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## **Preliminary Investigations in the Effect of Continually Changing Reinforcement on Learning and Extinction**

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I am submitting herewith a thesis written by Michael Dinoff entitled "Preliminary Investigations in the Effect of Continually Changing Reinforcement on Learning and Extinction." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Psychology.

Dr. Gerald R. Pascal, Major Professor

We have read this thesis and recommend its acceptance:

Dr. William O. Jenkins, Dr. Clifford Swesen, Dr. Merritt Moore, & Dr. William Cole

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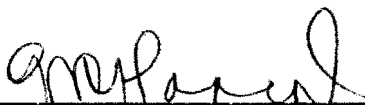
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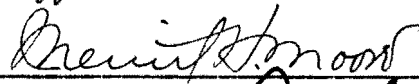


April 16, 1959

To the Graduate Council:

I am submitting herewith a thesis written by Michael Dinoff entitled "Preliminary Investigations in the Effect of Continually Changing Reinforcement on Learning and Extinction". I recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Psychology.

  
Major Professor

We have read this thesis and  
recommend its acceptance:

Accepted for the Council:

  
Dean of the Graduate School

PRELIMINARY INVESTIGATIONS IN THE EFFECT OF  
CONTINUALLY CHANGING REINFORCEMENT ON  
LEARNING AND EXTINCTION

---

A DISSERTATION

Submitted to  
The Graduate Council  
of  
The University of Tennessee  
in  
Partial Fulfillment of the Requirements  
for the degree of  
Doctor of Philosophy

---

by

Michael Dinoff

June 1960

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## CHAPTER I

### INTRODUCTION

#### Problem Area

In the vast majority of learning experiments within the laboratory, the reinforcing stimulus is very carefully controlled and is therefore, rarely manipulated from trial to trial to see its effects upon learning and extinction. Parameters of reinforcement such as quantity, quality, delay, rate and the like have all been investigated but are generally kept constant throughout the learning situation. McClelland (1951) points out that this may well be the reason for the apparent impermanence of laboratory learning as opposed to learning in nature. Outside of the laboratory the reinforcing stimuli, and, indeed most stimuli, vary from trial to trial either by virtue of subtle difference in the reinforcing agent or because the organism is reinforced in a different setting. The response is learned to many different stimulus complexes. One simply has to consider how a child learns a simple habit. Once a response is made, it is reinforced or punished by what the parent does. The next time the behavior occurs, it may happen in a different room with the parent absent or perhaps the other parent present. The reinforcement or punishment on this occasion will be con-

siderably different than in the first instance. On no two occasions will the reinforcement be exactly or even nearly the same. It is therefore suggested that learning in the presence of a wide variety of cues and reinforcements would influence conditioning and extinction. This paper will deal with an investigation in the systematic manipulation of the reinforcing stimulus.

### Background

Little research has been reported considering the importance of the general area of varied reinforcement during learning and its effect upon extinction. The earliest reports are by Tolman and Honzik (1930) who have shown that simple removal of reward during maze conditioning led to an increase in time and error scores. In its simplest form this is extinction. Another group which had never been reinforced showed a rapid decrease in time and error scores when reinforcement was presented. Elliot (1928) trained rats to run a fourteen choice T-maze. On the first nine days they received wet food for this and on the tenth, sunflower seed was substituted in the goal box. An immediate increase in time and error scores was apparent. On the tenth experimental day, the changed reinforcement day, the experimental animals did less eating and considerably more exploring. Elliot (1929) has shown a similar effect when drive was changed

from thirst to hunger and the incentive was not similarly changed.

Crespi (1942) has done some important work in the area of amount of reinforcement and in changes of amount during conditioning. Twenty-two hour deprived rats were divided into five groups reinforced by different incentive amounts. Significant differences in level of performance were shown in the runway situation with the animal receiving the larger incentive running faster. These findings are substantiated consistently in other research (Carpenter, 1953; Crespi, 1944; Faz, Miller & Harlow, 1953; Fletcher, 1940; Grindley, 1929; Hutt, 1954; Jenkins, 1943; Leonhardt, 1953; Maher & Wickens, 1954; Nissen & Elder, 1935; Reynolds, 1950a & 1950b; Wolfe & Kaplan, 1941; and Young & Shuford, 1955). There are only a few contradictory studies (Furchtgott & Rubin, 1953; Furchtgott & Salzberg, 1959; and Reynolds, 1949). Jenkins and Clayton (1949) present a good summary of this general area. Crespi also found that the larger the amount of incentive, the less variable is the group's performance. Subjects receiving no incentive, however, ran faster than did SS receiving a very small incentive. Behaviorally the smaller incentive groups show "frustrated" behavior or extraneous activities. In a second experiment Crespi reported that as incentive is increased the shape of the acquisition curve changes progressively from being positively accelerated, to

