn the checkback switch response in the X chamber. When they had reached a criterion performance at 90 percent correct in a training session of 25 to 50 trials (the number of trials determined by the subject's fatigue behavior and attention to the problem, or to his early success), the subjects were graduated to the Y chamber with the sliding door partition. This task required a subject to pass under the sliding door and press the checkback switch at the onset of the conditioned stimulus in the opposite end of the chamber. The criterion set for this phase was a performance level of 80 percent correct within a training session of 15 to 30 trials. When this criterion was achieved, the sliding door was replaced by the swinging-type door. The task remained the same except that the subject was required to push open the door to traverse the threshold from one chamber segment into the other in response to the conditioned stimulus. Maze training was initiated when the subjects achieved a performance level of 80 percent correct within 15 trials.

Training Under Condition II. Experimental condition II was basically identical to that of condition I with one exception: the Y chamber was used from commencement of training. The first task required of a subject was the response to the checkback switch with no partitions in the chamber. The sliding or swinging door was inserted when the subject reached a similar degree of performance as in condition I, and maze training in condition II was begun at the same stage of learning described for condition I.

Training Under Condition III. Experimental condition III training differed from conditions I and II, in that a subject was placed directly in compartment A of the maze, thus eliminating the separate X and Y chamber training. The monkey was trained to respond to the checkback switch which was presented in compartment A and when it had attained a performance level of at least 90 percent correct within 90 trials, it was graduated to learning the maze exits and the checkback responses in each maze compartment. Table II summarizes the basic procedures and performance levels achieved by the subjects under the three training conditions.

Prior to learning the maze traversal pattern, all the subjects were given an exploration period in the maze. The guillotine door between compartments A and B was raised and propped open and the two swinging doors separating compartments B and C were wired open thus allowing the subject an opportunity of investigating all exits in the first three compartments. This period was restricted to a maximum of 2 hours.

Table II. Summary of Basic Procedures



	RESPONSES REQUIRED:	CRITERIA OF MASTERY :
PHASE A	CHECKBACK SWITCH PRESS	CONDITIONS I AND II-90 % CORRECT IN A SESSION OF AT LEAST 25 TRIALS CONDITION III-90% CORRECT IN A SESSION OF 90 TRIALS
PHASE B	MOVEMENT THROUGH GUILLOTINE DOOR PLUS CHECKBACK SWITCH RESPONSE MOVEMENT THROUGH SWINGING DOOR PLUS CHECKBACK SWITCH RESPONSE	80% CORRECT IN A SESSION OF AT LEAST 15 TRIALS
PHASE C	TRAVERSAL OF KAM UNDER MANUAL CONTROLS	90% CORRECT IN A SESSION OF AT LEAST 90 TRIALS

In the maze, the manual mode of operation by the experimenter continued until a monkey was able to traverse the six compartments and respond correctly to all six checkback cues. During this period of training, the experimenter was present in the room which houses the maze. When the criterion of 100 percent correct was reached within 30 trials, the experimenter withdrew and the subject was left to perform in isolation. The experimenter continued to observe the progress of the subject through a one-way observation window and the maze was automatically programmed by the Animal Trainer Electronic (ATE).[1] The automatic timing sequence of the ATE presented the conditioned stimuli for each compartment 13 seconds after a correct response in the preceding compartment. The experimenter controlled the administration of shock during the initial stages of maze training from the exterior of the experimental room. When the subject had achieved a performance level of 100 percent correct within 120 trials, the automatic shock condition was programmed in the ATE. As a result, the subject was required to respond to the stimulus within 10 seconds after its onset or receive a continuous shock until an appropriate response was made. The training was terminated when the subject had completed 1050 trials at a performance level of between 93 and 100 percent correct on the completely automated program.

