1966

An Extension of the Reinforcement Contiguity Issue – The Effect of Retention in the Goal Box After Reinforcement

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AN EXTENSION OF THE REINFORCEMENT CONTIGUITY ISSUE- The Effect of Retention in the Goal Box After Reinforcement

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A Thesis

Presented to

the Graduate Faculty

Central Washington State College

In Partial Fulfillment

of the Requirements for the Degree

Master of Education

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by

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December, 1966

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER I

INTRODUCTION

While there are many competing theories of learning, including many restricted models, some of the older, more general positions are still in active competition. Under careful scrutiny it appears that some of the implications of these older theories have never been adequately examined.

Guthrie's (1935) learning theory, for example, seems to have stirred comparatively little activity in the way of experimental investigation. Probably the main reason for this is that his theory is not specific enough to lend itself easily to experimentation. Nonetheless, his basic theoretical points continue to reappear in the current views of Estes, Voeks, and Sheffield.

One aspect of Guthrie's theory that merits further investigation is his interpretation of reinforcement, which has contributed to the reinforcement-contiguity issue. Hull (1952), Spence (1960), Skinner (1953), and other reinforcement theorists hold reinforcement to be a necessary condition of learning. Learning becomes a function of successive reinforcement trials and learning

is a form of retroactive strengthening of stimulus-response association (Hull, Spence) or response (Skinner) with reinforcement.

Guthrie's learning theory falls within the group of theories which do not hold reinforcement to be a necessary condition for learning. According to Guthrie's theory (1935, 1952), learning consists of associations between stimulus and response. He offers one principle, necessary and sufficient for learning to occur--that the stimulus and response occur in temporal contiguity. An important corollary to this principle is that if two incompatible responses occur in the presence of the same stimulus, only the last stimulus-response association remains. In Hunt (Hunt, 1944:page 53), Guthrie states the role of reinforcement in this way:

> Reinforcement is here seen as terminating a sequence of behavior and, perhaps, the initial and maintained stimulation which originally leads to the behavior sequence. The function of reinforcement ("reward") is to "protect" the association made. This is done through removal of the organism from the environment in which the responses were made (and so new associations to those environmental stimuli cannot be made) and/or by changing the condition of the organism so that its internal stimulation will be different than before.

According to Guthrie, in a T-maze the stimulus-response association to be learned would be the correct turn

(response) at the choice point (with appropriate maintaining, or drive, stimuli), or approach response) to distinctive features of the goal box, (with appropriate maintaining, or drive, stimuli). Reinforcement in the goal box, then, would function to terminate the sequence of behavior, such as preventing incompatible responses to choice-point stimuli or goal-box stimuli and/or to remove appropriate maintaining, or drive, stimuli (hunger, e. g.). If the subject was retained in the goal box following reinforcement, he would be expected to make responses to goal-box stimuli, probably incompatible to approach response to goal-box stimuli. Guthrie uses the term "associative inhibition" to describe the process whereby new learning interferes with the original stimulus-response association.

It would appear, then, that Guthrie would offer a prediction contrary to the reinforcement theorists with regard to retention in the goal box after reinforcement. Hull, Spence, or Skinner would predict "no effect" as those theories view the reinforcement itself as being the crucial factor, not what happens following reinforcement. Guthrie would predict a retardation of learning due to associative inhibition arising from

further responses to goal-box stimuli. This seems to be a rather crutial issue and one which does lend itself to investigation.

Davis (1953) investigated this issue using a T-maze with rats as subjects. The control subjects were removed from the reinforced goal box immediately after consumption of reinforcement. The experimental subjects were retained in the goal box for sixty seconds after consumption of reinforcement.

The reinforced goal box had a small light above it, visible from the choice point. Thus, the correct stimulus-response association to be learned was light (stimulus) - approach (response). According to Guthrie, if the subject was retained in the goal box, the additional responses would be made in the presence of the light stimulus, and would likely be incompatible with the response of approach--thus, interfering with learning the light-approach association.