linear, to negatively accelerated. The larger the incentive the earlier in learning does performance stabilize. In a third experiment Crespi showed that increased incentives during learning result in "elation" effects, or, in other words a significantly superior level of performance is found. However, the elation effect was not consistently different whether the increased incentive was somewhat greater or much greater than the original reinforcement. When a decrease in incentive occurred during learning, "depression" effects resulted. These animals showed a significantly inferior level of performance compared to groups only receiving this lesser incentive. There was no consistent pattern of depression. "Frustrated" behavior accompanied the drop in the amount of reinforcement.

Dufort and Kimble (1956) trained forty rats to run an alley to secure a 10 per cent solution of sucrose. On the twenty-first trial, they were divided into groups receiving either a 5, 10, or 20 per cent solution, or nothing. An increase led to an increase in running speed while a decrease resulted in a proportional decrease. The increase from 10 to 20 per cent showed an increase that was proportionately greater than what was predictable from an a priori Hullian hypothesis. These findings are similar to Guttman's (1954). Four very experienced and four moderately experienced rats were given one fifty minute test on each of seven sucrose and seven glucose concentrations in addition to tests with water

reinforcement. Rate of pressing a bar seemed to have been an increasing function of concentration of either the glucose or sucrose with the rate of performance for the sucrose solution always above that for glucose at any given concentration. This is inconsistent with a drive-reduction position (Hull, 1943).

The above findings are questioned by Furchtgott and Rubin (1953) and Furchtgott and Salzberg (1959) in their similar experiments. Principally, the only differences they demonstrate is between above and below threshold concentrations.

Logan, Beier, and Ellis (1955) attempted to find out if reinforcement varied between two equally likely values what effect this change would have upon learning? They varied the dimensions of delay and magnitude of the reinforcer in two different groups respectively. The Ss were rats in a runway situation. The first group was reinforced with nine pellets and this was considered the preferred magnitude. One group was reinforced with five pellets (known as the mean group). The last group, on a random half of each block of ten trials, received either a nine pellet reward or a one pellet reward. Time delay was varied similarly in the other group of animals. Both the preferred magnitude and delay groups ran faster while the varied magnitude and delay (with considerable subject variability), performed more like the



average group confirming the author's Hullian prediction on the basis of average drive-reduction and certain other mathematical concepts.

A considerable literature is developing in the area of partially delayed reinforcement. Here reward is delayed on some of the trials and is immediate on the others. Crum, Brown, and Bitterman (1951) have clearly shown that delay on 50 per cent of the initial training leads to greater extinction resistance in a runway situation. This has been confirmed by Peterson (1956). Logan, Beier, and Kinkaid (1956) have demonstrated that resistance to extinction is increased only if the two delays are great extremes, i.e., variation between zero and thirty second delay, whereas, variation between zero and nine second and between one and nine second did not resist extinction as long. In an experiment that was essentially a replication of Logan, Beier, and Kincaid's experiment, Scott and Wike (1956) reported substantially similar results. Kintsch and Wike (1957) trained rats to run a T-maze for different degrees of partially delayed reward. After sixteen days of acquisition training the subjects were reinforced in the opposite arm of the T-maze immediately upon entry. The greater the change in partial delay, the slower the rate of learning. The less extreme the partial delay, the more readily did the subjects reverse their position when reinforcement was moved to the opposite arm.

In an effort to determine whether partially delayed reinforcement was experimentally similar to partial reinforcement, Wike and McNamara (1957) ran three matched groups of rats in a runway situation with the subjects receiving either 25, 50, or 75 per cent partially delayed reinforcement. They found that the lower the percentage of partial delay, the faster was running at the end of training but that extinction progressed more quickly. Further the 50 and 75 per cent delay groups were not significantly different from each other.

