AN EXPERIMENTAL STUDY OF THE EFFECT OF DIFFERENTIAL NON-REINFORCEMENT OF THE INCORRECT RESPONSE ON THE LEARNING OF THE CORRECT RESPONSE IN SIMPLE T-MAZE LEARNING

Thesis for the Degree of M. A.

MICHIGAN STATE COLLEGE

Morton D. Dunham

1949

This is to certify that the

thesis entitled

"An Experimental Study of the Effect of Differential Non-Reinforcement of the Incorrect Response on the Learning of the Correct Response in Simple T-maze Learning".

presented by

Morton D. Dunham

has been accepted towards fulfillment of the requirements for

Master of Arts degree in Psychology

M. Ray Denny

Major professor

Date November 29, 1949

AN EXPERIMENTAL STUDY OF THE EFFECT OF DIFFERENTIAL NON-REINFORCEMENT OF THE INCORRECT RESPONSE ON THE LEARNING OF THE CORRECT RESPONSE IN SIMPLE T-MAZE LEARNING

by

MORTON D. DUNHAM

A THESIS

Submitted to the School of Graduate Studies of Michigan State College of Agriculture and Applied Science in partial fulfillment of the requirements for the degree of

MASTER OF ARTS

Department of Psychology

1949

THESIS

ACKNOWLEDGEMENT

Grateful acknowledgement is made to Dr. M. Ray Denny for his advice and assistance throughout the course of this research.

TABLE OF CONTENTS

LIST OF TABLES

TABLE

LIST OF FIGURES

FIGURE

AN EXPERIMENTAL STUDY OF THE EFFECT OF DIFFERENTIAL NON-REINFORCEMENT OF THE INCORRECT RESPONSE ON THE LEARNING OF THE CORRECT RESPONSE IN SIMPLE T-MAZE LEARNING

INTRODUCTION

Extensive research has been carried out in regard to the concept of reward or reinforcement[1] in learning, and for many psychologists the strength of a habit is primarily a function of the number of reinforcements. Little is known, on the other hand, and little study has been made about the effect of non-reinforcement[2] or the non-reward of the incorrect response upon the learning of the correct response.

In recent analyses of discrimination learning and trial and error learning, Spence (4) and Hull (2) have found it necessary to incorporate the concept of non-reinforcement, assigning certain decremental or inhibitory properties to non-reinforcement. However, there exists

---

[1]Reinforcement refers to the strengthening of a stimulus-response relationship by fulfillment of a need or an expectancy; i.e. food reward for a hunger drive.

[2]Non-reinforcement or non-reward is the opposite of reinforcement and refers to the non-fulfillment of a need or an expectancy; i.e. the absence of food when hungry and expecting food.

very little experimental evidence to support the hypothesis of a cumulative, more or less permanent inhibitory effect from non-reinforcement of the incorrect response, even though it is well established that continuous non-reward of a previously reinforced response will be followed by the extinction of that response. In fact, separate studies by Spence (5) and Denny (1) which were only indirectly concerned with the role of non-reinforcement of the incorrect response upon the learning of the correct response, lead the above experimenters to question whether the non-reward of the incorrect response facilitates to any degree the learning of the correct response.

Spence (4), in the theoretical discussion of discrimination learning mentioned above, proposes that rewarding states of affairs result in the incremental strengthening of a response, and that non-reward results in the decremental weakening of a response. Each non-reinforcement leads to a decrement in the tendency of the reaction which just precedes the non-reinforcement. Spence (6) has used this same line of hypothesizing to explain transposition[3] phenomena in stimulus-response terms as opposed to a Gestalt patterning analysis. In his analysis it is

---

[3] Transposition refers to the tendency to respond to the relation between two stimuli rather than to either one of the absolute stimuli. Thus an animal which has been trained to select the brighter of two lights will often select the dimmer one (transpose) if it is presented together with a still dimmer light. The same phenomenon has been observed in regard to patterns, colors, and tones.

necessary to postulate both a stimulus generalization gradient[4] of excitation (reward) and a gradient of inhibition (non-reward) in order to give an adequate behavioristic explanation of transposition. Moreover, it is necessary that the inhibition of the wrong response be above and beyond any extinction effect suffered by both the correct and incorrect response through response alone; that is, through the inhibitory effect of reactive inhibition.[5]

In a similar discussion of trial and error learning, Hull (2) proposes that non-reinforcement results in the experimental extinction of incorrect responses. In his theoretical analysis, Hull hypothesizes about the changes that would occur in behavior under conditions in which three mutually incompatible responses are all elicited by the same stimulus, and only one of these responses - the weakest one - is the correct response. According to Hull's analysis the incorrect responses would gradually undergo extinction because of non-reinforcement, and the correct response would gradually be strengthened because of reinforcement. These reaction tendencies would compete and

---

[4]Stimulus generalization gradient refers to the generalization of response tendencies to similar stimuli which decreases proportionately with the increase in the difference between the original stimulus and the new stimulus.

[5]Reactive inhibition (I_R) is the drive state produced by a response which tends to inhibit the repetition of that response.

oscillate until the correct response by incremental reinforcement (strengthening) and the incorrect responses by decremental non-reinforcement (weakening) would no longer compete and the stronger correct response would always be elicited by the stimulus whenever it was presented.

Practically no experimental evidence exists in support of the above non-reinforcement hypotheses. In the learning of discrimination problems by chimpanzees, Spence (5) found that differential non-reinforcement of the incorrect responses had no effect on subsequent response strength of the correct response, unless these wrong responses had previously been reinforced.

Results similar to Spence's were obtained by Denny (1) in a partial reinforcement learning situation. Using a simple T-maze he found no differences in the learning of the following two groups: one group received 4 non-reinforcements to the incorrect side and 2 reinforcements to the correct side, the other group received 2 non-reinforced trials and also 2 reinforced trials to the correct side. However, Denny suggests that secondary reinforcing cues[6] in the delay boxes which were present just prior to the occurence of the non-reinforcement may have offset the effect of the subsequent non-reinforcement.

---

[6]Secondary reinforcing cues are those stimuli in a learning situation which have acquired a reward or subgoal value by being associated with reinforcing state of affairs.

At least one study with humans lends some support to the hypothesis that non-reinforcement of the incorrect response may aid in the learning of the correct response. Holsopple and Vanouse (3) conducted an experiment with eleven students of typing who were making four automatic and habitual errors in the spelling of words which outside of transcription they knew how to spell accurately. The students were given practice in which two of the words were constantly misspelled exactly as they had misspelled them in transcription, and in which two of the words were constantly practiced correctly. After equal amounts of practice the students were given dictation in which the four words appeared at least four times each. On the test no student made an error in spelling a word which he had practiced incorrectly while ten of the eleven students made errors on words practiced correctly.

Although there is little experimental evidence to support the hypotheses of Spence and Hull, it is assumed on the basis of their analyses that non-reinforcement of the incorrect response in a learning situation may operate to aid the learning of the correct response by weakening the incorrect response and thereby increasing the relative strength of the correct response. If experimental conditions could be arranged in two groups of subjects so that there were equal reinforcement of the correct response and

markedly unequal non-reinforcement of the incorrect response, it would be possible to test the above assumption.

The present study primarily attempts to do this, that is to compare learning under conditions of a differential amount of non-reinforcement of the incorrect response, and an equal amount of reinforcement of the correct response: and secondly, to compare the effects of differential non-reinforcement under conditions (1) where secondary reinforcing cues precede the non-reward end-box, and (2) where secondary reinforcing cues are eliminated as much as possible. The control of the secondary reinforcing cue aspect of the experiment was introduced because it was felt that perhaps the inconclusive or negative results obtained by other investigators were due to the camouflaging effects of preceding secondary reinforcement.

The complete hypothesis under investigation is that under conditions of controlled or minimized secondary reinforcement a definite difference in learning in favor of the greater non-reinforcement group will be found between the two groups receiving unequal amounts of non-reinforcement of the incorrect response; and, conversely, that under conditions of uncontrolled secondary reinforcement no significant difference in learning will be found between the groups receiving unequal amounts of non-reinforcement of the incorrect response.

EXPERIMENTAL PROCEDURE AND TECHNIQUE

A. Apparatus. The apparatus used was a single choice-point T-maze. The plan is shown in Fig. 1, and a photograph is shown in Fig. 2. The maze consisted of a starting box, a combination stem and constant choice-point, three interchangeable delay boxes, and two end-boxes or goal boxes. The apparatus was moveable and similar units were interchangeable. The sides and bottoms of all units were constructed of 3/4 inch, 4-ply veneering. The roof of the starting box was made of 1/4 inch veneering, that of the stem of glazed screen, the roof of the choice-point of translucent glass, those of the delay boxes of painted window-screen, and the roofs of the goal boxes was made of 1/4 inch hardware cloth. The translucent glass arrangement at the choice-point allowed the E to follow the path of the S through the choice-point without allowing the S to receive visual cues from the external environment. The roofs of the delay boxes of window-screen were painted so that the mesh was nearly entirely covered thus preventing S from seeing out.