In Davis' study the criterion for learning was five successive correct choices, and after twenty-three trials all subjects had met this criterion. Davis' results produced conflicting evidence with regard to the theory of associative inhibition. Of the four measures (trials-to-criterion, total correct turns, stereotypy,

mean log latencies) Davis utilized, only "trials-to-criterion" supported the associative inhibition theory. Davis commented that those results might have been a function of his arbitrary criterion of learning rather than the merits of the theory of associative inhibition. Examination of the Davis study suggests that his procedure and apparatus also may have had confounding effects on his results.

Davis avoided the possibility of a direction preference by having half of his control and experimental subjects reinforced in the left goal box and the remaining half in the right goal box. However, he did not circumvent the possibility of the animal learning a position habit. For any subject, the correct goal box was always on the left or on the right. According to Guthrie, the detrimental effect of additional responses in the goal box in the presence of the light (after reinforcement) would be more pronounced on the association of light-approach than on one of choice point stimuli - right turn response.

Second, Davis himself commented that his method of subject removal from the goal box may have created some ambivilent feelings with regard to entering the goal box. The subjects were dropped from the goal box into a

retaining box below the goal box. The control animals (who were not retained) experienced this occurrence at a closer proximity to the time of choice. Thus, the fear produced may have been more closely associated to the approach response for the control subjects, counteracting the predicted superiority of learning.

Guthrie (Guthrie, 1935:page 158), once commented that:

> sitting on tacks does not discourage learning. It encourages one in learning to do something else than sit.

The present experiment was designed to investigate the effect of retention in the goal box after reinforcement, with control of the possible variables of position habit and fear of the goal box present in the Davis (1953) study.

CHAPTER II

METHOD

Apparatus. The apparatus for the investigation consisted of a conventional T-maze with modified goal boxes (see Figure 1). The goal boxes consisted of six inch by six inch by ten inch wire cages enmeshed in thickly carpeted boxes of slightly larger dimensions. Once enmeshed within the carpeted box the wire cage was not visible, with the exception of the top, since the outer shell was without a top. The outer boxes were hinged on two sides in order that they could be swung open, facilitating placement or removal of the inner wire boxes (see Figure 2). Attached to the wire cages were twenty-four inch horizontal arms permitting the cages to be lifted from the outer box by a distance sufficient to shield the E from view by S.

The goal boxes were designed to eliminate both "anticipation of removal" responses which may accompany being "dropped" into a lower cage.

The maze was painted black. The distance from the starting box to the choice point was twenty-four inches and the distance from the choice point to either goal box was twenty-four inches. To prevent retracing, drop doors of black rubberized tile were placed at the starting