Data were recorded on paper and magnetic tape. Latencies were computed using automatic data processing methods. Subjects were observed on a closed circuit television system and their idiosyncratic behavior was noted. This equipment is described by Kaplan and Cooper.[1]

Subjects were trained in both morning and afternoon sessions in the early training stages for the purpose of accelerating the rate of learning and also to determine the influence that time of day might have upon learning. Training sessions for condition I subjects were at 9:00 a.m. and 1:00 p.m., for condition II subjects at 10:00 a.m. and 2:00 p.m., and for condition III subjects at 10:30 a.m. and 2:30 p.m.

Animals were divided into matched pairs for a subgrouping for two separate experimenters. Subgroup I consisted of animals B-22, B-42, and B-30; subgroup II contained animals B-36, B-38, and B-40. Each experimenter trained one animal in each of the three experimental conditions. This permitted evaluation of experimenter influences as a factor in the training. The two experimenters maintained as much constancy as possible in their procedures. Differences in procedure occurred only when unusual behavior of an animal required special treatment by the experimenter.

III. RESULTS

The average number of trials to criterion per subject and the average time to criterion per subject under the various phases of the three conditions of training are shown in Figure 6 and Figure 7, respectively. Phase A involved approximately half as many trials on the average under condition II (161 trials) as under condition I (296 trials) or condition III (291 trials) although the average time spent per subject was approximately equal to that spent under condition I (1.88 h and 1.97 h) and about half the average under condition III (3.93 h). Phase B involved approximately equal numbers of trials on the average under conditions I and II (75 and 81 trials). The time

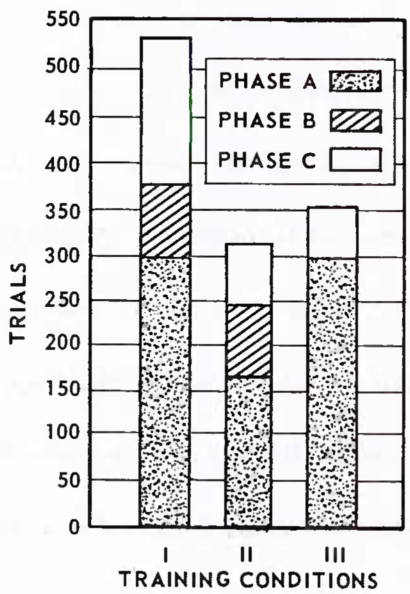


Figure 6. The average number of trials to criterion for the three training conditions

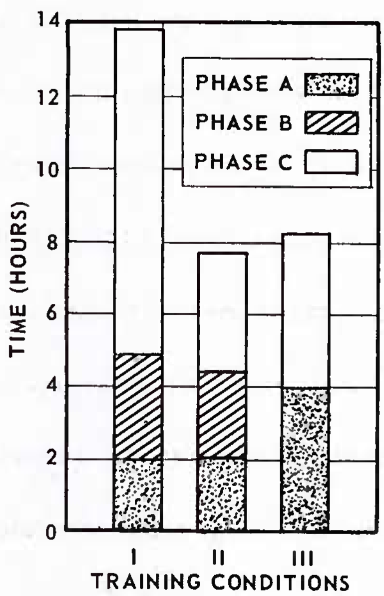


Figure 7. The average time to criterion for the three training conditions

spent under phase B was approximately 1/2 hour longer on the average under condition I. The third phase of training, phase C, took over twice as many trials on the average under condition I (157 trials) than either condition II (65 trials) or condition III (56 trials). The average time spent was also greater under condition I (9.02 h) than under condition II (3.30 h) or condition III (4.34 h). The subjects trained under condition I received a total of more trials and spent more total time in training than those under conditions II or III.

The major performance measure in the maze was the response latency measured from the onset of the stimuli presentation to the checkback switch response. These individual measures were averaged by compartment for each session in the maze and the averages were used in all further computations as the latency measures.