Wooden doors constructed of 1/4 inch pine were placed at the exit of the starting box and at each end of the delay boxes. The door at the choice-point was T-shaped and was designed to prevent the S from retracing his path once a choice had been made (See figures 1 and 2). The sides of the units were slotted allowing the doors to slide perpendicularly, and the doors were operated by a

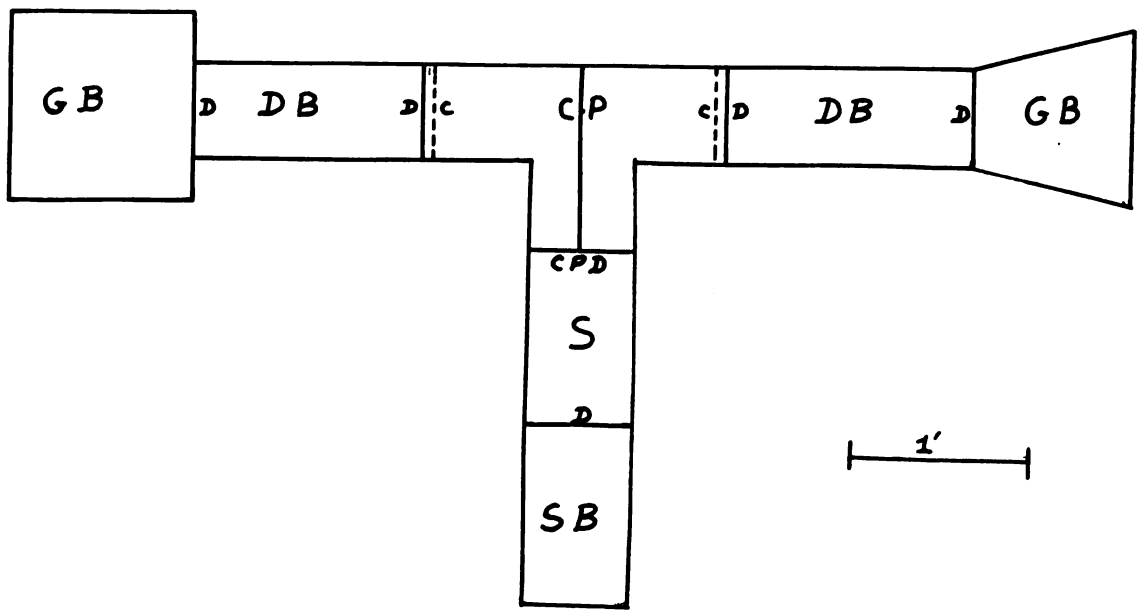

Figure 1

SB - starting box
S - stem
CP - choice-point
DB - delay box
GB - goal box
C - curtain
D - door
CPD - choice-point door

Figure 2

system of strings, pulleys, and counterweights suspended from the ceiling.

The goal boxes were constructed differentially in shape, size, color, and texture. The positive goal box was trapezoidal in shape, white in color, and was floored with thin gauge tin. The negative goal box was square, black, and floored with 1/4 inch hardware cloth.

Two of the delay boxes were painted grey, while the third was painted black and was floored with 1/4 inch hardware cloth to correspond to the negative goal box. Immediately in front of the entrances to the delay boxes a black curtain was suspended to prevent the S from receiving cues from the delay boxes while at the choice point intersection.

The starting box, stem and choice-point were painted grey.

Illumination was furnished by a 40 watt goose-necked desk lamp placed immediately above the stem so that it illuminated the interior of the stem and the choice point.

A mirror suspended at an angle over the choice-point allowed the E to follow the path of the S through the choice-point while E controlled the system of strings, weights and pulleys operating the doors from his position at the starting box.

B. Subjects. The subjects were albino rats from

the rat colony of the department of psychology of Michigan State College. The ages of the animals at the beginning of training varied from 130 to 150 days. A total of 62 animals were used of which 17 were males and 45 females.

C. Preliminary Training. All animals were placed on a strict food regimen one week prior to the experiment in which they were fed 8 grams of Purina Dog Chow per day at the same hour of the day as they were to run in the experiment. During this period the animals were handled to reduce emotionality. Two days prior to the day the learning series was to begin each group was run in a straight alley maze consisting of the starting box, one of the grey delay boxes, and one of the two goal boxes. These preliminary trials consisted of 3 experiences to the white goal box with food and 2 trials to the black goal box with no food for each of the two days. Thus the preliminary training consisted of a total of ten trials of which 6 were rewarded and 4 were non-rewarded.

D. Method of the Experiment. Following the preliminary training the animals were placed at random in one of three groups of either the experimental or control conditions.

Under the experimental conditions there were two groups of animals termed X-1 and X-4. The X-1 group consisted of 23 animals and the X-4 group consisted of 19 animals. They were run under conditions designed to con-

trol or eliminate secondary reinforcement of the incorrect response as much as possible. This was accomplished by using the black delay box followed by the black goal box, and the grey delay box followed by the white positive goal box. The animals in the X-1 group received a total of 3 trials per day, of which 1 was non-reinforced and 2 were reinforced. The animals in the X-4 group received a total of 6 trials per day, of which 4 were non-reinforced and 2 were reinforced. Thus each group of animals under the experimental conditions received an equal number of reinforced trials, and an unequal number (4:1 ratio) of non-reinforced trials per day.

The control group, designated K-4, consisted of 20 animals. They were run under conditions designed to produce secondary reinforcement in both delay boxes. This was accomplished by using the grey delay boxes interchangeably on both sides of the choice-point on both the reinforced and non-reinforced trials. It was assumed that both grey delay boxes which were used in both the preliminary training and in the training series in conjunction with the white positive goal box would acquire secondary reinforcing properties by being associated with the white box and through stimulus generalization. Thus on the non-reinforced trials in which the S was delayed in the grey delay box prior to entry in the negative black goal box, secondary reinforcement could operate to reinforce the

wrong response, and thus slow down the learning of the correct response.

The details of the daily experimental routine were as follows. On the first trial of the first day of the regular learning series each S was given a free-choice trial which was always followed by entry into the negative goal box and was thus non-reinforced. This response determined the preference and each S was trained to the side opposite this first free-choice.

The X-4 and K-4 groups were given free choices on the first two trials. On the third trial if a S had not completed a correct response it was forced to the correct side by blocking off the wrong alley at the choice point. After the third trial each S was given free choices until it had completed either 4 non-reinforced (NR) trials or 2 reinforced (R) trials. Any remaining trials were forced. In the event that an animal had made a correct response on one of the first two free-choice trials, it was continued on free trials until the completion of either 4 NR or 2 R trials and then it was forced. When the first two trials were correct responses an animal was, of course, forced to the incorrect side on the remaining 4 trials.

The X-1 group was also given 2 free-choice trials each day. In this group, for all animals that went wrong on the first trial, the forcing technique was modified for

the second trial. This was necessary in order to have only one NR trial and still have a measure using the first two free trials of each day. Instead of inserting the forcing block at the choice point, the door to the delay box on the incorrect side was closed and S was allowed to correct a partially wrong response and retrace its path to the correct side. Partially corrected responses were, of course, recorded as incorrect. All other forced responses were handled in the same manner as in the X-4 and X-1 groups. The criterion for having made a left or right response was the rat's touching the curtain with its nose.

All animals were delayed for 15 seconds in the delay boxes, and for 30 seconds in the negative goal box. If an animal refused to enter the goal box on non-reinforced trials it was removed from the delay box 60 sec. after the end-box door was opened. An animal which refused to leave the choice-point in 60 seconds was removed. Records were kept of such incomplete responses.

Food reward consisted of one medium-sized pellet of Dickinson Dog Food, about 0.35 grams. At the end of a day's run the animals were fed 8 grams of Purina Dog Chow in individual cages before return to the home cage.

The animals were picked at random from the home cage so that they were not ran in the same order on succeeding days of experimentation.

All animals were trained for a period of 9 days.

RESULTS AND DISCUSSION

A. Learning Measures. The measures of learning used were the mean numbers of correct responses on the initial trial and on the first two trials of each day. The initial trial measure was used because it provides for equalization of the number of previous food reinforcements, and because initial trials are not affected by the tendency towards spontaneous alternation. The mean number of correct responses on the first two trials of each day is considered to be a more stable measure because it provides for twice as many responses as the initial trial measure.