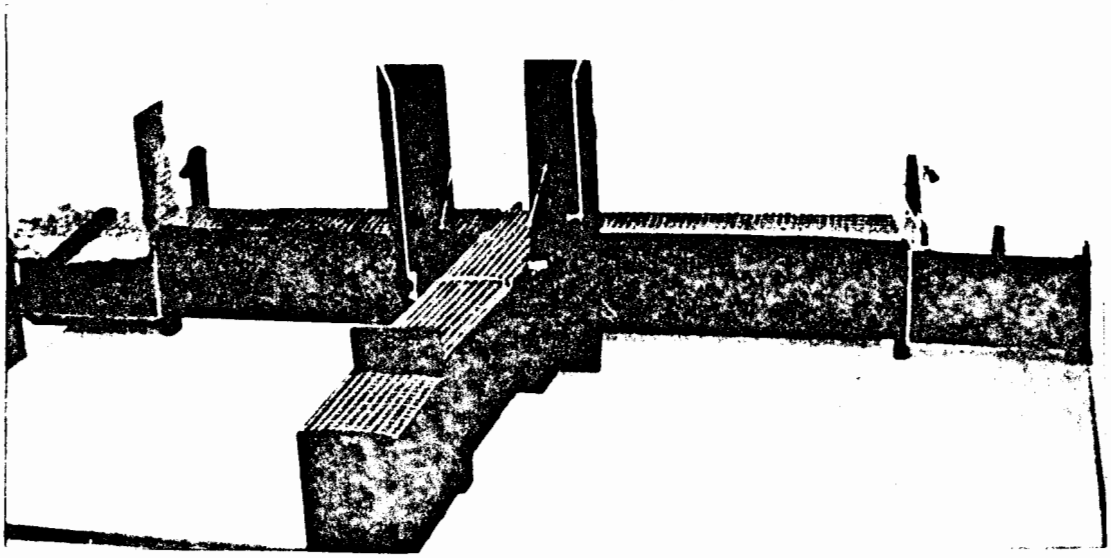

Figure 1

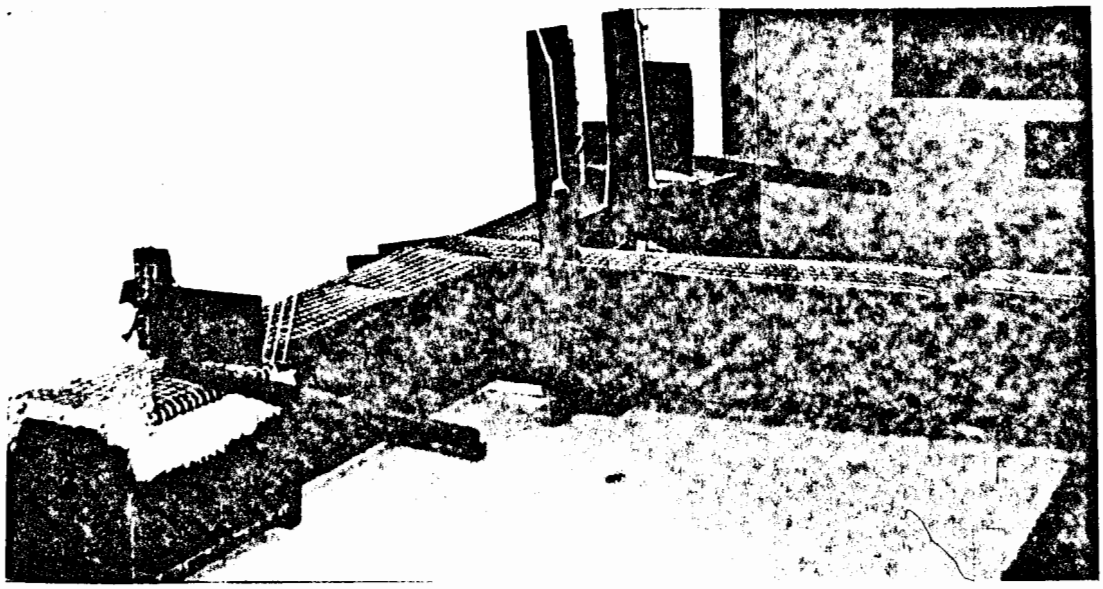

Figure 2

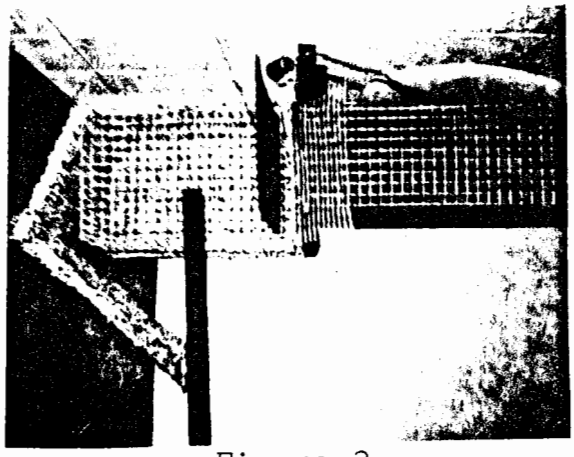

Figure 3

box, on either side of the choice point, and at the entrance to the goal boxes. There were operated from a panel between the choice point and the starting box. Above each goal box was a seven-watt light bulb on a switch, controlled by E so that the light was turned on only over the goal box with reinforcement on any particular trial. The seven-watt bulb provided the only illumination in the room.

Subjects. Ss were twenty-two female, laboratory rats, ninety to one-hundred twenty days old, randomly assigned to either the experimental or the control group, with eleven Ss in each group. Each S was then randomly assigned to a running position in the running order. This order was maintained throughout the experiment.