Thinking in terms of reward irregularity, one must also consider the area of partial reinforcement research. A thorough summary of the pertinent research is found in Jenkins and Stanley (1950). The more the organism is reinforced during conditioning, the higher the resulting level of performance during conditioning, but the more quickly the behavior deteriorates under extinction conditions. The findings are so regular and so consistent that partial reinforcement can be thought of as a law of behavior. However, different investigators account for the phenomenon by different theoretical arguments.

Reinforcement can be thought of as one stimulus of the total complex in the learning situation. If it is just "another" stimulus, variation of the reinforcement parameter should show behavioral change similar to that after any stimulus variation in the learning situation. An incomplete

review of the effect of stimulus variation during conditioning follows.

In a recently reported study, Brown and Bass (1958) tested the differential effect of constant and variable stimulus conditions during instrumental learning. They used three straight runways of exactly the same length with similar goal and end boxes. The alleys differed in width, color, floor texture and presence and type of barriers. Sixty rats were divided equally into two major groups and were food deprived. One major group of animals learned under constant conditions, i.e., all their learning trials occurred in the same runway and the animals were divided equally over the three runways. After training one-half of this group was extinguished in the same runway while the remaining subjects were rotated in counter-balanced order to receive four extinction trials in each of the three runways. The second major group were trained in all three runways receiving eight trials in each runway. Half were then extinguished under constant conditions while the remaining half were extinguished under changing alley conditions. It is interesting to note that learning was essentially the same whether the conditions were varied or constant. There is a suggestion, however, that the constant group led to slightly "better" performance. Resistance to extinction was unaffected by change or no change during learning. Furthermore, constant groups extinguished faster than did the

groups under varied conditions.

Wolfle (1935, 1936) has tried to answer the question "Is varied stimulation during learning as effective as constant stimulation?" He suggested that learning can take place with variability in the stimulus conditions associated with learning as long as a considerable portion of the stimulus complex remains intact or constant. Wolfle used varieties of a pencil maze. Seventy subjects learned the maze under constant conditions, i.e., the same form on each trial. There were five forms; all forms were shown to be of approximately equal difficulty. A group of seventy-six subjects learned all five mazes in random order but had the same total amount of maze experience as did the first group. The constant group was consistently superior to the varied group. In a replication with a second group of mazes, the same trend was consistently shown. In the second experiment a different element of the maze was systematically manipulated and showed greater differences than did the first experiment. Wolfle concludes from this that continual manipulation of different stimuli lead to different magnitudes of response handicap. The findings were the same when Wolfle used a finger maze also and when replicated at a later date (Wolfle, 1936). Essentially, the greater the degree of stimulus variation, the less efficient was learning. Grether and Wolfle (1936) performed a similar experiment with rats

and conclude that a small amount of variation does not retard learning but greater amounts of variation lead to proportional decrements in learning.

Young (1959) has a very thorough and recent review on the effect of stimulus variation during learning. In his own work he demonstrates learning although his Ss received no apparent drive-reduction for their efforts. His Ss ran from one compartment with a discriminably different stimulus complex than the former. The larger the stimulus change from compartment to compartment the faster the rats ran. There was a great deal of variability, however. His findings seem consistent with a Guthrian theory of reinforcement. It should be indicated that the effect was more apparent in deprived as opposed to satiated Ss.

McClelland and McGown (1953) argue that extinction is a function of the specificity of conditioning.

The more general the association formed during original learning, i.e., the more variable the conditions under which it is formed, or the more cues built into the association, the harder it should be to establish conditions which should lead to extinction of the original association through non-reinforcement. (1953, P.80)

They continue by arguing that this is a characteristic feature of learning in nature. As a result of the above thinking, the authors divided their animals into four groups. One group (the specific reinforced group) was always reinforced in the same spot of a circular maze. The second

group, controlled for this above group, was never fed in the maze although time in the maze was carefully controlled. The third group of animals (the general reinforcement group) was reinforced in a circular maze but had to make one or the other of two varying responses to obtain reinforcement, i.e., stopping, or running. The fourth group, controlled for the third, was not reinforced. The regular reinforced group extinguished as a 100 per cent reinforced group would while the variable group resisted extinction, indeed, showed no significant signs of extinction after twenty-five trials. "These findings are interpreted as showing that extinction is a function of the ease of discrimination between the cue pattern during reinforcement and the cue pattern during extinction." (1953, P. 86) The explanation is similar to that of the partial reinforcement effect. The interested reader is referred to Jenkins and Stanley (1950) for that explanation.