B. Comparison of learning for the three groups based on the first two trials measure. The results for the three groups based on the percentage of correct responses for the first two trials per day are shown in Fig. 3 and Table I. From an examination of the learning curves for the two experimental groups, X-4 and X-1, it will be seen that the X-4 group learns considerably faster than the X-1 group. On the last day of training the X-4 group is responding at a performance level of 87% correct, whereas the X-1 group has only attained a level of 62% correct responses. From Table I it is apparent that the overall learning scores for the two groups, based on days 2 to

Figure 3 - Learning curves for the three groups based on the percentage of correct responses for the first two trials per day.

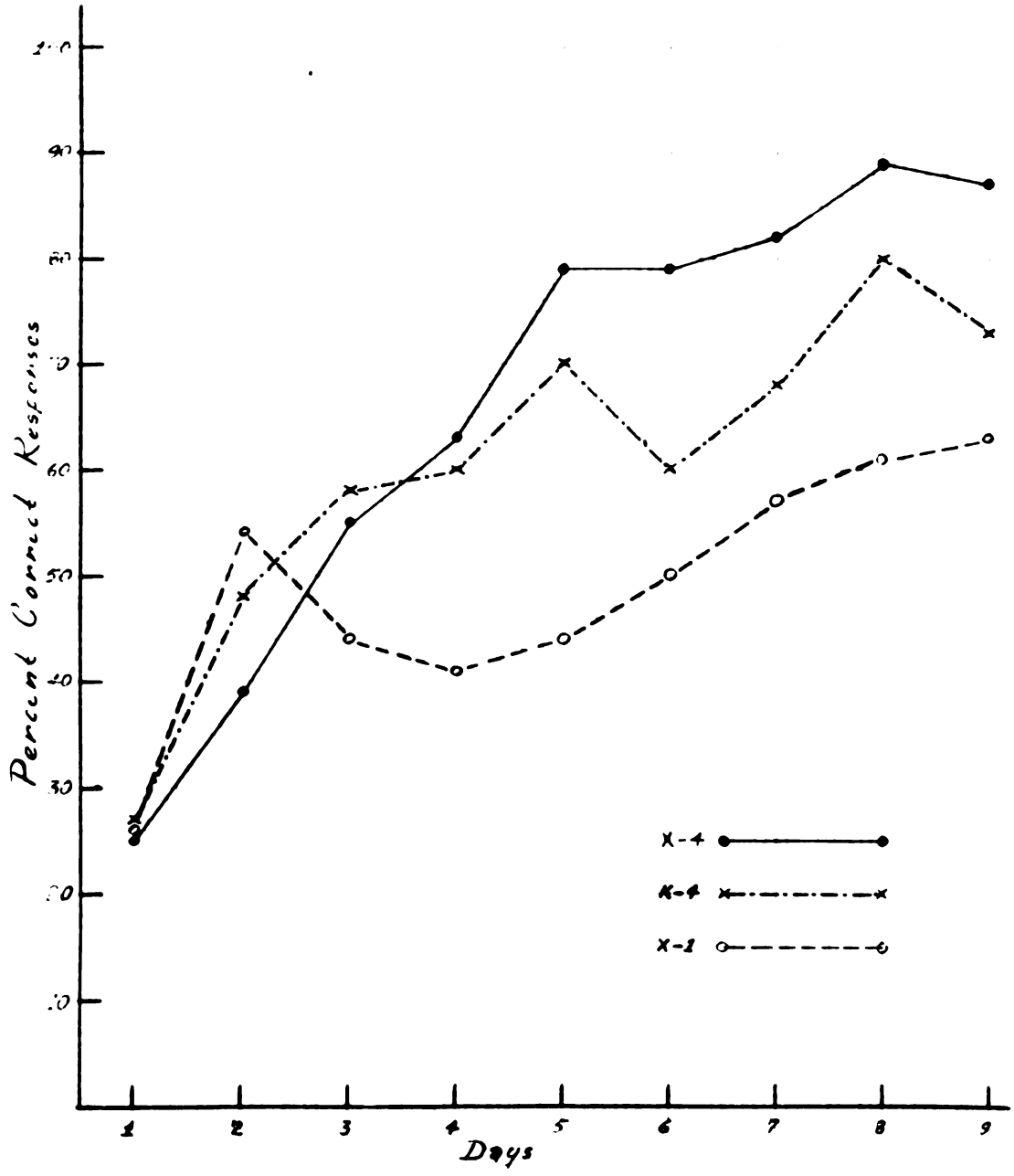

TABLE I

Comparison of the X-1 and X-4 groups and the X-1 and K-4 groups in terms of the mean number of correct responses on the first two trials per day for days two to nine.

Group	N	Mean	σ	σ_M	Diff	t	P
X-1	23	8.26	4.26	.91	3.21	2.63	.01 - .02
X-4	19	11.47	3.47	.82			
X-1	23	8.26	4.26	.91	2.04	1.81	.05 - .10
K-4	20	10.30	2.93	.67			

9[7], are significantly different. The mean difference of 3.21 correct responses for the first two trials gives a *t* of 2.65 which is significant between the one and two percent levels of confidence. A comparison of the X-1 group and the K-4 group shows that the learning curves are not as widely separated as in the X-1 and X-4 groups. However, the mean difference for these two groups for days 2 to 9 is 2.04 correct responses giving a *t* of 1.81 which is significant between the five and ten percent levels of confidence. These findings largely agree with the expectations as set forth in the introduction. As predicted the difference between the X-4 and X-1 groups is significant. It was also predicted that the difference between the K-4 and X-1 groups would not be significant, and while the results based on the first two free trials do not clearly support this hypothesis, the findings show a smaller difference between the latter two groups.

C. Comparison of learning for the three groups based on the initial trial measure. The results for the three groups based on the percentage of correct responses for the initial trial per day are shown in Fig. 4 and Table II. These results are in close agreement with the results using the first two trials measure. From Table II

---

[7]The data for the first day are excluded because the variable of differential non-reinforcement did not operate until after the first day of experimentation.

Figure 4 - Learning curves for the three groups based on the percentage of correct responses for the initial trial per day.

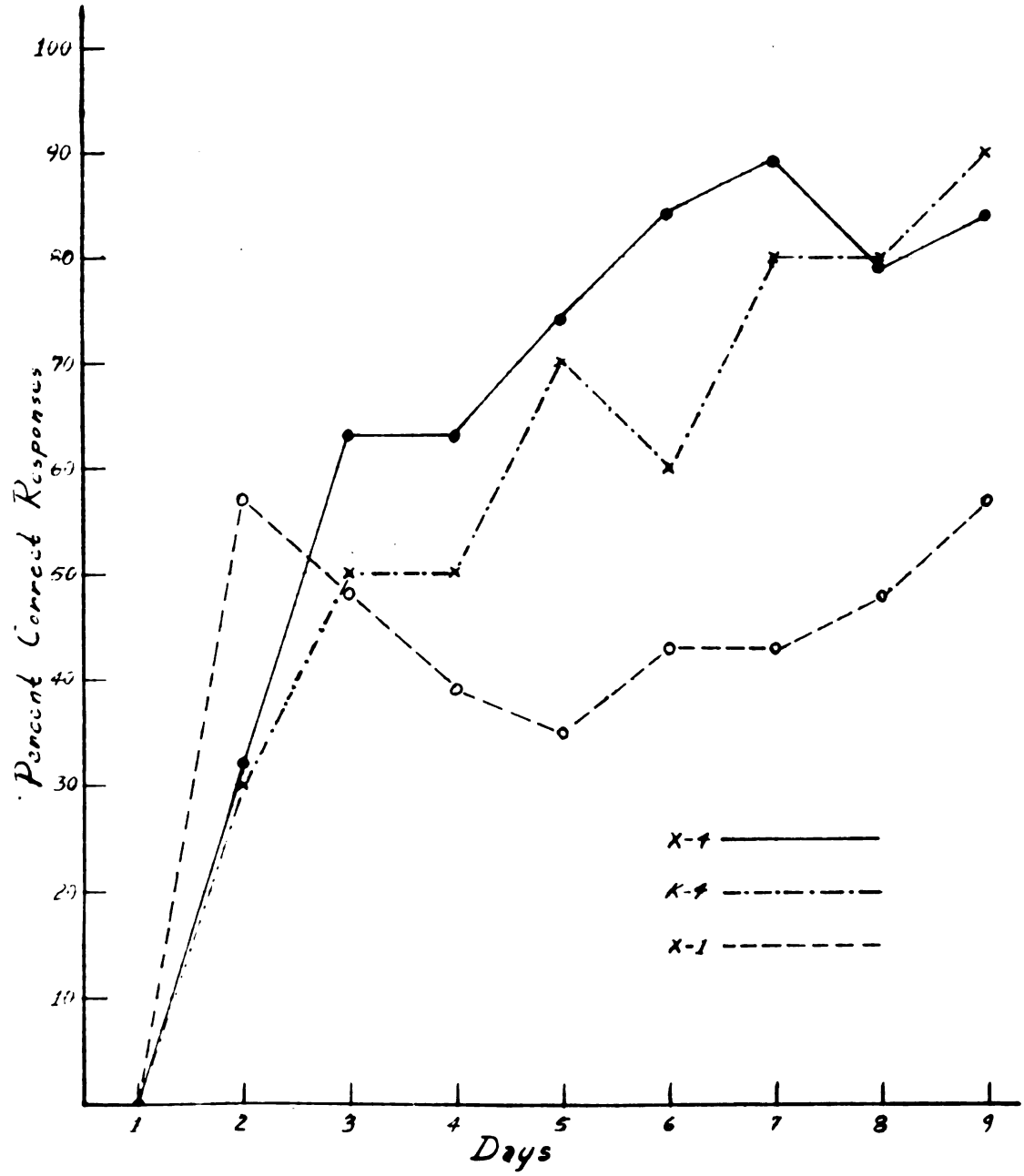

TABLE II

Comparison of the X-1 and X-4 groups and the X-1 and D-4 groups in terms of the mean number of correct responses on the initial trial per day for days two to nine.