Procedure. Ss in the control group were retained in the goal box until they had consumed the reinforcement or for ten seconds, whichever occurred first, and they were then removed from the goal box. Ss in the experimental group were retained in the goal box for one minute after the ten seconds permitted for consumption of the reinforcement, a total of 70 seconds.

Reinforcement consisted of four kernels of sugar-coated puffed rice. The reinforced goal box was always lighted, and the left-right position of the reinforced

goal box was randomly alternated among Ss and over trials for each S.

Fourteen days prior to the commencement of the experiment, Ss were placed on a 24-hour feeding schedule, with their usual daily diet available for only one hour. During this same fourteen-day period they were handled by the E in order for them to become accustomed to the E.

Several pilot studies were run to determine length of time required for consumption of reinforcement, type of goal box, type of goal-box removal, type and position of re-entry prevention doors, and quantity and quality of reinforcement that was reinforcing but did not interfere with other factors in the experimental sequence.

Ss were given two trials at the same time each day. The daily procedure for each S was as follows: Each S was placed individually in the starting box of the maze. As the S left the starting box, passed the choice points, and entered the goal box, the doors were closed in order to prevent re-entry into the various parts of the maze. The reinforced goal box was designated by illumination by the seven-watt light bulb attached to the goal box. This furnished the only light in the room.

For the contol group, S was retained in the reinforced goal box until he had consumed the food or for ten

seconds, whichever occurred first. Pilot work indicated that ten seconds was sufficient for food consumption. For the experimental group, S was retained in the reinforced goal box for the ten seconds plus an additional delay of one minute, to permit further responses in the goal box after consumption of reinforcement. For both groups, S was retained in the non-reinforced goal box for ten seconds, to prevent immediate removal from functioning as reinforcement for the incorrect choice. Table 1 provides a summary of the retention time in the goal box for both groups.

Table 1

Retention Time in the Goal Boxes

Group	Correct Choice (Reinforced Goal Box)	Incorrect Choice (Non-reinforced Goal Box)
Control	Retained until consumption of food or for 10 sec., whichever occured first.	Retained for 10 sec.
Experimental	Retained for 70 sec.	Retained for 10 sec.

Ss in both groups were removed from the goal box, as follows: The inner wire cage was lifted from the carpeted shell and used to transfer the S into a retaining cage where he remained for thirty minutes.

This process was repeated for the second trial each day, and then S was returned to him home cage where he was then given his daily food ration. If food was not consumed in one hour, it was removed. Thus, the Ss had been deprived of food for twenty-two hours at the time of each day's trials.

All Ss were given a minimum of twenty trials. The criterion of learning was five successive correct (reinforced) choices. Each was run until he met the criterion or until he had completed forty trials, whichever occurred first. The only difference in treatment between the two groups was that Ss in the experimental group were retained in the reinforced goal box for one minute longer than the ten seconds for Ss in the control group.

CHAPTER III

RESULTS

Three measures of learning were used: (1) number of trials completed for each subject; (2) number of correct choices in the first twenty trials; (3) number of subjects who met the criterion of learning within the forty trials. An additional measure of performance was the running speed for each block of four trials for the first twenty trials.

The termination of each S's participation was set at the criterion of five successive correct trials or completion of forty trials, whichever occurred first. Thus, for each S the number of trials completed was the number of trials to criterion or forty trials. These data were analyzed by the t-test. Comparison of the mean number of trials completed for the two groups (see Table 2) indicated that the experimental group had significantly more trials than the control group ($t = 3.09$, $df = 20$, $p < .01$). This comparison indicates inferior learning by the experimental group, even though the difference is minimized by the "ceiling effect"--i.e., the fact that the majority of the experimental subjects did not meet the criterion within

forty trials.

Each S ran a minimum of twenty trials. Thus, a second measure of learning efficiency was the number of correct choices within the first twenty trials. Comparison of the mean number of correct choices for the two groups (see Table 2) indicated that the experimental group made significantly fewer correct choices than did the control group ($t = 7.03$, $df = 20$, $p < .01$). Again, the experimental group displayed inferior learning, even for the first half of the learning trials.