More recently Hulicka (1955) accumulated data to support Wolfle's, and Grether and Wolfle's conclusions. She states that the more irregular the conditions of acquisition, the more resistant is the response to extinction. It is interesting to note that she found that irregularity in drive-reduction conditions did not affect resistance to extinction. McNamara and Wike (1958) have also shown that varied training conditions retard learning but enhance extinction.

### Statement of the Problem

A great deal of research has been done in the general area of manipulating reinforcement parameters. However, reinforcement per se has rarely been varied systematically from trial to trial. The research exceptions have been indicated. In these experiments, the nutritive value, the delay, or the units of reinforcement have been systematically varied and the results are not always conclusive as regards the experimental variable itself. The present study attempts to control for these factors and yet vary systematically properties of the reinforcing agent alone. Pigeons were the experimental subjects and they worked for food while they were at a controlled drive level. Since the caloric value in the food reward was kept constant from trial to trial, a Hullian prediction would be that the groups would show no difference in either conditioning or extinction as all groups would be drive-reduced similarly (Hull, 1943). On the basis of most of the stimulus variation experiments it is possible to predict that the more the cue change in reinforcement, the slower the rate of acquisition and the lower the subjects' performance level. It is possible to predict further that the groups with more extensive reinforcement variation should resist extinction longer much the same as is shown in the stimulus change and also in the partially-delayed reinforcement experiments. In

other words, they have been conditioned to changing cues and extinction can be viewed as another cue change. There is of course a third possibility. The more reinforcement variation, the higher the level of performance due to a sort of "grab-bag" motivating effect. This third alternative would fit in with the amount or "bits" research and the novel stimulation research. The more stimulus change groups should be similar to getting more units for their efforts in terms of more cue-change. Specific directional predictions were not made although on the basis of previous pilot study work (see Chapter II) a trend could be predicted.



## CHAPTER II

### THE EFFECT OF VARYING REINFORCING STIMULI ON THE HUNTER-PASCAL CONCEPT FORMATION TEST

As a preliminary investigation into the area of reinforcement variation, an attempt was made to determine the effect of reinforcement change on human subjects. The Hunter-Pascal Concept Formation Test (Pascal and Jenkins, 1957) was the apparatus used to test the effect of varying the reinforcing stimuli during the course of learning. This test was chosen partly because of the ready availability of normative data and partly because it involves a complex task which would seem more closely related to ordinary conditions of learning than to the "simpler" learning that usually is attempted in the laboratory. Also, there is a fairly extensive literature on this test making it easier to compare human and animal learning on the same or similar tests.

#### Method

Thirteen Ss were tested on the Hunter-Pascal Concept Formation Test. One S was eliminated due to an error in test administration. The twelve remaining Ss were divided equally into four groups; each group receiving a different experimental treatment. The Ss were drawn from an introductory psychology course and a junior sociology class at the Univer-

sity of Tennessee. There is no reason to assume that these Ss were from any but the same source population on the basis of previous research evidence. All Ss were tested in the same room in the South College Building at the University of Tennessee.

Each S in Group I took the Hunter-Pascal test in the prescribed manner and this group served as controls. The Ss in Group II were given the Hunter-Pascal test but were reinforced with nine different stimuli each of which was presented randomly before any one was repeated. Group III was given a new reinforcement at the onset of each new Hunter-Pascal problem and the reinforcement continued throughout that problem. Group IV had as many reinforcements as there were presentations in each problem. These were continually randomized but the S had to find each stimulus before any one was repeated (see Table I). Except for the reinforcement variation the test was administered according to the directions in the Hunter-Pascal manual. The dimensions suggested in the manual were followed closely in the construction of the Hunter-Pascal apparatus. The reinforcing stimuli used were a poker chip (the standard reward for college students), a miniature screwdriver, a rubber stopper, a washer, a nail, a package of safety matches, a small pencil, a bent safety pin, and a large knotted rubber band. Although not specifically evaluated, there was no a priori assumption that any of these objects would have any

