RESISTANCE TO EXTINCTION AS A FUNCTION OF THE PERCENTAGE OF DISCRIMINATION WITH FIXED RATIO REWARD

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RESISTANCE TO EXTINCTION AS A FUNCTION OF THE PERCENTAGE OF DISCRIMINATION WITH FIXED RATIO REWARD

By

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INTRODUCTION

During the past few years psychologists have recognized that there are important differences in behavior between situations utilizing continuous and non-continuous reward techniques, particularly when resistance to extinction is considered. Until recently, few studies dealt with percentage of responses rewarded (partial reward) or the pattern of rewarded and non-rewarded responses.

In a recent review of partial reinforcement, Jenkins and Stanley (1) make the following generalizations:

> " 1. Acquisition. Response strength is built up somewhat more rapidly under a schedule of 100% reinforcement than under a partial regimen. Differences in learning, however, are not always large, and with prolonged training the ultimate level of acquisition for partially rewarded subjects may approach that for the 100% ones.
> 2. Maintenance. While the behavior in post acquisition performance is stable in the partial reinforcement situation, it is usually at a lower level than in the 100% instance. Nevertheless, differences are not always statistically significant and may well be of no great practical consequence.
> 3. Resistance to extinction. The most striking effects of partial reinforcement are apparent in response strength as measured by resistance to extinction. In almost every experiment, large and significant differences in extinction favoring the groups partially reinforced in conditioning over the 100% ones were found. The practical implications of this principle for maintaining behavior is obvious: Administer the reinforcing stimulus in conditioning according to a partial schedule, and the behavior will be maintained for long periods in the absence of external support from primary reward."

Skinner was one of the first to investigate the phenomena associated with partial reward (1933 and 1936). Using his technique of periodic reconditioning, which formed the basis for his earliest investigations, Skinner measured the rate of bar pressing in a standard Skinner box situation. By employing this bar pressing apparatus, he first studied behavior using a periodic reward technique (reward per unit time) and later studied behavior as a function of reward per number of responses (reward at a fixed ratio) (5). He was presumably studying a response chain which involved at least three elements: the bar pressing response, the approach to the food tray, and the eating of the food (5, p. 54). With respect to fixed ratio reward, he asserted (5, p. 300):

> " As a rather general statement it may be said that when reinforcement depends upon the completion of a number of similar acts the whole group tends to acquire the status of a single response and the contribution to the reserve tends to be in terms of groups."

Skinner's thinking was in part used as a basis for a previous study (7). Using Skinner's analysis, it was reasoned that if discrimination were perfect, then the number of blocks of responses* to extinction under fixed ratio reward would be equal to the number of blocks of responses to extinction under continuous reward (2). The groups of the previous

*Block of responses is equivalent to a specified behavior sequence terminated by reward, e.g., with one to five ratio, the block is a sequence of five bar presses, the last of which is followed by reward.

study (7) did not attain perfect discrimination, but the results did imply that the amount of discrimination attained before extinction was a pertinent variable in predicting the number of bar presses to extinction for the fixed ratio groups. A group receiving one reward to five bar presses did not, even after having received 80 rewards on the partial schedule, make five times the number of bar presses to extinction of the control group (continuous reward). The function was thought to be more nearly that the number of bar presses to extinction under fixed ratio reward is equal to the product of the number of bar presses to extinction under continuous reward, the number of bar presses in the fixed ratio block, and the percentage of discrimination at the end of training (2, 3).

Partial reward in the present study is viewed as leading to rather complex behavior. Behavior under partial reward is considered to be discrimination learning; the animal is learning that certain cues lead to reward and certain other cues do not lead to reward. If the animals were to learn to discriminate perfectly, then one would expect that the number of responses to extinction under partial reward training would equal the product of the responses to extinction following training under continuous reward and the number of responses in the fixed ratio block during acquisition. This follows from the view of the extinction procedure that during extinction the animals

which were trained under partial reward are receiving the same number of non-rewards per block of responses as the animals which were continuously rewarded.

With the apparatus employed in the present study, it is possible to determine how well animals can learn to use the cues in the experimental situation (click for rewarded response; no click for non-rewarded responses) and how well other animals can learn with no discriminable cues in the experimental situation (click for both rewarded and non-rewarded responses). With a conventional Skinner box, in which the bar and food dish are adjacent, it is not possible to record approaches to the food dish independently of the bar pressing response and thus a measure of discrimination can not automatically be recorded. With the apparatus designed for the present study, the bar and the food dish are at opposite ends of a short alley, allowing the bar pressing response to be recorded independently of the approach to the food dish.

STATEMENT OF THE PROBLEM

The present study was designed to test some notions (2, 3) which were derived from the data of Wells' study (7) under a different ratio of reward. Wells' data seemed to indicate that the number of extinction trials under one to five ratio were equal to the product of the number of trials to extinction under continuous reward, the amount of discrimination at the end of training, and the number of bar presses in the fixed ratio block. The present study was designed to test this notion with one to three ratio of reward and to find out the effect of a discriminable cue upon the learning of the discrimination and extinction.

The measure of discrimination in the present study is as follows: the animal was considered to have made a correct approach to the food dish, <u>if and only if</u> it approached the food dish after pressing the bar the appropriate number of times. For animals trained with one to three fixed ratio reward, the correct discrimination was pressing the bar three times and then approaching the food dish only after the third bar press. For continuously rewarded animals, the correct discrimination was pressing the bar and approaching the food dish after each bar press. The percentage of discrimination was equal to the number of correct approaches to the food dish per 10 blocks of responses multiplied by 10.