Stabilization of performance in the maze under automatic control was defined as occurring on the first of 2 successive days for which the average of the latency scores was not greater than the average of the succeeding 10 days latency scores. This definition allows the experimenter to establish a subject's level of performance without basing it entirely on 1 day's exceptional performance. All subjects had reached this performance level by the 9th day of training under automatic control. The response latency averaged over each day and for each condition as well as for all subjects is indicated in Figure 8. Averages for the three conditions of training are all approximately at the same level by the 6th day. The group curve shows that the average latency for traversal from one compartment to another is about 2 seconds once the subjects have learned the task. The average response latencies per day for each experimenter's subjects are shown in Figure 9. Although the difference is sometimes slight, it is significant that after the subjects' performance has stabilized as a group, the average for one group is never below the average for the other group.

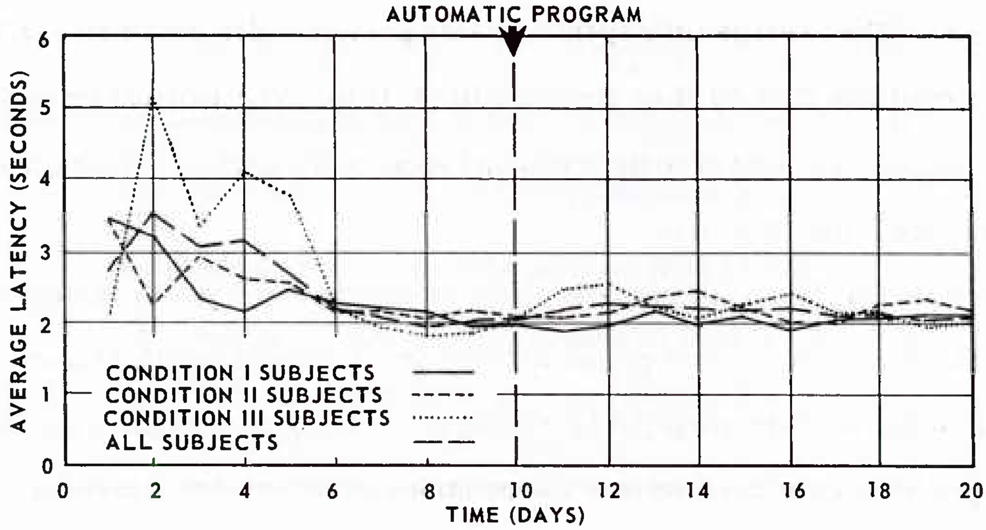


Figure 8. Average response latencies per day for all subjects starting with initial training through automatic programming

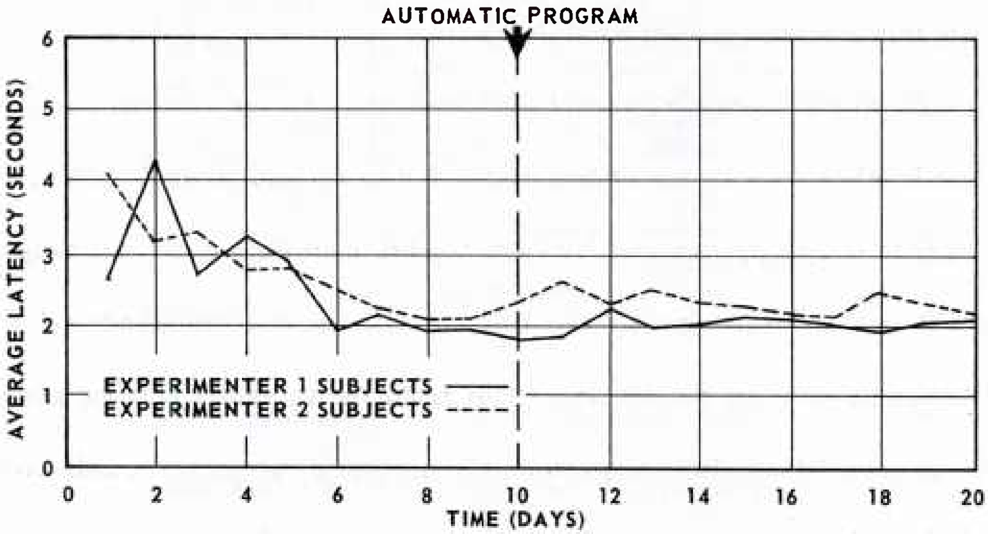


Figure 9. Average response latencies per day for the two experimenters' subjects starting with initial training through automatic programming