Group	N	Mean	σ	σ_M	Diff	t	P
X-1	23	3.70	3.63	.77	1.98	2.13	.02 - .05
X-4	19	5.68	2.21	.52			
X-1	23	3.70	3.63	.77	1.35	1.53	.10 - .20
K-4	20	5.05	1.83	.42			

it will be seen that the difference between the X-4 and X-1 groups is significant between the two and five percent levels of confidence, while the difference between the K-4 and X-1 groups is signficant only at the twenty percent level of confidence. These findings support the theoretical expectations as given in the introduction.

An examination of the learning curves for the X-1 group in Figures 3 and 4 reveals a rapid rise in performance on the second day followed by a sudden fall on days 3 and 4 for the two trials measure and a fall on days 3, 4, and 5 for the initial trial measure. The higher score on the second day in the X-1 group may possibly be explained by the fact that all Ss in this group are consistently reinforced to the correct side on the last two trials of the first day, whereas most of the Ss of the X-4 and K-4 groups received secondary reinforcement of the wrong response by way of the delay box for the last two trials. The decrease in performance in group X-1 may possibly be explained by the fact that any rewarding property originally possessed by the negative delay box extinguishes much more slowly because there is only one non-reinforcement to that side per day.

D. Comparison of learning of the three groups with regard to strength of initial preference. It will be recalled that on the first trial of the first day of the regular training series each S was given a free-choice trial

Figure 5 - Learning curves for the three subgroups with a strong position preference as based on the percentage of correct responses for the first two trials per day.

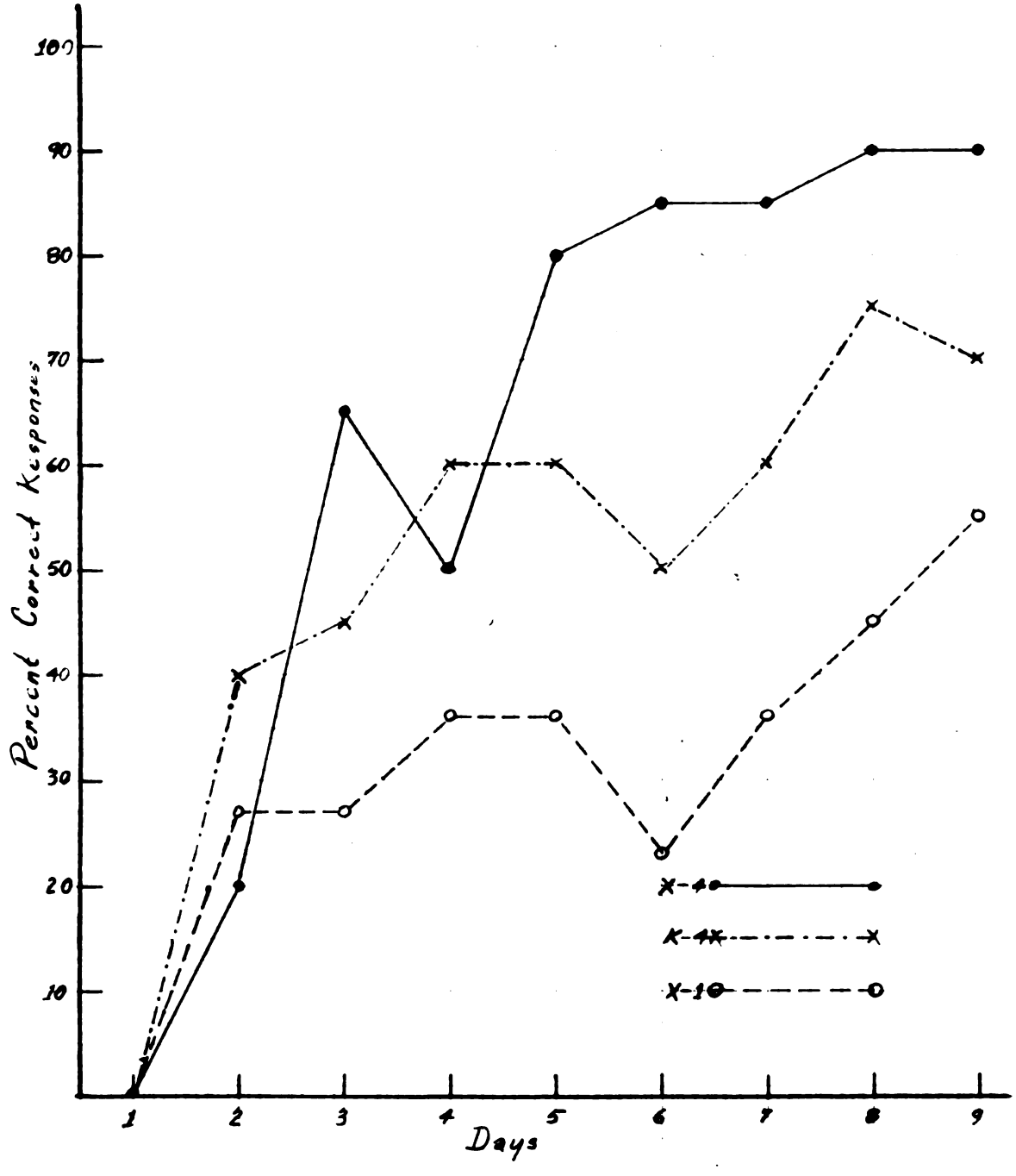

TABLE III

Comparison of the X-1 and X-4 subgroups and the X-1 and K-4 subgroups with a strong position preference in terms of the mean number of correct responses on the first two trials per day for days 2 to 9.

Subgroup	N	Mean	σ	σ_M	Diff	t	P
X-1	12	5.75	3.59	1.14	5.57	3.74	$<.01$
X-4	10	11.30	2.86	.95			
X-1	12	5.75	3.59	1.14	3.47	2.35	.02 - .05
K-4	10	9.20	2.89	.96			

in order to establish a position preference, and that each S was trained opposite to this preference. Inasmuch as each S was also given a free-choice on the second trial it was possible to estimate the relative strength of the preference. Those Ss going left-left or right-right on the first two trials were designated as having a strong position preference, and those Ss going left-right or right-left on the first two trials were designated as having a weak position preference. In this manner each of the three groups, X-4, X-1, and R-4, was divided into two sub-groups of strong or weak preference, and a comparison of learning for each of the sub-groups with a strong or weak preference was made. These comparisons follow.

E. Comparison of learning for the three sub-groups with a strong position preference as based on the first two trial measures. The results for the three sub-groups with strong position preference based on the percentage of correct responses for the first two trials per day are shown in Fig. 5 and Table III. An examination of the learning curves in Fig. 5 reveals that the X-4 strong preference subgroup learns considerably faster than the X-1 group with strong preference. The X-4 group on the ninth day has attained a level of 90% correct response, whereas the X-1 group has only reached a level of 55% correct response on the ninth day. The R-4 group falls between the two reaching a level of 70% correct response. It may be

seen in Table III that the difference between the X-4 and X-1 group is significant at less than one percent level of confidence, and that the difference between the X-1 and K-4 group is significant between the two and five percent levels of confidence. These findings fully support the original hypothesis that a significant difference would be found between the X-1 and X-4 groups. The hypothesis that no significant difference would be found between the X-1 and K-4 groups is not borne out, although, as in the comparison between the complete groups, a smaller difference is found between the latter two groups. It should also be noted, that the decrement in performance of the X-1 group on days 3 and 4 as observed in Fig. 3 does not occur in the sub-group composed of Ss with a strong position preference. As will be shown later, the decrement comes from the Ss with a weak position preference.