Specific hypotheses are as follows:

Hypothesis I: If a discriminative cue is present during training and extinction under partial reward, so that it differentiates the rewarded bar press from the non-rewarded bar press, then the number of bar presses to extinction following training under fixed ratio reward will be equal to the product of the number of bar presses to extinction following continuous reward, the number of bar presses in the fixed ratio block, and the final percentage of discrimination attained.

Hypothesis II: If no specific cue is present during the fixed ratio schedule, then the number of bar presses to extinction will be less than the number of bar presses to extinction following training under fixed ratio reward with a cue, but greater than the number obtained following continuous reward with a cue.

Let: $E_{fr,c}$ = the number of bar presses to extinction under fixed ratio reward with a cue present.

$E_{fr,nc}$ = the number of bar presses to extinction under fixed ratio reward with no cue present.

$E_{c,c}$ = the number of bar presses to extinction under continuous reward with a cue present.

R = the number of bar presses in the fixed ratio block.

D = the final percentage of discrimination at the end of fixed ratio training.

Hypothesis I asserts that: If a discriminative cue is present. . ., then $E_{fr,c} = E_{c,c} \times R \times D$

Hypothesis II asserts that: If no specific cue is present. . ., then $E_{c,c} < E_{fr,nc} < E_{fr,c}$

APPARATUS

The apparatus (see Figure 1) employed was a short unpainted wooden alley, the interior of which was lined with sheet metal. The inside dimensions were 6 inches in height, 4½ inches in width, and 24 inches in length. The top was a hinged door constructed of hardware cloth framed with wood. A metal food tray lined with felt was located at the end of the short alley. Food dropped into this tray via a felt-lined chute from the electrically operated food releasing mechanism connected to one end of the box. A 6-inch metal portion of the floor (treadle) just beneath the food dish was hinged so that it was depressed when the animal stepped on it, closing the microswitch, thus recording all approaches to the food dish. A 2-inch metal bar projected into the box at the end opposite to the food dish. The food releasing mechanism was activated when a pressure of 30 grams was applied to this bar, except when the control box was set for partial reward. An audible click was produced by the activation of the food releasing mechanism. With partial reward the click occurred only following the rewarded bar presses.

Illumination was furnished by a 7½ watt bulb which hung 12 inches above the center of the box. Water was present at all times and was introduced through a glass

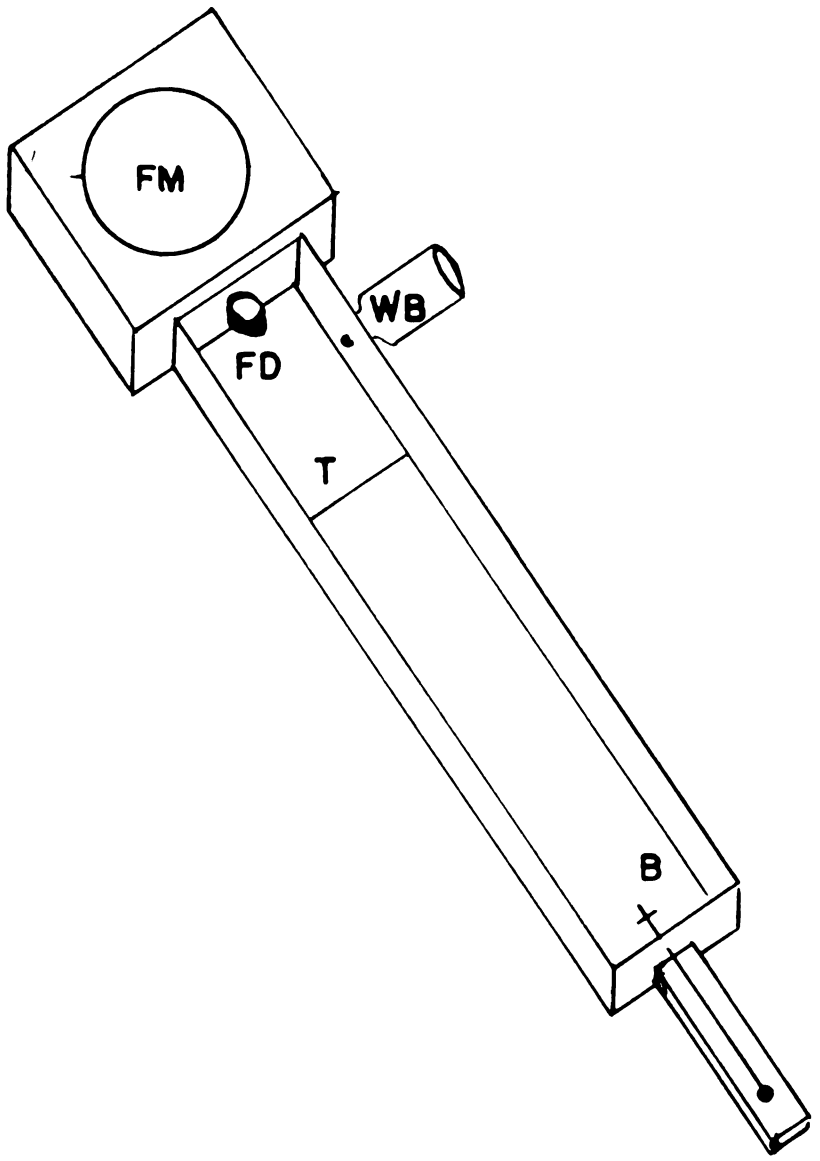

FIGURE I. A SCHEMATIC PRESENTATION OF THE BAR PRESSING APPARATUS. B-BAR, T-TREADLE, FD-FOOD DISH, WB-WATER BOTTLE, FM-FEEDING MECANISM

tube connected to a bottle on the outside of the box near the food dish (see discussion p. 33).

The feeding mechanism, bar, and polygraph were connected to an electric control box which was designed and constructed by T. H. Maatsch.