TABLE I

## DESIGN OF THE HUNTER-PASCAL EXPERIMENT

| Group | Subjects | Conditions   |
|-------|----------|--|
| I     | 3        | Hunter-Pascal administered in the usual manner   |
| II    | 3        | Nine different reinforcing stimuli presented randomly but not repeated until all nine were presented |
| III   | 3        | A new reinforcement for each new problem. (Five reinforcing stimuli)                                 |
| IV    | 3        | As many different reinforcements per trial as presentations  |

greater or lesser stimulus value than any other one. It is possible that for any given S an item might have had more stimulus value but it is also likely that the effect might cancel out between Ss. The examiner made a great effort to insure that adequate rapport was established prior to testing.

Each record was scored according to the procedure given in the Hunter-Pascal manual. It is possible to evaluate learning on this test by both an error score and a presentation score and both were used.

### Results

For each S a presentation and error score was available. Table II shows the presentation scores on each problem. Because of the overlap from group to group and the use of small groups of Ss, classical statistics would show unacceptable confidence levels. However, by using their means, the groups would be ranked by performance from best to worst I, IV, III, II, and the medians would rank IV, I, III, II. It would seem that some trends are indicated although the subject to subject variability would confound the confidence level. Nonetheless on both the mean and median scores, groups II and III did more poorly than either the control group or group IV. Group IV performed better than did group I as indicated by the median presentations.

TABLE II

## HUNTER-PASCAL PRESENTATION SCORES

|  | Problems |      |      |      |      | Total |
|--|----------|------|------|------|------|-------|
|  | IV       | V    | VI   | VII  | VIII |       |
| Group I (control)  |          |      |      |      |      |       |
| 1  | 4        | 4    | 10   | 24   | 80   | 122   |
| 2  | 8        | 8    | 10   | 48   | 48   | 122   |
| 3  | 12       | 4    | 10   | 12   | 32   | 70    |
| Mean   | 8.0      | 5.3  | 10.0 | 28.0 | 53.3 | 104.7 |
| Median   | 8        | 4    | 10   | 24   | 48   | 122   |
| Group II (continual variation)                               |          |      |      |      |      |       |
| 1  | 12       | 4    | 15   | 60   | 80   | 171   |
| 2  | 18       | 16   | 40   | 60   | 80   | 214   |
| 3  | 27       | 4    | 10   | 18   | 8    | 67    |
| Mean   | 19.0     | 8.0  | 21.7 | 46.0 | 56.0 | 150.7 |
| Median   | 18       | 4    | 15   | 60   | 80   | 171   |
| Group III (new reinforcement - new problems)                 |          |      |      |      |      |       |
| 1  | 16       | 8    | 10   | 6    | 40   | 80    |
| 2  | 4        | 24   | 15   | 60   | 80   | 183   |
| 3  | 30       | 16   | 10   | 18   | 80   | 154   |
| Mean   | 16.7     | 16.0 | 11.7 | 28.0 | 66.7 | 139.0 |
| Median   | 16       | 16   | 10   | 18   | 80   | 154   |
| Group IV (number of reinforcement - number of presentations) |          |      |      |      |      |       |
| 1  | 16       | 4    | 10   | 54   | 80   | 164   |
| 2  | 24       | 8    | 10   | 24   | 8    | 74    |
| 3  | 6        | 8    | 10   | 30   | 24   | 78    |
| Mean   | 15.3     | 6.7  | 10.0 | 39.3 | 37.3 | 105.3 |
| Median   | 16       | 8    | 10   | 30   | 24   | 78    |

The data is somewhat more consistent on the error scores (see Table III). Here the groups are ranked IV, I, III, II on both the means and medians for the total score. It is interesting to note that there is no overlap in the error scores between the subjects of groups I and II. These data show the same trend that was suggested by the presentation scores. This finding is to be expected since the error score and presentation score correlate highly (Pascal and Jenkins, 1957). It should be observed that the same general findings show themselves on most of the individual problems.