Days 11 through 20 of testing in the maze under automatic control were taken as a base line of performance on the maze traversal task. Morning latencies for this period averaged slightly faster (0.2 seconds) than the afternoon sessions' average (Figure 10). Averages of the latency scores per compartment for days 11 through 20 are shown in Figure 11 for the three differently trained groups and for the total group. The same pattern of averages is evident in two of the groups (conditions II and III) and to some degree in the third group (averages for exits A-B, D-E, and E-F). Similar patterns of response latencies are seen if the subjects are regrouped and averaged according to the experimenter who trained them (Figure 12). The subject trained under condition I by experimenter 2 developed a compartment response pattern which accounts for much of the variation shown in the averages in Figures 11 and 12.

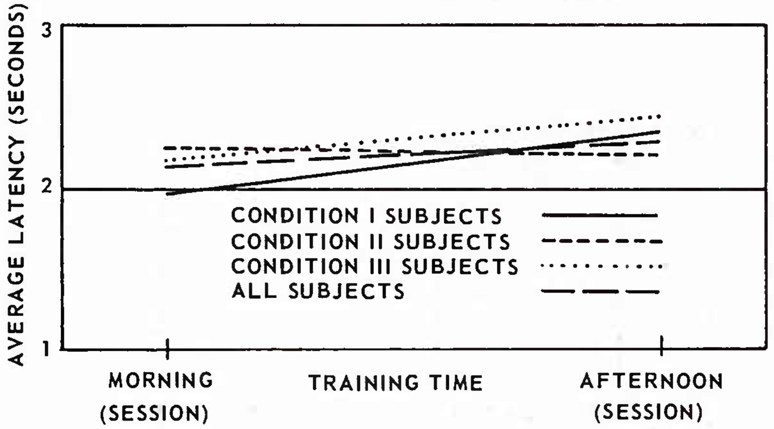


Figure 10. A comparison of morning and afternoon latencies by training condition

The errors committed by the subjects during the preautomatic control period have not been presented since factors for presentation of conditioned and unconditioned stimuli varied in the manual aspects of the program to meet the idiosyncrasies of a subject. During the manual operation phases, the principal interest was to show the

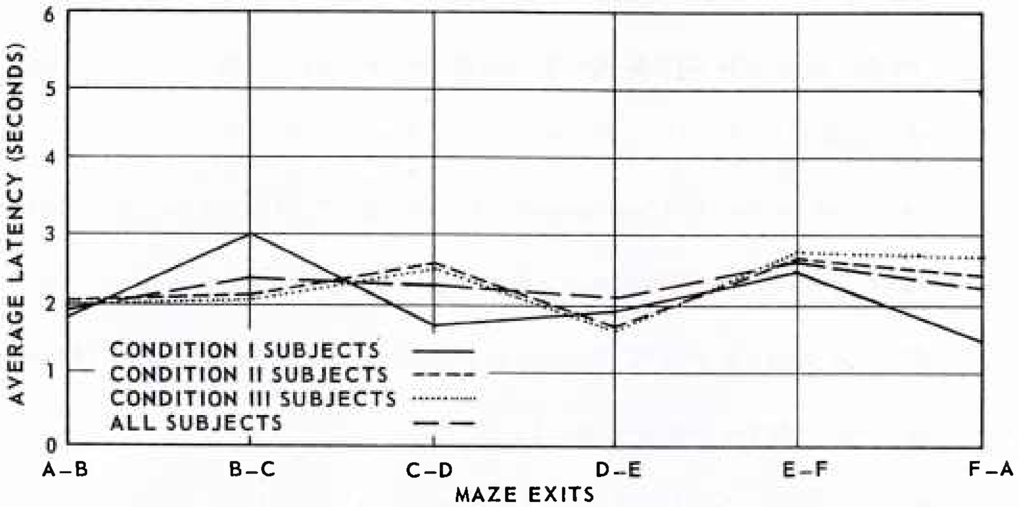


Figure 11. The average of the latency scores per maze compartment for training days 11 through 20