A record was made on a ploygraph of the number, duration and spacing of the bar pressing responses; the occurrences of reward; time and presence of the animal on the treadle, i.e., presence of the animal at the food dish or at the water bottle.

SUBJECTS

The animals used in the present study were 53 female albino rats from the colony maintained by the Department of Psychology of Michigan State College. Thirty-one of the animals were naive and were 90-100 days old when started on the experiment. Six of these animals were eliminated from the study for reasons given in the procedure. Twenty-two of the animals were used on a previous Skinner box study and were approximately 200 days old when started on the present study. Five of these animals did not finish the study.

PROCEDURE

Preliminary Training

All animals received 9 grams of Purina Dog Chow for five days and then were not fed for 48 hours prior to training. While the animals were on this feeding schedule they lived in individual feeding cages. Animals were never handled to tame them. The only handling by the experimenter occurred in the transporting of the animals to the feeding cages and thence seven days later to the apparatus.

Before each animal was introduced into the apparatus, the bar was in place and two pellets of "lab chow" tablets (0.045 gm. each; made by P. J. Noyes Company, Lancaster, N.H.) had been placed in the food tray. Animals were allowed to explore and press the bar, however no single bar press was rewarded until the two pellets of food had been eaten. After the animal had eaten the two pellets of food, each subsequent bar press was rewarded with a pellet of food on the condition that the animal had eaten the pellet that was in the food dish prior to the occurrence of that particular bar press. Accordingly, no more than one pellet of food was in the food dish at any one time. This procedure was followed in order to eliminate hoarding on the part of the animals.

If an animal did not approach the end from which the

bar projected, a scratching sound was made at the end near the bar to induce the animal to that end of the alley. If an animal had not eaten after 30 minutes in the apparatus, it was discarded. If an animal had not pressed the bar for 30 minutes after having eaten the two pellets, it was discarded. In total, five animals were discarded for failing to eat and three animals for failing to press the bar. In addition, three animals were discarded because of miscellaneous apparatus failure. Thus 42 animals completed the training program, and this report is based upon data obtained from these animals.

After 10 pellets had been received in this manner, the food releasing mechanism was loaded with 40 pellets, extraneous cues were discontinued and the animal was allowed to proceed at its own pace with continuous reward at a ½-second delay after each bar press. These 40 continuously rewarded bar presses will hereafter be referred to as the pre-training blocks of responses.

Training

Immediately following these continuously rewarded trials, each animal was then given the remaining trials according to the group to which he had been previously assigned. For the sake of brevity, let us introduce the following symbols to represent the groups: FR_c - experimental

group receiving a cue for rewarded bar presses, FR_{nc} - experimental group receiving no cue for rewarded bar presses, C_{100} - control group receiving 100 continuously rewarded bar presses, and C_{50} - control group receiving 50 continuously rewarded bar presses. The treatment of the groups following pre-training is as follows:

FR_c (n=11) This group received 100 rewards with partial reward at the ratio of one reward to three bar pressings. For this group the food releasing mechanism made no click when food was not presented. The control box activated the food releasing mechanism only on every third bar press (rewarded bar press).

FR_{nc} (n=9) This group received 100 rewards with partial reward at the ratio of one reward to three bar presses. For this group the food releasing mechanism was activated every time the bar was pressed but food was given only on every third bar press. This was accomplished by placing food in every third hole of the magazine. Thus each bar press was followed by a click, but only every third bar press was followed by reward. This is the no cue group.

C_{100} (n=12) This group received 100 continuously rewarded bar presses.

C_{50} (n=10) This group received 50 continuously rewarded

bar presses. This group was added after the above three and was included to check the effect of the lowered discrimination in the C_{100} group after 50 rewards, on the number of trials to extinction.

All of the pre-training trials, training trials, and extinction trials were given on the same day. No interval of time was introduced by the experimenter between the divisions of the study. Each animal performed at its own rate during each division of the study.

Extinction

Immediately following training, each animal was kept on its training schedule, although no further rewards were administered. Two criteria of extinction were considered; failure to press the bar for three minutes and failure to press the bar for ten minutes.

RESULTS

In the present study the training and pre-training data were recorded as the percentage of discrimination during a set of ten blocks of responses (see p. 2), i.e., the ratio of the number of correct approaches to the food dish per ten blocks of responses multiplied by 100. Since Snedecor (6, p. 316, 447) advises the use of an arc sine transformation when dealing with percentages, the pre-training and training data were transformed into arc sines using the table presented by Snedecor (6, p. 449).

Since one of the requirements for the use of analysis of variance is homogeneity of variance, Bartlett's test was applied to the arc sines of the percentages of discrimination. The group variances were heterogeneous for the training data, therefore the decision was made to use non-parametric statistics. The Mann-Whitney U-test (4, pp. 128-130) was applied to the pre-training and training data. The results of these analyses are summarized in Tables I, IIIa and IIIb.

Table I summarizes the results of the U-test as applied to the last ten blocks of responses during pre-training. There were no significant differences in percentage of discrimination between groups of sophisticated animals and groups of naive animals, although (Table II) the groups of

TABLE I

SUMMARY OF THE RESULTS OF THE U-TEST COMPARING GROUPS ON THE LAST 10 PRE-TRAINING BLOCKS

Comparisons between:	U	E(U)	σ_u	p
Soph. and naive	135	184	35.01	< .17
C_{100} and C_{50}	90	66	16.25	< .15
C_{100} and FR_c	42	54	14.07	n.s.
C_{100} and FR_{nc}	41	42	11.83	n.s.
FR_c and FR_{nc}	32.5	31.5	9.45	n.s.
FR_c and C_{50}	68.5	49.5	13.16	n.s.
FR_{nc} and C_{50}	27	38.5	11.05	< .30

TABLE II

SUMMARY OF THE MEAN PERCENTAGE OF DISCRIMINATION ON THE LAST 10 PRE-TRAINING BLOCKS

Groups	Sophisticated	Naive	Group Means
FR_c	66.7	45.0	52.2
FR_{nc}	65.0	44.0	50.0
C_{100}	52.0	44.3	47.5
C_{50}	43.3	24.0	34.5
Means	53.1	39.9	

sophisticated animals were consistently superior to the groups of naive animals. In addition, there were no significant differences between groups during the last ten pre-training blocks. This latter result is to be expected since all groups had been treated alike up to this point of the study. We can say that all groups began the training period at approximately the same level of discrimination. It is interesting to note (see Table II) that at this point, although the animals had received 40 continuously rewarded blocks of responses, the discrimination was low (approximately 45 percent).