A third measure is the number of Ss who met the criterion of learning. At the completion of forty trials, eight of eleven Ss in the control group and two of eleven in the experimental group had met the criterion of learning. Analysis of these data by Chi Square indicates that this difference is significant at the .05 level of confidence ($X^2 = 4.58$, $df = 1$). This measure also indicated inferior learning by the experimental group.

Table 2

Comparison of Mean Number of Trials to Criterion and Number of Correct Responses in the First Twenty Trials

Data	Experimental Group	Control Group	t
Trials to Criterion	37.545	24.545	3.087**
Number Correct Responses	8.545	10.727	7.032**

p .01

Table 3

Summary of Trend Analysis of Variance for Running Speed for Blocks of Four Trials for First Twenty Trials

Source	Sum of Squares	df	Mean Square	F
Treatments	17,539.282	1	17,539.282	< 1.0
error	567,684.473	20	28,384.224	
Trials	163,515.510	4	40,878.8775	2.7163
Trials X Treatments	18,237.945	4	4,559.4862	< 1.0
error	1,203,957.345	80	15,049.4668	
Total	1,970,934.555	109		

The fourth measure of interest is one of performance more than of learning. This is the running speed for each S for each block of four trials for the first twenty trials. These data were analyzed by a trend analysis of variance and are summarized in Table 3. None of the comparisons was significant. Thus, there was no effect on speed of running of conditions or trials.

CHAPTER IV

DISCUSSION

This study investigated one prediction of Guthrie's theory of learning (1936, 1952)--that retention in the goal box after reinforcement increases the likelihood of incompatible responses to the goal stimuli and, thus, decreases learning. Three measures of learning were used: number of trials to criterion, total number of correct trials in the first twenty trials, and number of subjects who met criterion of five successive correct responses within forty trials. If the opportunity to make further responses to the goal-box stimuli after reinforcement interferes with learning, the experimental Ss, who were retained in the goal box following reinforcement, should have fewer total correct responses, should require more trials for learning, and fewer should reach the criterion.

The results of this study strongly support the theory of the influence of associative inhibition on learning. The experimental Ss showed inferior learning on all three of the measures of learning.

There are, however, some areas that may deserve further investigation. Perhaps the criterion of five successive correct responses was inadequate as a measure

of learning. However, Table 4 makes evident the fact that there was a significant difference between the two groups, at the .05 level of confidence, also for the criteria of three and four consecutive correct responses. Unfortunately, the data do not offer figures of six, seven, or more successive correct responses. Another study might lengthen the criterion and/or increase the total number of trials in which all subjects participate. This study required only twenty. In Davis' study, each subject ran twenty-three trials, and he obtained data sufficient to provide figures on the number of subjects making six and seven successive correct responses. His data indicates that there was no significant difference in performance using these levels. However, in the present study the difference between the two groups increased with increased successive correct responses to criterion.

The present findings also support the suggestion that in Davis' study the Ss were learning a position habit. All of his Ss showed faster learning than in the present study, and learning a right or left turn at the choice point would be easier than learning to approach a light, with its location randomly alternated. As mentioned earlier, according to Guthrie's theory,

Table 4

Comparison of Mean Number of Trials to Criterion for Two-, Three, Four, and Five Successive Correct Responses

Number of Successive Correct Responses	Experimental Group	Control Group	t
Two	7.272	5.363	.86
Three	20.454	9.636	2.279*
Four	31.181	18.727	2.368*
Five	37.545	24.545	3.087**

$p < .05$

$p < .01$

responses in the goal box following reinforcement and in the presence of the light would be more detrimental to learning the response of approach to the light than to learning a right or left turn at the choice point.

Several pilot studies were used to determine the time factors related to consumption of reinforcement, the retention period which seemed appropriate, the quantity of reinforcement, and the most effective method of removal. This study was the first, however, to utilize this particular method of removal. An investigation of the effects of this type of removal might determine if in itself it acts as rewarding or fear provoking.