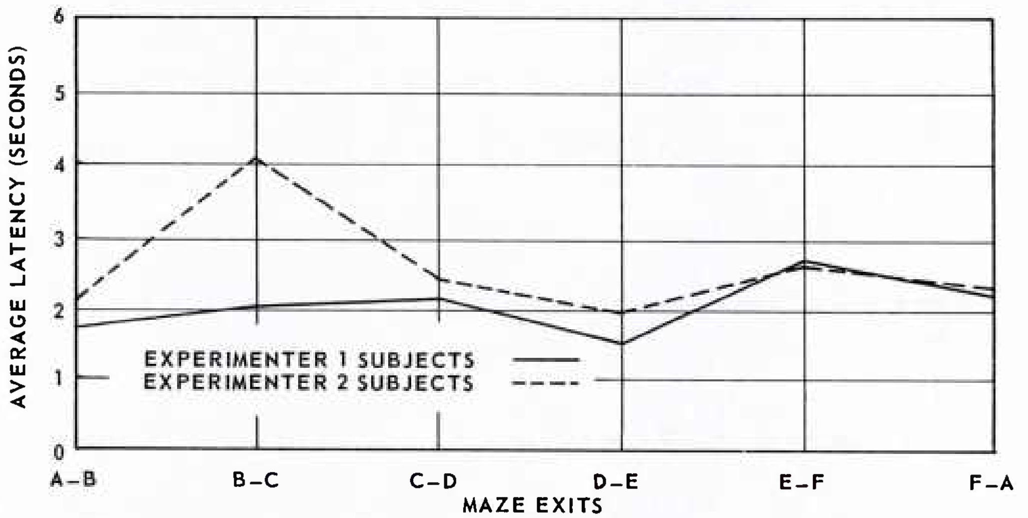


Figure 12. The average of the latency scores per maze compartment for the two experimenters' subjects

time and trials required to reach the criterion of mastery which permitted a subject to advance to the next stage of training.

The errors committed by the subjects after placement on the automatic program of 1050 trials in the maze were of three types:

1. Failure to respond to the checkback switch within a 10-second interval.

2. Failure to exit within the 10-second interval.

3. Retracing.

The first type of error, failure to respond to the checkback switch within the 10-second interval, resulted when a subject hit the checkback switch but did not completely close it. The stimuli would remain functioning until the correct response was made and a continuous shock began after 10 seconds.

Failure to exit within the 10-second time interval occurred when a subject was slow or hesitated in traversing from one compartment to the next.

Retrace type errors were defined as a subject making a correct response but keeping one of the doors open with a hand or foot thus retreating into the previous compartment. During the manual control phase in the KAM, retraces occurred most often between compartments A and B as the guillotine-type sliding door was operated by air pressure and would remain open long enough to allow the subject to return to compartment A.

The errors observed are shown in Table III. Condition I animals made an average of 4.5 errors, condition II animals made an average of 6 errors, and condition III animals made an average of 18 errors. Since condition III involved 22 errors of all types on the part of the poorest performer in a total of at least 1050 trials, it appears that the performances were markedly stable.