Although the author has discussed the results as indicating trends, it should be mentioned that with two subjects in each group performing almost the same and the third subject reversing, the results could easily be chance results and not represent any trend. In any case, the experiment will need to be repeated to see whether or not these are but chance trends.

### Discussion

Although none of the findings show statistical significance some trends are possibly indicated on the basis of these results. The most striking of these are that groups II and III do more poorly than do groups I and IV and group II is consistently the poorest. This could be interpreted as a drastic stimulus change which impairs the Ss performance

TABLE III

## HUNTER-PASCAL ERROR SCORES

|  | Problems |      |      |      |      | Total |
|--|----------|------|------|------|------|-------|
|  | IV       | V    | VI   | VII  | VIII |       |
| Group I (control)  |          |      |      |      |      |       |
| 1  | 8        | 3    | 5    | 11   | 37   | 64    |
| 2  | 13       | 10   | 6    | 19   | 15   | 63    |
| 3  | 21       | 8    | 9    | 3    | 7    | 48    |
| Mean   | 14.0     | 7.0  | 6.7  | 11.0 | 19.7 | 58.3  |
| Median   | 13       | 8    | 6    | 11   | 15   | 63    |
| Group II (continual variation)                               |          |      |      |      |      |       |
| 1  | 18       | 7    | 8    | 28   | 35   | 96    |
| 2  | 19       | 11   | 14   | 28   | 29   | 101   |
| 3  | 43       | 4    | 16   | 10   | 4    | 67    |
| Mean   | 26.7     | 7.3  | 12.7 | 22.0 | 22.7 | 88.0  |
| Median   | 24       | 7    | 14   | 28   | 29   | 96    |
| Group III (new reinforcement - new problem)                  |          |      |      |      |      |       |
| 1  | 24       | 5    | 5    | 2    | 17   | 53    |
| 2  | 8        | 21   | 5    | 29   | 28   | 91    |
| 3  | 51       | 7    | 3    | 5    | 41   | 101   |
| Mean   | 24.3     | 11.0 | 4.3  | 12.0 | 28.7 | 81.7  |
| Median   | 24       | 7    | 5    | 5    | 28   | 91    |
| Group IV (number of reinforcement - number of presentations) |          |      |      |      |      |       |
| 1  | 27       | 4    | 6    | 23   | 25   | 85    |
| 2  | 39       | 4    | 3    | 6    | 2    | 54    |
| 3  | 12       | 8    | 2    | 10   | 6    | 38    |
| Mean   | 26.0     | 5.3  | 3.7  | 13.0 | 11.0 | 57.0  |
| Median   | 27       | 4    | 3    | 10   | 6    | 54    |

in group II. The author originally believed that this group would perform better since he hoped to increase the S's "attending" to the task as a result of the fact that he would continually be "surprised" by what he found behind the appropriate door. It would now seem that because of the complexity of the task, the Ss in group II had to attend to two things simultaneously; he had to attend to the problem and to the continual change in reinforcement, one interfering with the other as indicated by both error score and presentation score. The Ss in group III performed better than did those in group II since the stimulus change for the former was not as great. Their performance is more like that of the control group than is that of the members of group II, since throughout any problem they had only one reinforcer. Group IV tended to perform somewhat better than did the control group. By having only the same number of reinforcements as there were presentations these Ss got some additional information. They were in essence informed as to the end of a trial as well as the end of the problem as were all the subjects. This finding is understandable in light of previous research at the University of Tennessee on the Hunter-Pascal Test (Pascal and Jenkins, 1957). Subjects who were given both end-of-trial and end-of-problem information showed some tendency to learn more quickly.

In the light of the above findings, more research is indicated. To cancel out the effect of the complexity of the



problem, the experiment should be repeated using a simpler learning task. It also seems essential to run a study on sub-human subjects to see how they react to continual change in reinforcement. The next research step, then, is to design a parallel experiment using animals as Ss. This design will be presented in Chapter IV.

### Summary

Three Ss were tested in each of four groups on the Hunter-Pascal Concept Formation Test under four different conditions of reinforcement. Aside from the control group there was a group subjected to conditions of continually changing reinforcement, a group that had a different reinforcing stimulus for each of the five Hunter-Pascal problems, and a group that was reinforced with as many objects as there were presentations during a trial.