The findings of the present study question the implications of reinforcement theorists (Hull, Spence, Skinner) that reinforcement following a stimulus-response association is sufficient for learning that stimulus-response association. The present study supports Guthrie's interpretation of the role of reinforcement, that it functions to "protect" the stimulus-response association preceding it by removal of the organism from the environment in which the responses were made (so new associations to those environmental stimuli cannot be made).

CHAPTER V

SUMMARY

To investigate the effect on learning of retention in the goal box after reinforcement, two groups of eleven laboratory rats were given a maximum of forty trials to learn the correct response in a T-maze. The reinforced goal box was signified by illumination from a 7-watt light. The right-left position of the reinforced goal box was randomly alternated among subjects and over trials for each S. Ss in the control group were removed from the goal box immediately after consumption of the reinforcement; the Ss in the experimental group were retained for sixty seconds after consumption of the reinforcement.

Three measures of learning were analyzed by a t-test: number of trials completed for each subject; number of correct choices in the first twenty trials; number of subjects who met the criterion of five successive correct responses within forty trials. An additional measure of performance was the running speed for each block of four trials for the first twenty trials. The experimental Ss showed inferior learning on all three measures of learning. There was no difference between the groups on running speed.

The results support the associative inhibition segment of Guthrie's contiguity theory. In general, these findings suggest that responses following reinforcement in the presence of goal stimuli have an effect on learning.

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APPENDIX A

RECORD OF CONTROL GROUP CHOICES TO CRITERIA

SUBJECTS:	1	2	3	4	5	6	7	8	9	10	11
TRIAL											
1	O	O	X	O	O	X	O	O	O	X	O
2	X	X	X	O	X	O	X	X	O	O	X
3	X	O	X	X	X	O	X	X	X	O	O
4	X	X	O	X	X	O	X	X	O	O	X
5	X	X	O	X	O	O	O	O	X	O	O
6	O	O	X	X	O	O	O	O	X	O	O
7	X	X	O	X	O	X	X	X	O	X	O
8	O	X	X		O	X	X	O	O	O	X
9	X	O	O		X	O	X	X	O	X	O
10	X	X	X		O	X	X	X	O	X	O
11	X	X	X		X	X	X	X	X	O	X
12	X	O	O		X	X		O	O	X	X
13	X	O	O		X	O		X	O	X	X
14		O	X		X	X		X	X	X	O
15		X	X		O	X		X	X	X	X
16		X	X		X	O		X	O	X	O
17		O	X		X	O		O	O		O
18		X	X		X	O		X	O		X
19		O			O	O		X	O		X
20		O			O	O		O	O		X
21		O			O	O		O	O		O
22		X			X	O		X	X		X
23		O			X	X		O	O		O
24		O			X	X		O	X		O
25		X			X	X		X	X		X
26		O			X	X		O	X		O
27		X				O		O	X		X
28		X				O		O	X		O
29		X				X		X			O
30		X				X		X			X
31		X				O		O			O
32						O		O			O
33						X		O			X
34						X		X			O
35						O		O			X
36						X		X			X
37						O		X			O
38						O		O			X
39						X		X			O
40						O		X			X