Table IIIa summarizes the results of the U-test comparing groups on successive 10 blocks of responses during training. The experimental groups do not seem to perform different from each other during training except during the last 10 blocks of responses, but as can be seen in Figure 2 and Table IV, the percentages of discrimination for both groups are extremely low even at the end of training. The results indicate that the auditory cue apparently does not easily facilitate discrimination.

The results of the U-test as summarized in Table IIIa indicate that the control group performs significantly superior to both of the experimental groups through 60 blocks of responses. After 70 blocks of responses the discrimination for the control group decreases as can be seen in Figure 2, and the cue group shows an increase in

TABLE IIIa

SUMMARY OF THE RESULTS OF THE U-TEST COMPARING GROUPS ON EACH SET OF 10 BLOCKS DURING TRAINING

Comparisons between:			U	E(U)	σ_u	p
T-10	$C_{50\&100}$	and FR_c	380	121	26.18	<.0001
T-10	$C_{50\&100}$	and FR_{nc}	168	99	22.98	<.0030
T-10	FR_c	and FR_{nc}	39.5	49.5	13.16	n.s.
T-20	$C_{50\&100}$	and FR_c	412.5	121	26.18	<.0001
T-20	$C_{50\&100}$	and FR_{nc}	183.5	99	22.98	<.0004
T-20	FR_c	and FR_{nc}	47.5	49.5	13.16	n.s.
T-30	$C_{50\&100}$	and FR_c	366.5	121	26.18	<.0001
T-30	$C_{50\&100}$	and FR_{nc}	169	99	22.98	<.0030
T-30	FR_c	and FR_{nc}	64.5	49.5	13.16	.25
T-40	$C_{50\&100}$	and FR_c	374	121	26.18	<.0001
T-40	$C_{50\&100}$	and FR_{nc}	200.5	99	22.98	<.0002
T-40	FR_c	and FR_{nc}	61.5	49.5	13.16	n.s.
T-50	$C_{50\&100}$	and FR_c	380.5	121	26.18	<.0001
T-50	$C_{50\&100}$	and FR_{nc}	175.5	99	22.98	<.0010
T-50	FR_c	and FR_{nc}	73.5	49.5	13.16	.07
T-60	C_{100}	and FR_c	101.5	66	16.25	<.03
T-60	C_{100}	and FR_{nc}	89	54	14.07	<.02
T-60	FR_c	and FR_{nc}	16.25	49.5	13.16	n.s.

TABLE IIIa (Continued)

Comparisons between:			U	E(U)	σ_u	p
T-70	C_{100}	and FR_c	88	66	16.25	< .20
T-70	C_{100}	and FR_{nc}	95	54	14.07	< .0040
T-70	FR_c	and FR_{nc}	71	49.5	13.16	< .11
T-80	C_{100}	and FR_c	90	66	16.25	< .15
T-80	C_{100}	and FR_{nc}	85.5	54	14.07	< .03
T-80	FR_c	and FR_{nc}	69.5	49.5	13.16	< .13
T-90	C_{100}	and FR_c	75	66	16.25	n.s.
T-90	C_{100}	and FR_{nc}	88.5	54	14.07	< .02
T-90	FR_c	and FR_{nc}	69.5	49.5	13.16	< .23
T-100	C_{100}	and FR_c	39	66	16.25	< .10
T-100	C_{100}	and FR_{nc}	74	54	14.07	< .16
T-100	FR_c	and FR_{nc}	87	49.5	13.16	< .0050