F. Comparison of learning for the three sub-groups with a strong position preference as based on the initial trial measures. The learning curves for the strong preference sub-groups based on the initial trial measure do not differ appreciably from those based on the first-two trial measures. The results are shown in Fig. 6 and Table IV. The difference between the X-1 and X-4 sub-groups is again significant beyond the one percent level of confidence, and the difference between the X-1 and K-4 sub-groups is also

Figure 6 - Learning curves for the three subgroups with a strong position preference as based on the percentage of correct responses for the initial trial per day.

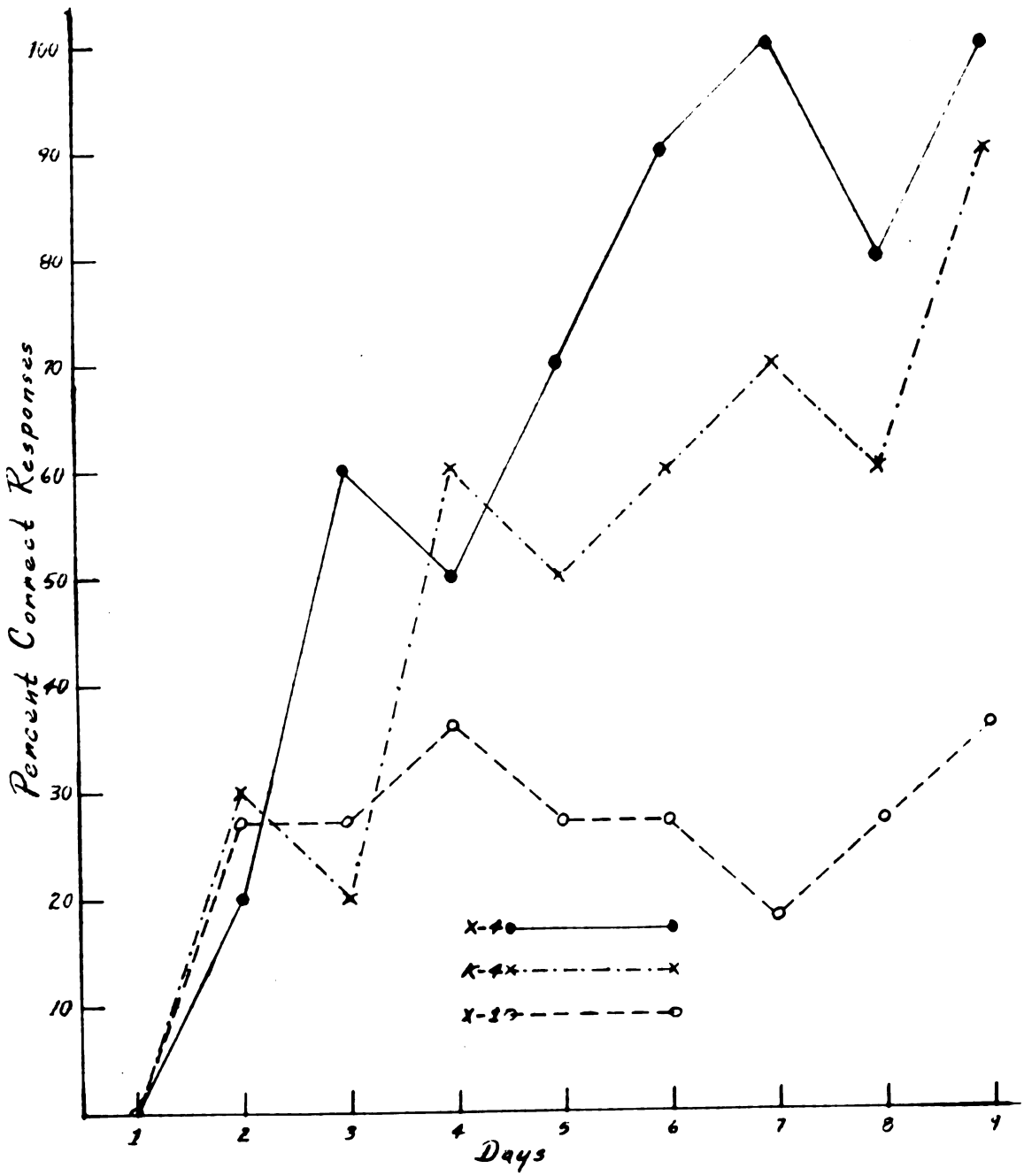

TABLE IV

Comparison of the X-1 and X-4 subgroups and the X-1 and K-4 subgroups with a strong position preference in terms of the mean number of correct responses on the initial trial per day for days two to nine.

Subgroup	N	Mean	σ	σ_M	Diff	t	P
X-1	12	2.27	2.26	.72	3.43	3.73	$<.01$
X-4	10	5.70	1.73	.58			
X-1	12	2.27	2.26	.72	2.04	2.14	.02 - .05
K-4	10	4.30	1.85	.62			

significant between the two and five percent levels of confidence. One of the most obvious and significant findings in this preference analysis is that the X-1 sub-group with the strong position preference to the wrong side showed, over a period of nine days little if any learning of the correct response after the second day. Contrariwise the X-4 strong position preference sub-group shows a great deal of learning, even more, as will be shown later, than the X-4 weak position preference group. This seems to indicate that in order for a strong, incorrect habit to be overcome by a weak, correct habit within a limited number of trials it is necessary that there be available a certain minimum number of trials of the wrong habit for the extinction of this response.

G. Comparison of learning for the three sub-groups with a weak position preference as based on the first two trial measure. The results for the three sub-groups with weak position preference based on the percentage of correct responses on the first two trials are shown in Fig. 7 and Table V. These learning curves show a much different pattern than has been revealed heretofore. The most outstanding characteristic of these curves is their variability and fluctuation. In all three sub-groups the learning fluctuates widely from day to day, learning is not appreciable, and smooth clear-cut learning curves are not found. Also to be noted again is the large decrement in

Figure 7 - Learning curves for the three subgroups with a weak position preference as based on the percentage of correct responses for the first two trials per day.

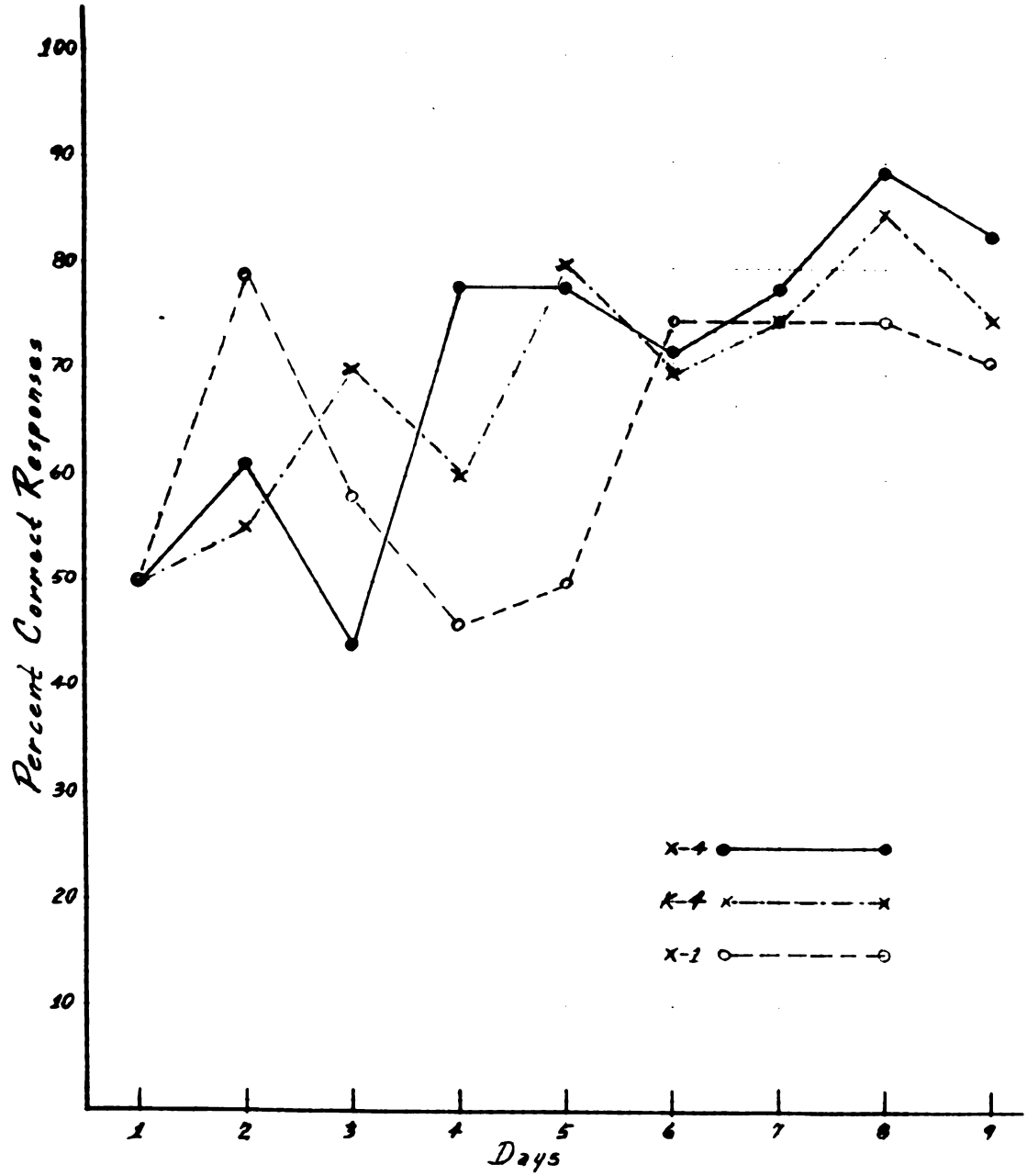

TABLE V

Comparison of the X-1 and X-4 subgroups and the X-1 and K-4 subgroups with a weak position preference in terms of the mean number of correct responses for the first two trials per day for days two to nine.