RECORD OF EXPERIMENTAL GROUP CHOICE TO CRITERIA

SUBJECTS:	1	2	3	4	5	6	7	8	9	10	11
TRIAL											
1	0	0	0	0	X	0	X	0	X	0	0
2	X	X	X	0	X	0	X	0	0	X	0
3	X	0	X	0	0	0	0	X	X	X	0
4	0	0	X	X	0	0	0	0	0	0	0
5	0	0	0	X	0	0	X	X	0	0	0
6	0	X	0	0	0	X	X	X	X	0	0
7	X	0	X	0	X	0	X	X	0	0	X
8	X	X	X	X	X	X	X	X	0	0	0
9	0	X	0	X	0	0	0	0	X	0	0
10	0	0	0	X	0	X	0	X	X	X	X
11	0	X	X	0	0	0	0	X	0	X	0
12	X	0	0	X	0	0	X	0	X	X	0
13	0	X	0	0	0	0	0	0	0	0	X
14	X	0	X	0	0	0	0	X	X	X	X
15	X	0	X	0	0	0	X	X	0	0	0
16	X	X	X	0	0	0	0	X	X	X	X
17	0	X	0	0	X	0	0	X	X	X	0
18	0	0	X	X	X	X	X	X	0	0	0
19	0	0	X	X	0	0	X		0	0	0
20	0	0	0	X	0	X	0		0	0	X
21	0	X	0	0	X	0	0		0	X	X
22	0	X	0	X	0	X	X		0	0	X
23	X	0	0	0	X	X	X		X	X	X
24	0	X	0	0	0	0	0		X	X	0
25	0	0	0	X	0	0	X		0	0	0
26	0	0	0	0	X	0	0		X	X	0
27	0	0	0	X	0	0	X		0	0	X
28	X	X	0	0	0	X	X		0	0	X
29	0	X	0	X	0	X	0		0	X	0
30	0	0	X	X	0	0	X		0	X	0
31	X	X	0	0	0	X	0		0	X	X
32	X	X	0	X	0	X	X		X	0	0
33	X	X	X	0	X	0	0		0	0	X
34	0	X	X	0	X	X	0		0	0	X
35	0	X	X	0	X	X	X		X	X	X
36	X		0	0	0	X	0		X	0	0
37	0		0	0	0	X	X		0	X	X
38	X		0	X	X	0	0		0	X	0
39	X		X	0	0	X	0		0	0	0
40	0		X	0	X	X	0		X	0	0

APPENDIX B

RECORD OF CHOICES OF CONTROL GROUP FIPST TWENTY TRIALS

SUBJECTS:	1	2	3	4	5	6	7	8	9	10	11
TRIAL											
1	0	0	X	0	0	X	0	0	0	X	0
2	X	X	X	0	X	0	X	X	0	0	X
3	X	0	X	X	X	0	X	X	X	0	0
4	X	X	0	X	X	0	X	X	0	0	X
5	X	X	0	X	0	0	0	0	X	0	0
6	0	0	X	X	0	0	0	0	X	0	0
7	X	X	0	X	0	X	X	X	0	X	0
8	0	X	X	X	0	X	X	0	0	0	X
9	X	0	0	0	X	0	X	X	0	X	0
10	X	X	X	X	0	X	X	X	0	X	0
11	X	X	X	0	X	X	X	X	X	0	X
12	X	0	0	0	X	X	X	0	0	X	X
13	X	0	0	0	X	0	X	X	0	X	X
14	X	0	X	X	X	X	X	X	X	X	0
15	0	X	X	0	0	X	X	X	X	X	X
16	0	X	X	0	X	0	0	X	0	X	0
17	X	0	X	0	X	0	0	0	0	0	0
18	0	X	X	X	X	0	X	X	0	X	X
19	0	0	0	0	0	0	0	X	0	0	X
20	0	0	X	X	0	0	X	0	0	X	X

RECORD OF CHOICES OF EXPERIMENTAL GROUP FIRST TWENTY TRIALS

SUBJECTS:	1	2	3	4	5	6	7	8	9	10	11
TRIALS											
1	0	0	0	0	X	0	X	0	X	0	0
2	X	X	X	0	X	0	X	0	0	X	0
3	X	0	X	0	0	0	0	X	X	X	0
4	0	0	X	X	0	0	0	0	0	0	0
5	0	0	0	X	0	0	X	X	0	0	0
6	0	X	0	0	0	X	X	X	X	0	0
7	X	0	X	0	X	0	X	X	0	0	X
8	X	X	X	X	X	X	X	X	0	0	0
9	0	X	0	X	0	0	0	0	X	0	0
10	0	0	0	X	0	X	0	X	X	X	X
11	0	X	X	0	0	0	0	X	0	X	0
12	X	0	0	X	0	0	X	0	X	X	0
13	0	X	0	0	0	0	0	0	0	0	X
14	X	0	X	0	0	0	0	X	X	X	X
15	X	0	X	0	0	0	X	X	0	0	X
16	X	X	X	0	0	0	0	X	X	X	X
17	0	X	0	0	X	0	0	X	X	X	0
18	0	0	X	X	X	X	X	X	0	0	0
19	0	0	X	X	0	0	X	X	0	0	0
20	0	0	0	X	0	X	0	0	0	0	X