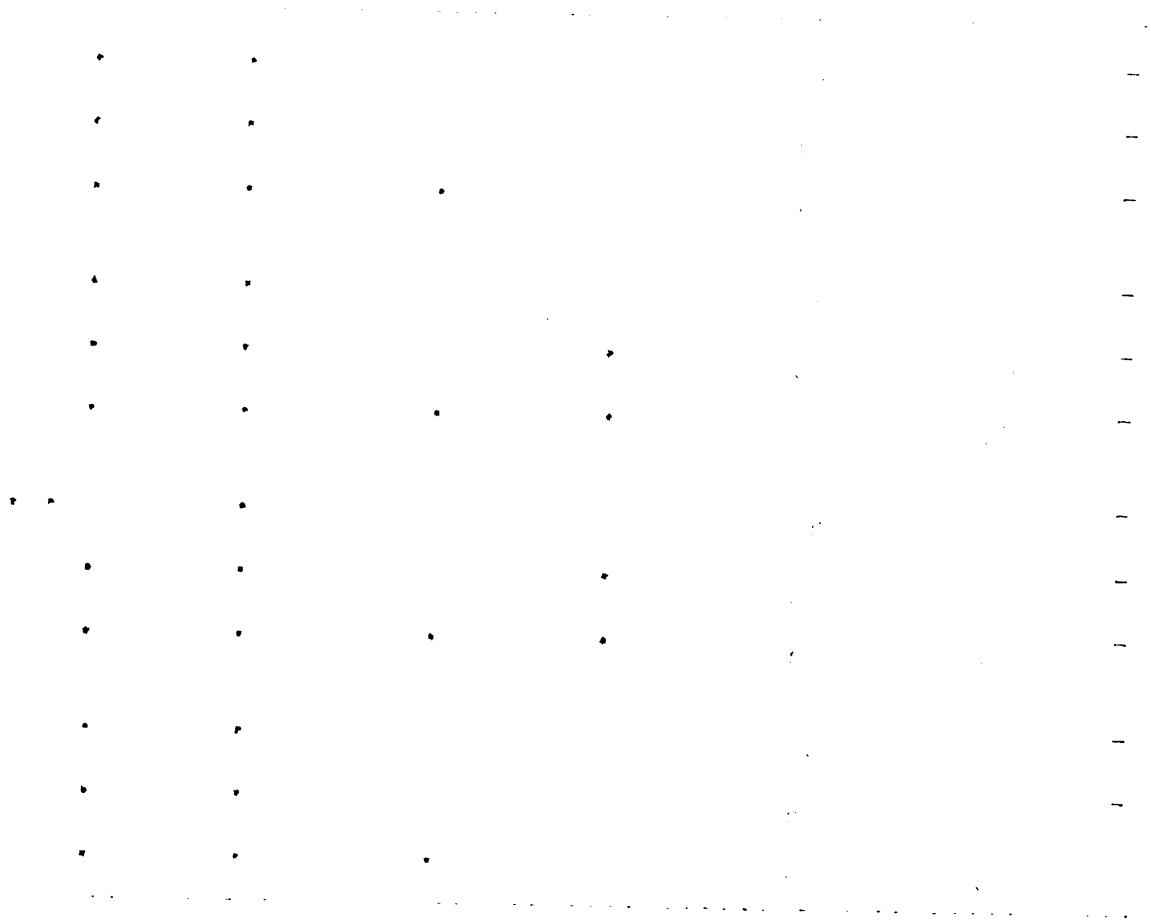

TABLE IIIb

SUMMARY OF THE RESULTS OF THE U-TEST COMPARING SCORES FOR EACH GROUP WITH SCORES FOR THE SAME GROUP AT A DIFFERENT POINT IN TRAINING

Comparisons between:			U	E(U)	σ_u	p
$C_{50\&100}$	and	C_{100}				
T-10	and	T-100	185	132	27.75	<.06
T-10	and	T-60	109.5	132	27.75	n.s.
C_{100}	and	C_{100}				
T-60	and	T-100	108.5	72	17.32	<.04
T-60	and	T-90	104.5	72	17.32	<.07
T-70	and	T-100	104.5	72	17.32	<.07
FR_{nc}	and	FR_{nc}				
T-10	and	T-100	33.5	40.5	11.33	n.s.
FR_c	and	FR_c				
T-10	and	T-100	102	60.5	15.23	<.0080
T-10	and	T-90	77	60.5	15.23	<.26
T-90	and	T-100	89	60.5	15.23	<.06

TABLE IV

MEAN PERCENTAGES OF DISCRIMINATION FOR THE LAST 10 PRE-TRAINING BLOCKS AND FOR THE SUCCESSIVE SETS OF 10 BLOCKS OF RESPONSES DURING TRAINING

Successive 10 blocks	FR_c	FR_{nc}	$C_{50\&100}$*
Last 10 pre-training	52.2	50.0	41.3
10	7.3	6.7	34.1
20	3.6	4.4	39.2
30	14.5	3.3	42.2
40	13.6	3.3	39.5
50	13.6	4.4	40.8
60	11.8	10.0	46.7
70	22.7	5.6	40.8
80	16.4	5.6	35.0
90	16.4	2.2	20.0
100	32.7	5.6	19.3

*First 50 blocks includes data for both C_{100} and C_{50}. Blocks 50 through 100 include data for C_{100} only.