Certain idiosyncratic behavior was noted during training. The subjects trained under condition I developed various patterns of pacing and excessive movements. For example, subject B-22 was continually biting parts of the maze structure and scraping

Table III. Errors by Training Condition and Subject in the Maze

Condition	Subject	Type of Error			Total
		Checkback	Exit	Retrace	
I	B-22	0	0	1	1
I	B-36	3	0	5	8
				mean	4.5
II	B-42	2	1	2	5
II	B-38	5	0	2	7
				mean	6
III	B-30	3	9	2	14
III	B-40	3	18	1	22
				mean	18

its teeth along the sides of the Plexiglas walls. Subject B-36 developed bridging habits in KAM compartments A and C in order to avoid touching the shock grids even though no shocks were being transmitted. This behavior affected its overall performance to such a degree that for 4 consecutive training days in the maze, the scoring of performance accuracy was not possible as the animal would not traverse the maze. To overcome this type of behavior, all metal parts of the compartments that afforded a handhold for a subject were wired for shock. When unable to avoid the shock, subject B-36 began to respond to the conditioned stimulus (the bell and light) although his performance continued to be erratic for the succeeding 6 training days. It is of interest to note that prior to the development of bridging patterns, B-36 had been performing at a level of between 60 to 71 percent correct. Although B-22 developed biting habits, its performance was not affected to any appreciable degree as in the case of B-36.

During the course of training under condition II, both B-42 and B-38 developed peculiar movements. Subject B-42 performed ritual-type patterns of pacing and routine inspection of the maze construction. In the early stages of maze training, the subject found that it was able to lift the sliding door between compartments A and B thus escaping into compartment B prior to the onset of the conditioned stimulus. The experimenters secured the door before initiating the program and when the subject discovered that it was unable to lift the door, this behavior ceased. Other than biting the checkback light in response to the conditioned stimulus in compartments B and E, subject B-38 was observed to sit quietly in each compartment awaiting the next cue with no excessive movement.

The subjects trained under condition III, B-30 and B-40, remained quiet during the early phases of training and did not exhibit any development of idiosyncratic movements. B-30 continued to behave in this manner throughout the entire period of its training. However, B-40 developed the habit of swinging or sitting on top of the doors between compartments B and C. This occurred on the 23rd day of training when the subjects were on the completely automatic program. B-40 refused to exit from compartment C into D, thus avoiding any shock administered. The metal parts of the compartment which allowed the subject a handhold were wired for shock and after 3 days of erratic performance, the previous performance level of 100 percent correct was regained. B-40 also exhibited another behavioral pattern which did not affect its general performance in the maze. In responding to the conditioned stimulus in compartments B and E, this animal would hit the checkback switch from a position to the side of the switch. The animal would characteristically jump to the side as it hit the switch in these compartments.

IV. DISCUSSION

From the data obtained, it appears that while very little difference exists in the results obtained on the six subjects trained under the three experimental conditions, condition II is the procedure of choice for future work. It is recognized that this conclusion is based on two animals per sample and warrants further investigation.

While the two subjects of condition II may have been more docile and more intelligent performers, it is nonetheless clear that they learned the problem almost as rapidly as those of condition I (means for conditions I and II are 33 and 46 minutes, respectively). The two subjects of condition II advanced to maze training in 100 trials less than the number required for the other two groups and did this in a mean time lower than that of the other groups. These animals achieved mastery of the maze and progressed to automatic control most rapidly of the three groups.

Of the six animals studied, all but one reached the criterion of mastery in 20 days. The sixth achieved this goal in 27 days. A new subject was started every 1 or 2 weeks. At no time were more than four animals under training at the same time, thus allowing 3 hours in the morning and 3 hours in the afternoon for their respective runs.

Training time on automatic control of the ATE required approximately 8 minutes for one animal to make 30 responses or to traverse the maze five times. Setting up recording equipment required some additional time of the experimenter, but one trial session could be completed in less than 1/2 hour, thus permitting training of nine subjects in an 8-hour work day if each subject worked only a single session. The results suggest that animals once trained on this problem can be maintained at a high level of excellence by biweekly training, thus permitting the training of larger numbers of subjects during the same period. The six subjects under discussion were all trained during a 4-month period. It is clear that two animals per month can be trained under the regimen herein described. Obviously, with more complex tasks, training time will be longer and fewer subjects can be trained per given time.