Subgroup	N	Mean	σ	σ_M	Diff	t	P
X-1	11	10.58	3.41	1.03	1.09	.63	.50 - .60
X-4	9	11.67	3.96	1.40			
X-1	11	10.58	3.41	1.03	.82	.66	.50 - .60
K-4	10	11.40	2.11	.70			

performance in the X-1 sub-group. A slight decrement is also observed in the X-4 and K-4 sub-groups when weak position preferences are present. Table V shows that no significant difference obtains between the X-1 and X-4 sub-groups and between the X-1 and K-4 sub-groups; the ts are between the fifty and sixty percent levels of confidence for both comparisons. These findings clearly indicate that the degree of position preference plays a significant role in determining the course of learning under the present experimental conditions.

H. Comparison of learning for the three sub-groups with a weak position preference as based on the initial trial measure. Figure 8 and Table VI reveal substantially the same findings for the weak preference sub-groups when the initial trial measure is employed except that the X-4 group shows little day to day fluctuation. There are no significant differences between the X-1 and X-4 sub-groups and between the X-1 and K-4 sub-groups. The inconsistency in performance of the weak position preference sub-groups and the fact that the overall performance and final level of performance in the X-4 and K-4 groups is no better than in the group with the strong preference to the wrong side poses the question as to what is the relationship between speed of learning and final level of performance and the strength of the initial response

Figure 8 - Learning curves for the three subgroups with a weak position preference as based on the percentage of correct responses for the initial trial per day.

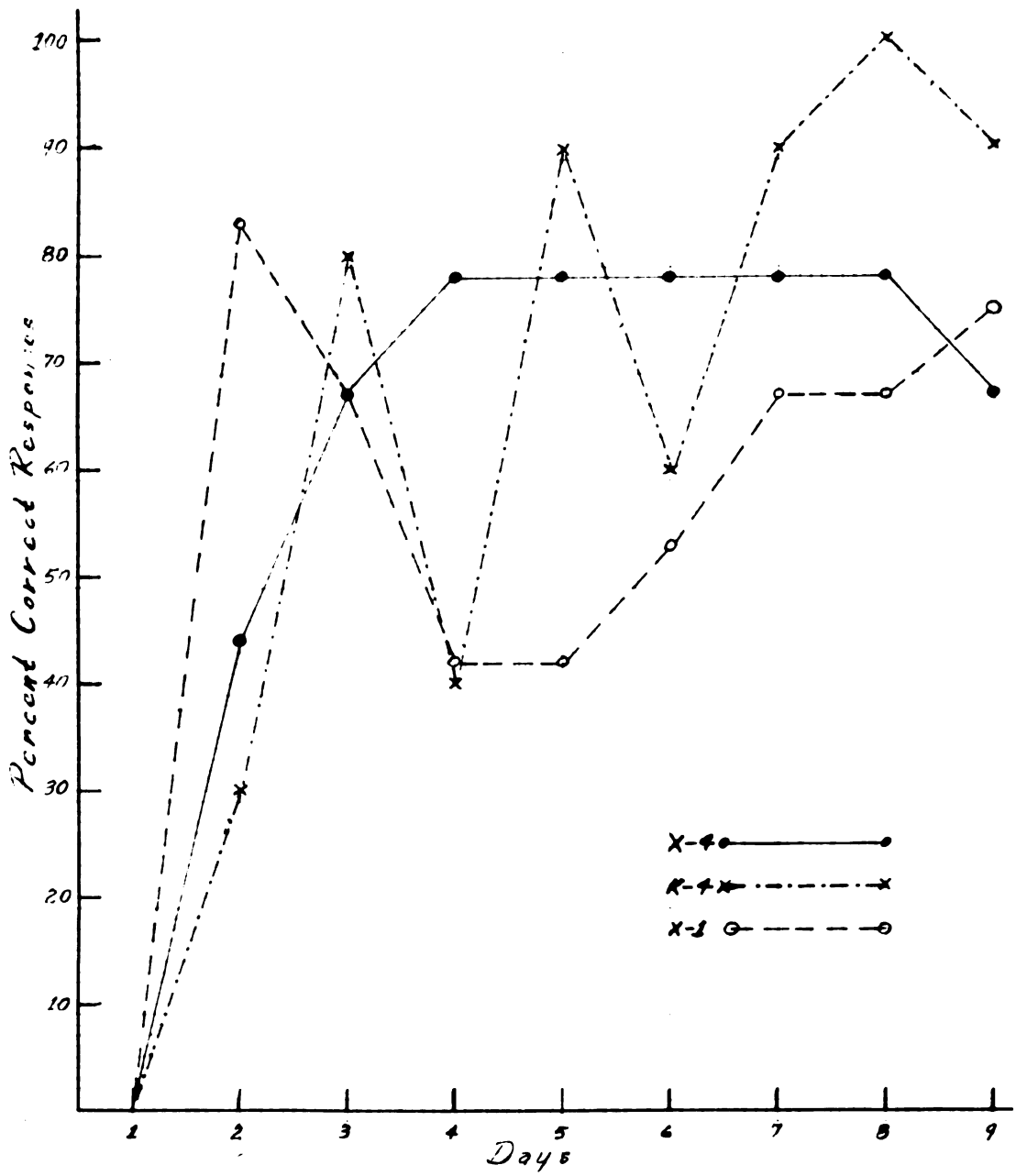

TABLE VI

Comparison of the X-1 and X-4 subgroups and the X-1 and K-4 subgroups with a weak position preference in terms of the mean number of correct responses on the initial trial per day for days two to nine.

Subgroup	N	Mean	σ	σ_m	Diff	t	P
X-1	11	5.00	2.35	.71	.67	.57	.50 - .60
X-4	9	5.67	2.63	.93			
X-1	11	5.00	2.35	.71	.80	.93	.30 - .40
K-4	10	5.80	1.47	.49			

tendency as measured by the direction of the initial response in a T-maze situation. From these data the relationship does not clearly seem to be one in which training against a strong preference will take more trials than training against a weak response, that is, as current learning theory would predict. More research would seem to be warranted in this direction.

ADDITIONAL THEORETICAL CONSIDERATIONS

The fact that a significant difference in learning was obtained between the complete groups receiving unequal amounts of non-reinforcement to the incorrect side indicates that non-reinforcement of the wrong response in a differential response situation is an important factor in the learning of the correct response. The fact that both of the groups which received 4 non-reinforcements per day learned significantly better than the *X*-1 group seems to indicate that secondary reinforcement does not appreciably counteract the effects of subsequent non-reinforcement, at least under the temporal and stimulus conditions employed in the present study. In this context it should be pointed out that in the *X*-4 group, the group in which the delay boxes were made differential, that the differences between

the boxes were not striking. Both boxes were the same size and shape and possibly indiscriminably different in brightness, since one was grey and the other black, with little light entering either box. The main difference was probably in the tactual impressions from the floor, but under-the-surface floor-cues were uncontrolled. In other words some animals of the X-4 group may have received secondary reinforcement for wrong responses by way of stimulus generalization for a considerable number of trials. Also for all groups, cues at the choice-point were uncontrolled and could have served to reinforce wrong responses secondarily. All this means, of course, is that despite the symmetrical properties of the maze non-reinforcement to the incorrect side is a significant variable.

It also seems probable that whatever cues are distinctive in the total maze situation may acquire the property to mediate non-reinforcement. After a number of days of training any secondary reinforcing values (positive expectancy) possessed by the cues on the wrong side seems to extinguish. In turn these cues seem to acquire negative expectancy value. This hypothesis is based on the typical recoil behavior of the animals in the X-4 group on the trials to the wrong side late in the learning series.