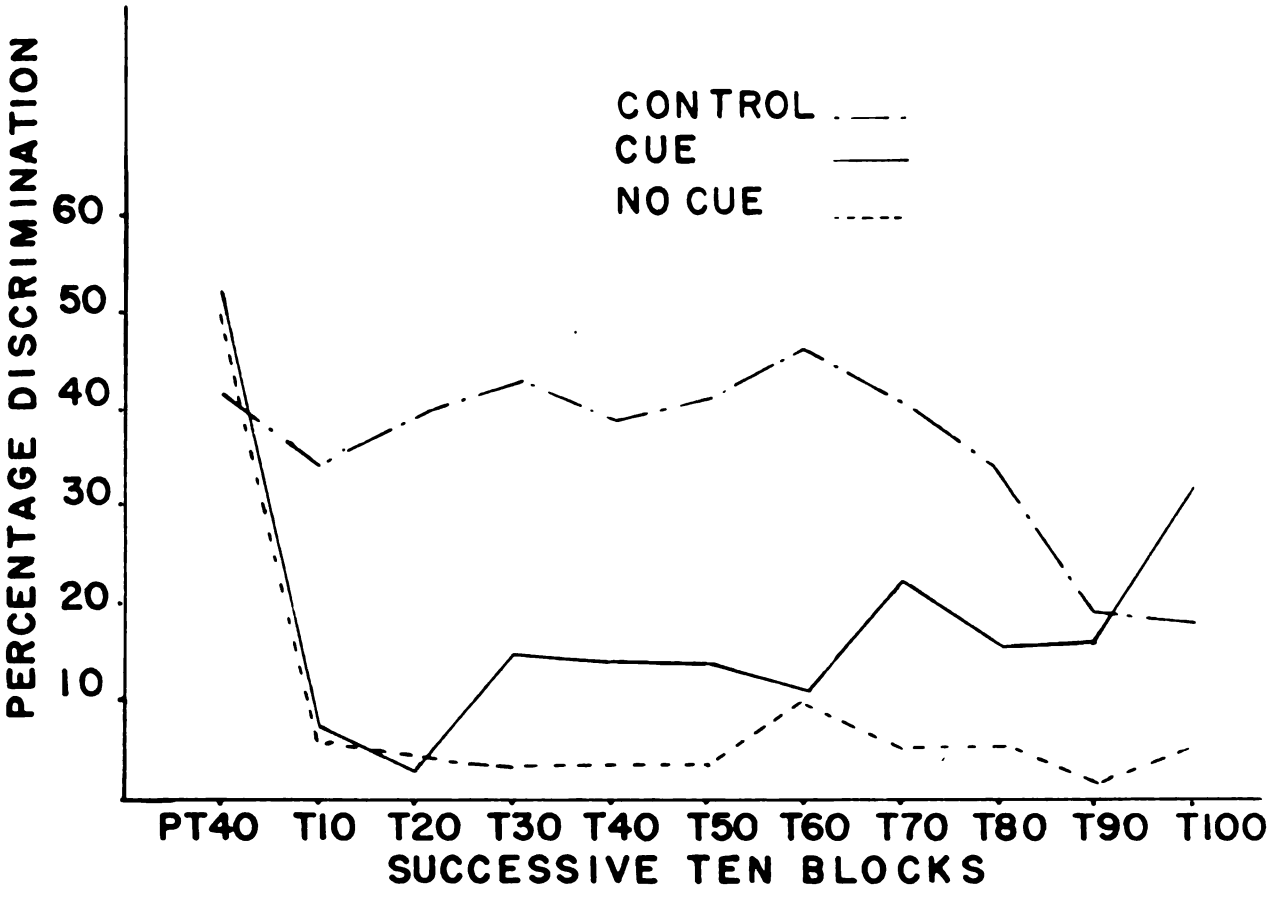

FIGURE 2. MEAN PERCENTAGE OF DISCRIMINATION FOR SUCCESSIVE TEN BLOCKS OF RESPONSES FOR THE LAST TEN PRE-TRAINING BLOCKS, PT40, AND FOR THE TRAINING BLOCKS, T10 THROUGH T100, FOR EACH OF THREE GROUPS, CUE GROUP, NO CUE GROUP, AND CONTROL GROUP

discrimination. After 70 blocks the control group no longer performs significantly superior to the cue group but does stay significantly superior to the no cue group until the last 10 blocks of responses.

Figure 2 and Table IV show the mean percentage of discrimination for the three groups on successive 10 blocks of responses. No group attained a mean percentage of discrimination above 50 percent during training. At the end of pre-training all groups were performing with approximately 50 percent discrimination. When the experimental groups were switched to training conditions, the discrimination dropped below 10 percent and then gradually increased for the cue group. U-test of the significance of change in discrimination training are given in Table IIIb. It is seen that the no cue group did not show any change in discrimination at all during the discrimination training. The cue group showed a slight but significant increase in discrimination during training, most of which occurred on the last 10 blocks of responses. The control group showed a significant drop in discrimination during training between T-60 and T-100 (see also Figure 2).

In Figure 2 and Table IV the first 50 blocks for the control group is a composite of the scores of the C_{100} and the C_{50} groups. From T-60 to T-100 the scores for the control group contain only data for the C_{100} group.

The extinction data were transformed into logarithms

to correct for heterogeneity before an analysis of variance was to be performed. This transformation did not correct the heterogeneity of variance, so a square root transformation was employed. The square root transformation corrected for heterogeneity, but then the means and standard deviations became highly correlated. To use an analysis of variance the means and standard deviations must be independent, therefore, it was decided not to try further transformations but instead to use the Mann-Whitney U-test. The results of this analysis are summarized in Table V. There were no significant differences between any of the groups on the number of bar presses to extinction for the three minute criterion. However, there was a significant U between the control group and the cue group on the ten minute criterion, whereas the three minute criterion did not clearly distinguish these two groups (see discussion p. 31). All other U's for the ten minute criterion were not significant.

The means of the trials to extinction for the groups (see Table VI) did order themselves according to the predictions of Hypothesis II if we omit the very deviant score which occurred in the no cue group (See Table IX, appendix) for the ten minute criterion; but Hypothesis II is not confirmed because the U's between the control group and the no cue group, and the cue group and the no cue group are not significant. We can note at this point that the lowered discrimination in the control group after 50 rewards did

TABLE V

SUMMARY OF THE RESULTS OF THE U-TEST COMPARING GROUPS ON THE TWO EXTINCTION CRITERIA

Comparisons between:	U	E(U)	σ_u	p
		3 minute criterion		
C_{100} and FR_c	92.5	66.0	16.25	<.12
C_{100} and FR_{nc}	67.0	54.0	14.07	n.s.
FR_c and FR_{nc}	39.5	49.5	13.16	n.s.
C_{100} and C_{50}	48.0	60.0	15.17	n.s.
		10 minute criterion		
C_{100} and FR_c	26.5	66.0	16.25	<.02
C_{100} and FR_{nc}	45.5	54.0	14.07	n.s.
FR_c and FR_{nc}	61.0	49.5	13.16	n.s.
C_{100} and C_{50}	52.0	60.0	15.17	n.s.

TABLE VI

SUMMARY OF THE MEAN BAR PRESSES TO EXTINCTION FOR THE TWO EXTINCTION CRITERIA

Groups	3 Minute Criterion	10 Minute Criterion
C_{50}	23.6	62.6
C_{100}	16.7	49.9
FR_c	43.0	99.7
FR_{nc}	29.6	64.8*

*Omitting the one very deviant score (see Table IX, appendix).

not significantly alter the number of bar presses to extinction (see comparison between C_{100} and C_{50} in Table V).