The types of measure provided by this maze traversal pattern include examination of the subjects for their respective auditory and visual sensitivity and for their discrimination of pain from the shock. Moreover, factors involved in a conditioned response are clearly operative. In addition, a sense of time requisite to shock avoidance is necessary for effective performance.

Motor dexterity is required of a subject in terms of finger and hand manipulation of the checkback switches. More gross muscle units are called into play in order for a subject to perform the low hurdle response in traversing compartments C to D and the high hurdle in traversing compartments F to A.

Latency of response per compartment permits measure of motivation and fatigue. By decreasing the conditioned stimulus to the unconditioned stimulus time interval and by decreasing the conditioned stimulus to conditioned stimulus or compartment to compartment intervals, it is possible to increase the arduousness of the task and thus require an exercise stressor on a subject.

Every evidence in the results supports the hypothesis that the traversal task provides a stable response. While each subject manifests its own idiosyncrasies in learning and performing, its error scores are low and its compartment to compartment time of response would appear to be consistent for each subject. Time of day may affect the latency variability by compartment. This finding is not sufficiently documented at this time to permit conclusive comment.

The results additionally afford the following conclusions of interest in logistical planning:

a. Two experimenters are required for training animals under conditions I and II. Until automatically-operated X and Y chambers are constructed, the sliding and swinging door phases necessitate the assistance of a technician to manually operate the doors.

b. Two assistants may be necessary the 1st day or 2 of maze training until a subject has learned to exit properly and has discovered the checkback switches in all of the compartments. Two assistants are required for the phase during which the stimuli are presented automatically and shock is administered manually. This involves a period of 1 or 2 days depending upon the performance of a given subject. Communication is necessary between the central control room and the exterior of the maze room during this phase. Since an animal may retrace or discover a way of avoiding shock, the experimenter would be required to manually operate, terminate and/or restart a program. When an animal is placed on the completely automatic program and is proficient in maze traversal, one operator will suffice in the central control room. This operator is able to monitor this subject via closed circuit television and maintain adequate surveillance.

V. SUMMARY

Six male monkeys (Macaca mulatta), naive to psychological testing, were given training on a traversal pattern in a shock avoidance maze. Three training conditions were employed to determine the most efficient means for training subjects to master a problem in the shortest possible time. Performance was under automatic control and permitted stimuli to be presented every 10 seconds over a period of 8 minutes. Latencies ranged between approximately 1.5 and 3.5 seconds for conditioned stimulus-conditioned response intervals. It was shown that the task required of the subjects entailed an involvement of the auditory and visual senses as well as pain thresholds and learning a time sequence. The task involved motor dexterity as demonstrated by the use of muscles in the finger, hand, arm, and leg. Results indicated that these animals could learn the maze problem to a stable and high level of performance in 20 to 27 days. The training condition whereby the animals were first trained in a two-chambered box and graduated to the six-compartmented maze was deemed the most practical.

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Six male monkeys (Macaca mulatta), naive to psychological testing, were given training on a traversal pattern in a shock avoidance maze. Three training conditions were employed to determine the most efficient means for training subjects to master a problem in the shortest possible time. Performance was under automatic control and permitted stimuli to be presented every 10 seconds over a period of 8 minutes. Latencies ranged between approximately 1.5 and 3.5 seconds for conditioned stimulus-conditioned response intervals. The tasks required of the subjects entailed an involvement of the auditory, visual, and pain senses and also some form of temporal sense. In addition, the tasks involved a capacity for motor dexterity as demonstrated by the use of muscles required in the performance. Results indicated that these animals could learn the maze problem to a stable and high level of performance in 20 to 27 days. The training condition using the two-chambered box was chosen for subsequent studies because the subjects trained by this method performed to a degree deemed more efficient in comparison to the other methods.

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