Furthermore, the X-4 subjects which were performing near the one-hundred percent correct level early in the learning series showed characteristic behavior on being

forced to the incorrect side. These Ss attempted to climb out of the maze at the choice-point, ran back and forth in the stem, and upon finally entering the negative goal-box immediately tried to climb out of the box. This frustration type behavior and the fact that the inter trial interval was fifteen minutes or more may be considered as evidence against interpreting the inhibitory or extinguishing properties of the non-reinforced trials as due to reactive inhibition. Rather, we postulate that a frustration drive state produced by repetitive non-reinforcement makes the animal avoid the cues on the wrong side and makes possible the reinforcement of a response which avoids these cues; that is, additionally rewards a response to the correct side. Such a state of affairs would account for the faster learning in the X-4 and K-4 groups.

The present findings support the theoretical hypotheses of Hull (2) and Spence (4) in assigning decremental or inhibitory properties to non-reinforcement. However it should be emphasized that the relationship between non-reinforcement and the strength of the original response is some function whereby an increase in the position preference to the wrong side increases the importance of non-reinforcement of the wrong response in the learning of the correct response. This relation might be expected from current stimulus-response learning theory. Thus with a large differential between opposing response tendencies,

the combined decremental and incremental process which weakens the strong incorrect tendency as well as strengthens the correct tendency will allow the correct and originally weaker response tendency to develop to a point of dominating the incorrect response in a fewer number of trials. This hypothesis now has empirical confirmation. Further experiments need to be directed towards determining the effect of the strength of the original position preference on differential response learning.

The present findings, however, do not agree with the results obtained by Denny (1) in a similar experimental set-up. Why does the present study indicate that non-reinforcement is a relevant variable while the study by Denny gave negative evidence? The main difference between these two studies is probably the difference in the ratio and the absolute number of non-reinforcements given. In the study by Denny one group received 2 reinforced and 4 non-reinforced trials per day and the other group received 2 reinforced and 2 non-reinforced trials per day. Therefore, the ratio was 2 to 1 as compared to the 4 to 1 ratio in the present study, and the group which had the lesser number of non-reinforced trials in Denny's study received 2 non-reinforcements per day as contrasted to the one non-reinforcement per day given the X-1 group in the present study. Because the learning curve for the X-1 group is abnormally depressed (see Figs. 3 and 4) it is very likely that the crucial factor in showing that non-rein-

forcement was an important variable was the fact that only 1 non-reinforcement instead of 2 was given.

It is also true that secondary reinforcement in the delay box was uncontrolled in Denny's study, but we see from the present results that this factor played only a minor role in negating the influences of non-reinforcement.

SUMMARY AND CONCLUSION

This experiment was designed to test the hypothesis that a significant difference in learning in favor of the greater non-reinforcement group would be found between two groups receiving equal reinforcement of the correct response and unequal non-reinforcement of the incorrect response, especially if secondary reinforcement on the wrong side was minimized as much as possible.

The apparatus was a single choice-point T-maze consisting of interchangeable parts, and designed to control secondary reinforcement and extra-maze cues as much as possible.

Subjects were 62 albino rats of which 17 were male and 45 were females. The Ss were divided into three groups: (1) The X-4 group consisted of 19 Ss which received 2 reinforced trials to the correct side and 4 non-reinforced trials to the incorrect side per day. (2) The X-1 group consisted of 23 Ss which received 2 reinforced trials

to the correct side and 1 non-reinforced trial to the wrong side per day. In both of the X groups secondary reinforcement was controlled as much as possible. (3) The K-4 group consisted of 20 Ss which received 2 reinforced trials to the correct side per day and 4 non-reinforced trials to the incorrect side per day. In the K-4 group secondary reinforcement was uncontrolled. All groups received training for 9 days.

The results in terms of the mean number of correct responses from days 2 to 9, based both on the first-two trial measure and on the initial trial measure revealed a significant difference between the groups X-4 and X-1. The differences between the X-1 and K-4 groups though still in favor of the K-4 group was somewhat less significant.

Each of the three groups were divided into two sub-groups on the basis of the relative strength of the initial position preference. It was found that with the sub-groups with the strong position preference to the incorrect side the differences between the X-1 and X-4 sub-groups and the X-1 and K-4 sub-groups were large and even more significant than with the complete groups; while all differences between the weak position preference sub-groups were small and insignificant.

Evidence of a frustration type of behavior was observed in some S upon receiving forced non-rewarded responses to the wrong side and some theoretical implica-

tions of this behavior were discussed.

From the present study the following conclusions seem warranted.

1. Differential response learning, in addition to being a function of the number of reinforcements may also be a function of the number of non-reinforcements of the incorrect response. This has been found to be true when a differential of four non-reinforcements to one has been used.

2. If secondary reinforcement of the incorrect response precedes non-reinforcement of the incorrect response there seems to be a slight but noticeable slowing in the learning of the correct response. With better control of secondary reinforcement this affect might be even more noticeable.

3. In general an increase in the strength of the position preference to the wrong side increases the effect of the non-reinforcement of the wrong response on the learning of the correct response.

4. Simple T-maze learning seems to be a rather unexpected and complicated function of the strength of the original position preference.

BIBLIOGRAPHY

References

1. Denny, M. R., The role of secondary reinforcement in a partial reinforcement learning situation. J. Exp. Psych. 1946, 36, 373-389.

2. Hull, C. L., Simple trial and error learning. J. Comp. Psych. 1939, 27, 233-258.

3. Holsopple, J. Q. and Vanouse, I., A note on the beta hypothesis of learning. School and Society. 1929, 29, 15-16.

4. Spence, K. W., The nature of discrimination learning in animals. Psychol. Rev. 1936, 43, 427-449.

5. Spence, K. W., Analysis of the formation of visual discrimination habits in chimpanzees. J. Comp. Psych. 1937, 23, 77-100.

6. Spence, K. W. The differential response in animals to stimuli varying within a single dimension. Psychol. Rev. 1937, 44, 430-444.

Supplementary References

1. Brunswik, E., Probability as a determiner of rat behavior. J. Exp. Psych. 1939, 25, 175-197.

2. Hilgard, E. R., Theories of Learning. New York: Appleton-Century-Crofts, Inc. 1948.

3. Hilgard, E. R. and Marquis, D. G., Conditioning and Learning. New York: D. Appleton-Century. 1940.

4. Hull, C. L., Principles of Behavior. New York: D. Appleton-Century. 1938.

5. Krechevsky, I., A note concerning 'The nature of discrimination learning in animals'. Psychol. Rev. 1937, 44, 97-104.

6. McGeoch, J. A., The Psychology of Human Learning. New York: Longmans, Green and Co. 1942.

APPENDICES

APPENDIX A

ORIGINAL DATA

Table VII - Record of original responses for the X-1 group.
"x" correct response "o" incorrect response

Subject Number	Trials 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Total Correct
1	o	o	x	o	x	o	x	x	x	o	o	o	o	x	x	o	x	x	9
2	o	x	x	x	o	o	o	x	o	x	x	o	x	o	o	x	x	o	9
3	o	x	x	x	x	x	x	o	o	o	x	x	x	x	x	x	x	x	14
4	o	x	o	x	o	x	o	x	o	o	o	x	o	x	o	x	o	x	8
5	o	x	x	x	x	x	o	o	x	o	o	x	x	x	x	x	x	x	13
6	o	x	x	o	x	o	x	x	x	o	x	x	o	x	x	x	x	o	12
7	o	o	o	x	x	o	o	o	o	x	x	o	o	x	o	x	o	x	7
8	o	x	x	x	x	x	o	o	x	x	x	x	x	x	x	x	x	x	15
9	o	x	x	x	x	o	x	x	x	x	x	x	x	x	x	x	o	x	15
10	o	x	o	o	o	o.	o	o	o	o	o	x	x	o	o	o	o	o	3
11	o	x	x	x	x	x	o	o	o	x	o	x	o	x	x	x	x	x	12
12	o	x	x	x	x	x	x	x	o	x	x	x	x	x	o	o	x	x	14
13	o	x	x	x	o	o	x	x	x	x	x	x	x	x	x	x	x	o	14
14	o	o	o	x	o	x	x	o	x	o	x	x	x	x	x	x	x	x	12
15	o	x	x	o	x	o	o	o	o	x	o	x	o	x	x	x	x	x	10
16	o	o	o	o	o	o	o	o	o	x	o	o	o	x	o	x	x	o	4
17	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	x	o	x	2
18	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	x	1
19	o	o	x	o	x	x	x	x	x	x	o	o	o	o	o	o	o	x	8
20	o	o	o	o	o	o	o	o	o	o	o	o	o	x	o	x	o	o	2
21	o	o	o	o	o	x	x	x	o	x	x	x	x	x	x	o	o	x	10
22	o	o	o	o	o	o	o	o	o	x	o	o	o	o	o	x	o	o	2
23	o	o	x	x	o	o	o	x	o	o	o	o	o	o	o	x	x	x	6
Total Correct	12	12	13	12	11	9	9	10	8	12	10	13	10	16	11	17	13	16	202