It is very doubtful that the results of this study are any test of Hypothesis I as it is stated. When Hypothesis I was derived, it was implicitly assumed that animals would approach 100 percent discrimination at the end of pre-training (3, p. 117). The percentage of discrimination at the end of pre-training reached a level of only around 45 percent. It was thought, therefore, that if we used the percentage of discrimination achieved at the end of pre-training as a base from which to consider the percentage of discrimination achieved by the cue group during discrimination training, then we might arrive at a result more nearly in line with the actual number of trials to extinction. This method is admittedly ex post facto, but it is capable of test in a situation where the ratio of reward is different than the one employed in the present study.

Table VII summarizes the prediction of Hypothesis I, predictions using the ex post facto method, and the actual scores for the experimental group receiving the cue. There is no support for Hypothesis I as it is stated, but the assumption behind Hypothesis I was that all animals would approach 100 percent discrimination at the end of pre-training. This assumption is not satisfied, however, hence it is doubtful that this study is an adequate test of Hypothesis I as stated. The ex post facto method gives closer predicted

TABLE VII

SUMMARY OF THE PREDICTED TRIALS TO EXTINCTION BY TWO METHODS, AND THE ACTUAL TRIALS TO EXTINCTION FOR THE CUE GROUP FOR THE TWO EXTINCTION CRITERIA

Method for Prediction	3 Minute Criterion	10 Minute Criterion
Hypothesis I	16	49
Ex post facto method	31	94
Actual bar presses to extinction	43	100

results for the ten minute extinction criterion (see discussion p. 35) than does Hypothesis I.

DISCUSSION

The generalizations concerning acquisition put forth by Jenkins and Stanley (see p. 1) receive some support from the results of the present study. The continuously rewarded group in the present study did perform at a higher level of discrimination than did the experimental groups until the end of training, when the performance level of the control group was not significantly different from the experimental groups. Of course, the fact that there was no difference at the end of acquisition between the control and experimental groups may have been due to factors other than the difference in the ratio of reward. For example, the continuously rewarded group showed an unexplainable drop in discrimination on the last half of the training trials.

In addition to the support for the generalizations of Jenkins and Stanley on acquisition, the data of the present study lend support to their generalizations in reference to the number of trials to extinction. The experimental group receiving the cue made more bar presses to extinction than did the control group on the ten minute criterion, whereas the three minute criterion did not clearly differentiate these two groups. However, the control group and the no cue group did not differ with respect to the number of trials to extinction with either criterion, which suggests a

limitation on the generalizations which were drawn by Jenkins and Stanley.

"Extinction" is a term applying to relative states of affairs since animals continue to make the responses which previously led to reward although the criterion has been reached. Therefore, the criterion, as in the present study, often makes a difference in the results obtained. The extinction criterion should be a long enough period of time to pick up any true differences. A short period of time used as a criterion, as the three minute criterion used in the present study, often does not distinguish between the groups. In fact, during training animals often do not respond for short periods of time, but we do not call this extinction.

When the experiment was designed, it was expected that animals would display higher percentages of discrimination. The question arises: Is 50 percent discrimination the best that rats can do under the conditions of the present study? Due to the construction of the apparatus (see p. 10) it was possible that there was confounding of approaches to the food dish with approaches to the water tube. Both of these types of approaches would have been recorded on the tape, but there is no way of separating the two with the present method of recording. To avoid this confounding error the water bottle should be moved to the center of the alley.

In the Wells' study (7), the index of discrimination

was the mean number of approaches to the food dish per 10 blocks of responses. This method of calculating discrimination only considers that approaches occurred and not when they occurred.

Now if we take an example, we can point out the differences in the two methods of calculating discrimination. Consider that animals pressed the bar nine times without approaching the food dish and thereafter approached the food dish three times before pressing the bar again, then this, as it is understood by the gross method, would yield perfect discrimination for the three blocks of responses with one to three ratio of reward. The method used in the present study would consider that this was zero percent discrimination for three blocks of responses with one to three ratio of reward. The gross method tends to enhance the degree of discrimination.

The method used in the present study is more in line with the methods used in other types of discrimination studies, i.e., for example, in a discrimination apparatus, considering whether each choice is correct or incorrect and then using the ratio of correct choices to total choices multiplied by 100. In the present study, if the approach to the food dish was to be called correct, the animals were required to press the bar three times and only three times before approaching the food dish. That is, they had to pattern their bar presses in groups of three. The cue group

received an auditory cue to signal the presentation of food. This should have facilitated the patterning of responses, but after 100 rewards at one to three ratio of reward, these animals had not learned to use the cue to any appreciable extent. With more rewards, they might have achieved a higher level of discrimination. The no cue group, on the other hand, apparently did not learn to pattern their bar presses on the basis of other cues not introduced by the experimenter.

Therefore in view of the unexpected low discrimination even after 40 continuously rewarded blocks of responses, it would be well to take the discrimination after the continuously rewarded blocks into consideration in the prediction of the number of bar presses to extinction. This percentage of discrimination at the end of 40 continuously rewarded blocks (pre-training) might be considered the maximum percentage of discrimination attainable in the present situation. We could then use this percentage of discrimination as a base in place of 100 when calculating the discrimination at the end of training. Hypothesis I, as it is stated in the beginning of this paper, receives no support from the findings of the present study but if revised could receive some support. The revision suggested is in line with the assumption on which Hypothesis I is based, i.e., that animals would achieve a high degree of discrimination after the continuously rewarded blocks of responses.

SUMMARY

The present study was designed to check the following hypotheses:

Hypothesis I: If a discriminative cue is present during training and extinction under partial reward, so that it differentiates the rewarded bar press from the non-rewarded bar press, then the number of bar presses to extinction following training under fixed ratio reward will be equal to the product of the number of bar presses to extinction following continuous reward, the number of bar presses in the fixed ratio block, and the final percentage of discrimination attained.

Hypothesis II: If no specific cue is present during the fixed ratio schedule, then the number of bar presses to extinction will be less than the number of bar presses to extinction following training under fixed ratio reward with a cue but greater than the number obtained following continuous reward.

Two experimental groups and two control groups performed in a modified Skinner box situation. All animals received 40 continuous rewards. One control group (n=12) received 100 additional continuous rewards, the second (n=10) received 50 additional continuous rewards. Both experimental groups received 100 additional rewards at a

fixed ratio of one reward to three bar presses. One experimental group (the cue group, n=11) received an auditory cue (click) when food was to be presented and no sound when food was not to follow the bar press. The second experimental group (the no cue group, n=9) received a click following every bar press. Extinction trials followed immediately for all groups.

The results indicate superior performance for the control group over the experimental groups until the end of acquisition when there are no differences between the control group and the experimental groups, although at the end of acquisition the cue group is superior to the no cue group. The control group shows a significant decline in percentage of discrimination after 60 rewards, whereas the cue group shows an increase in discrimination. The no cue group shows no change in discrimination over training.

There were no differences on the number of bar presses to extinction for a three minute extinction criterion. However, on the ten minute criterion, there was a difference between the control group and the experimental group receiving the cue. No other comparisons were significantly different. Hypothesis I was not confirmed and a revision is suggested. Hypothesis II was not confirmed.

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APPENDIX

TABLE VIII

MEAN PERCENTAGE OF DISCRIMINATION FOR SUCCESSIVE 10 BLOCKS OF RESPONSES FOR ALL ANIMALS DURING TRAINING

Groups	Animals	Successive 10 blocks of responses									
		10	20	30	40	50	60	70	80	90	100
C_{100}	7	80	100	80	30	40	100	100	10	40	10
Soph.	8	80	20	80	100	70	100	80	100	80	90
	9	20	30	40	40	30	20	50	80	30	0
	10	20	40	20	20	50	50	10	10	0	0
	11	20	40	20	20	0	0	10	0	0	0
Naive	27	100	30	20	30	20	10	10	10	20	10
	102	30	20	0	0	0	0	0	0	10	0
	105	0	0	0	0	60	70	50	50	10	40
	107	20	30	0	30	90	40	60	50	20	10
	108	50	40	50	10	60	70	70	50	20	30
	109	50	70	60	70	70	50	30	60	0	40
	110	20	30	20	60	10	50	20	0	10	0
C_{50}	13	50	70	100	100	30					
Soph.	14	10	0	0	0	20					
	15	80	70	80	60	20					
	16	20	30	100	60	70					
	17	10	80	40	70	60					
Naive	23	40	30	60	40	0					
	24	20	50	50	10	60					
	103	20	20	40	10	30					
	104	0	20	0	20	70					
	28a	10	20	0	20	70					
Means		34.1	39.2	42.2	39.5	40.8	46.7	40.8	35.0	20.0	19.3

TABLE VIII (Continued)

Groups	Animals	Successive 10 blocks of responses									
		10	20	30	40	50	60	70	80	90	100
FR_c	1	0	0	10	10	30	0	20	20	40	10
Soph.	2	0	0	0	0	10	20	0	0	0	0
	3	0	0	10	10	10	0	40	40	30	40
	4	0	0	30	80	50	60	50	40	60	40
	5	0	0	0	0	0	10	50	0	20	60
Naive	26	0	0	0	0	10	10	20	40	30	40
	31	0	20	30	20	10	0	10	0	0	50
	32	0	0	0	0	0	0	0	0	0	30
	100	20	10	10	20	20	10	0	0	0	20
	101	60	10	40	0	10	0	0	10	0	60
	300	0	0	30	10	0	20	60	30	0	10
Means		7.3	3.6	14.5	13.6	13.6	11.8	22.7	16.4	16.4	32.7
FR_{nc}	19	10	0	0	0	0	0	0	0	0	0
Soph.	20	20	0	0	10	0	0	10	0	10	40
Naive	21	0	0	0	0	0	10	10	0	0	0
	22	0	10	0	10	10	0	0	0	0	0
	33	0	0	0	0	0	0	0	0	0	0
	106	0	0	0	0	0	0	0	0	10	10
	117	0	0	0	0	0	0	0	0	0	0
	119	10	10	0	0	0	30	0	20	0	0
	200	20	20	30	10	30	50	30	30	0	0
Means		6.7	4.4	3.3	3.3	4.4	10.0	5.5	5.5	2.2	5.6

TABLE IX

MEAN BAR PRESSES TO EXTINCTION FOR ALL ANIMALS

Group	Animal	Criterion 3M	Criterion 10M	Group	Animal	Criterion 3M	Criterion 10M
C_{100}	7	4	129	FR_c	1	4	81
Soph.	8	10	59	Soph.	2	15	132
	9	28	36		3	135	144
	10	36	89		4	12	24
	11	0	4		5	90	95
Naive	27	5	5	Naive	26	72	179
	102	26	46		31	19	117
	105	46	89		32	6	6
	107	3	80		100	9	108
	108	1	3		101	81	81
	109	12	15		300	31	129
	110	19	42				
C_{50}	13	19	24	FR_{nc}	19	37	63
Soph.	14	3	9	Soph.	20	79	403
	15	7	76	Naive	21	78	174
	16	36	44		22	9	9
	17	51	91		33	11	11
Naive	23	0	16		106	2	20
	24	37	82		117	37	68
	103	8	20		119	3	3
	104	64	211		200	10	170
	28a	11	53				