Table VIII - Record of original responses for the X-4 group.
"x" correct response "o" incorrect response

Subject Number	Trials 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Total Correct
1	o	o	o	o	x	x	x	o	x	o	x	o	x	o	o	x	x	o	8
2	o	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	17
3	o	x	x	x	x	o	o	x	o	x	o	o	o	o	o	x	o	x	8
4	o	x	o	x	x	o	x	x	x	o	x	x	x	x	x	x	o	x	13
5	o	x	x	x	o	o	x	x	x	x	x	x	x	x	x	x	x	x	15
6	o	x	o	x	x	o	x	o	x	x	x	o	x	x	x	x	x	x	13
7	o	o	o	o	o	x	o	o	o	x	x	x	x	x	x	x	x	x	10
8	o	o	x	x	x	x	o	x	x	x	x	x	x	x	x	x	x	x	15
9	o	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	17
10	o	o	o	o	o	o	o	o	o	x	o	x	x	x	o	x	x	x	7
11	o	x	o	x	o	o	x	x	x	o	x	x	x	x	x	x	x	x	13
12	o	o	o	o	x	o	o	x	x	x	x	o	x	o	x	x	x	x	10
13	o	x	o	o	x	o	x	x	x	x	x	x	x	x	x	x	x	x	14
14	o	o	o	o	x	x	x	o	x	x	x	x	x	x	x	x	x	x	13
15	o	o	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	16
16	o	o	o	o	o	x	o	x	o	x	x	x	x	x	x	x	x	x	11
17	o	o	o	o	x	x	x	x	x	x	x	x	x	x	x	x	x	x	14
18	o	o	o	o	o	o	x	o	x	x	x	x	x	o	x	x	x	o	9
19	o	x	o	o	o	o	o	o	o	x	o	o	o	o	o	x	o	x	4
Total Correct	0	9	6	9	12	9	12	12	14	16	16	14	17	14	15	19	16	17	227

Table IX - Record of original responses for the K-4 group.
"x" correct response "o" incorrect response

Subject Number	Trials 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Total Correct
1	o	x	x	x	o	o	o	x	x	x	o	o	x	x	x	o	x	x	11
2	o	x	o	x	x	x	x	x	o	x	x	o	x	x	x	x	x	x	14
3	o	x	o	x	o	o	o	o	x	o	o	x	x	x	x	x	x	o	9
4	o	o	o	o	x	o	o	x	o	x	x	x	x	o	o	x	x	x	9
5	o	o	o	o	o	x	x	o	x	o	o	o	o	o	o	x	x	o	5
6	o	o	o	o	o	x	o	x	x	x	x	o	o	x	x	x	x	o	9
7	o	o	x	x	x	x	x	x	x	x	x	o	x	x	x	x	x	x	15
8	o	o	o	x	o	x	x	o	o	x	x	x	x	x	x	x	x	x	12
9	o	x	o	x	x	x	o	o	x	x	x	x	x	x	x	x	x	x	14
10	o	x	o	x	x	x	x	x	x	x	x	x	x	x	x	x	x	o	15
11	o	o	o	x	o	o	o	x	x	o	o	o	x	x	x	o	x	x	8
12	o	x	o	o	x	x	o	x	x	o	o	x	o	x	x	o	o	x	9
13	o	o	x	x	o	x	x	x	o	x	x	x	x	o	x	x	x	x	13
14	o	o	x	x	o	x	x	o	x	o	x	o	x	o	o	x	x	o	9
15	o	o	o	o	o	o	x	x	o	x	o	o	x	x	x	x	x	o	8
16	o	x	o	x	x	x	o	x	x	x	o	x	x	o	x	o	x	x	12
17	o	o	o	o	o	x	o	o	o	x	o	x	o	o	o	x	o	o	4
18	o	x	x	o	x	o	o	x	x	x	x	x	x	o	x	x	x	x	13
19	o	x	x	x	x	x	x	x	x	x	x	x	x	o	x	x	x	o	15
20	o	x	o	x	x	o	x	x	x	o	x	x	x	o	x	x	x	o	12
Total Correct	0	10	6	13	10	13	10	14	14	14	12	12	16	11	16	16	18	11	216

APPENDIX B

COMPARISONS

Table X - Comparison of groups in terms of the percentage of correct responses on the first two trials.

Day	Group X-1 N 25 Number Correct	Group X-1 N 25 Percent Correct	Group X-4 N 19 Number Correct	Group X-4 N 19 Percent Correct	Group K-4 N 20 Number Correct	Group K-4 N 20 Percent Correct
1	12	26	9	24	10	25
2	25	54	15	39	19	48
3	20	44	21	55	23	58
4	19	41	24	63	24	60
5	20	44	30	79	28	70
6	23	50	30	79	24	60
7	26	57	31	82	27	68
8	28	61	34	89	32	80
9	29	63	33	87	29	73
Total Correct	202		227		216	
Total Percent Correct		48.79		66.37		60.00

Table XI - Comparison of groups in terms of the percentage of correct responses on the initial trial.

Day	Group X-1 N 23 Number Correct	Group X-1 N 23 Percent Correct	Group X-4 N 19 Number Correct	Group X-4 N 19 Percent Correct	Group K-4 N 20 Number Correct	Group K-4 N 20 Percent Correct
1	0	00	0	00	0	00
2	13	57	6	32	6	30
3	11	48	12	63	10	50
4	9	39	12	63	10	50
5	8	35	14	74	14	70
6	10	43	16	84	12	60
7	10	43	17	89	16	80
8	11	48	15	79	16	80
9	13	57	16	84	18	90
Total Correct	85		108		102	
Total Percent Correct		41.06		63.16		56.67

Table XII - Comparison of subgroups with strong position preference in terms of the percentage of the correct responses on the first two trials.

Day	Group X-1 N 11 Number Correct	Group X-1 N 11 Percent Correct	Group K-4 N 10 Number Correct	Group K-4 N 10 Percent Correct	Group X-4 N 10 Number Correct	Group X-4 N 10 Percent Correct
1	0	00	0	00	0	00
2	6	27	8	40	4	20
3	6	27	9	45	13	65
4	8	36	12	60	10	50
5	8	36	12	60	16	80
6	5	23	10	50	17	85
7	8	36	12	60	17	85
8	10	45	15	75	18	90
9	12	55	14	70	18	90
Total Correct	63		92		113	
Total Percent Correct		31.82		51.11		62.78

Table XIII - Comparison of subgroups with strong position preference in terms of the percentage of correct responses on the initial trial.

Day	Group X-1 N 11 Number Correct	Group X-1 N 11 Percent Correct	Group X-4 N 10 Number Correct	Group X-4 N 10 Percent Correct	Group K-4 N 10 Number Correct	Group K-4 N 10 Percent Correct
1	0	00	0	00	0	00
2	3	27	2	20	3	30
3	3	27	6	60	2	20
4	4	36	5	50	6	60
5	3	27	7	70	5	50
6	3	27	9	90	6	60
7	2	18	10	100	7	70
8	3	27	8	80	6	60
9	4	36	10	100	9	90
Total Correct	25		57		44	
Total Percent Correct		25.25		63.33		48.89

Table XIV - Comparison of subgroups with weak position preference in terms of the percentage of correct responses on the first two trials.

Day	Group X-1 N 12 Number Correct	Group X-1 N 12 Percent Correct	Group X-4 N 9 Number Correct	Group X-4 N 9 Percent Correct	Group K-4 N 10 Number Correct	Group K-4 N 10 Percent Correct
1	12	50	9	50	10	50
2	19	79	11	61	11	55
3	14	58	8	44	14	70
4	11	46	14	78	12	60
5	12	50	14	78	16	80
6	18	75	13	72	14	70
7	18	75	14	78	15	75
8	18	75	16	89	17	85
9	17	71	15	83	15	75
Total Correct	139		114		124	
Total Percent Correct		64.35		70.31		68.89

Table XV - Comparison of subgroups with weak position preference in terms of the percentage of correct responses on the initial trials.

Day	Group X-1 N 12 Number Correct	Group X-1 N 12 Percent Correct	Group X-4 N 9 Number Correct	Group X-4 N 9 Percent Correct	Group K-4 N 10 Number Correct	Group K-4 N 10 Percent Correct
1	0	00	0	00	0	00
2	10	83	4	44	3	30
3	8	67	6	67	8	80
4	5	42	7	78	4	40
5	5	42	7	78	9	90
6	7	58	7	78	6	60
7	8	67	7	78	9	90
8	8	67	7	78	10	100
9	9	75	6	67	9	90
Total Correct	60		51		58	
Total Percent Correct		55.56		62.96		64.44