Although not subjected to statistical treatment the data may possibly show some trends. On both error and presentation score the continually changing reinforcement led to the poorest performance followed closely by the group that had a new reinforcer with each new problem. The group reinforced with the same number of reinforcements as there were presentations tended to have lower scores than the controls since they got information on both trial and problem termination.

## CHAPTER III

### DISCRIMINATION EXPERIMENT

Before beginning the major experiment outlined in Chapter IV it was essential to demonstrate that pigeons discriminate between colored breads. It is known that pigeons have excellent color vision. Jones (1954) has demonstrated that pigeons are capable of discriminating between colors in a simple discrimination setting. Although we know pigeons will discriminate colors, it was imperative that a similar discrimination could be established to colored bread, the reinforcing agent in the present research.

#### Procedure

Four birds were used in this pilot study. One was reinforced by receiving yellow bread for pecking at a window in a Skinner Box, a second for blue bread, a third for red bread, and the last for random reinforcements of red, yellow, and blue on a three minute aperiodic (A.P.R.) schedule. (See Chapter IV for a description of the apparatus, conditioning methods, and feeding procedures.) When the Ss' responding stabilized they were switched to a differently colored reinforcer to see if they would show a change in responding indicating that a discrimination occurred. All animals varied between 70 to 75 per cent of

their twenty-four hour deprived weight and were twenty-three hours hungry at the time of the experimental sessions. Each S was fed his own color of bread in his home cage after a few days of eating stale white bread. It should be indicated that the four Ss were highly sophisticated experimentally in that they had all been conditioned to a "preferred" food (standard pigeon grain) previously, but were never extinguished. All Ss had some eating experience with the new food during the early days of deprivation. The sessions were initially one hour long but were changed to one half hour sessions.

### Results and Discussion

The most startling and dramatic finding is that two Ss, although they originally ate the colored bread, starved themselves to death in the presence of food of different color that had enough of the essential ingredients to sustain life. Further they responded well initially in the Skinner Box but ceased upon not finding the old, "familiar" reward. Table IV shows the total responses for each of the Ss for the first three days. If S did not respond in a three minute period a hand reinforcement was delivered. If he didn't respond in the next three minutes, he was removed from the apparatus.

As can be seen in Table IV Ss clearly discriminated

TABLE IV

TOTAL RESPONSES FOR FIRST THREE EXPERIMENTAL  
DAYS WITH COLORED BREAD  
AS THE REINFORCER

| S  | Color  | First Hour | Second Hour | Third Hour |
|----|--------|------------|-------------|------------|
| 18 | varied | 187        | 238         | 0          |
| 19 | blue   | 978        | 7           | 0          |
| 20 | yellow | 1517       | 352         | 222        |
| 21 | red    | 971        | 0           | 1          |

between the former preferred food and the colored food and seem to be extinguishing. Reconditioning was begun to the assigned food color. Subjects 18 and 21 died without ever showing signs of reconditioning. The only food they received in the Skinner Box or in their home cage was the colored bread. This seems to indicate that Ss who died had a very strong grain-eating habit and were unable to generalize the eating habit in a situation involving marked cue change. Levi (1945), a pigeon expert, says that stale bread is a good basic food so that malnutrition alone cannot account for the results. The two remaining Ss were continually fed stale bread for three months after the experiment until one died. Neither of the two remaining Ss showed signs of nutritional inadequacy during the experiment.

In the early days of reconditioning Ss 19 and 20 show considerable variability. When both Ss stabilized, approximately at the same time, their reinforcing agents were switched. These findings are summarized in Table V. Both Ss showed a marked increment in responding on the first day of reinforcement change. On the second day both showed a very marked decrement. On the third day both showed some recovery. Unfortunately the experiment was terminated at this point so that we cannot tell if the recovery would have been complete. However, it seems clear that Ss were able to discriminate between the two food

TABLE V

RATE OF RESPONDING IN THIRTY MINUTE SESSIONS  
FOR THREE DAYS JUST PRIOR TO AND  
FOLLOWING REINFORCEMENT CHANGE

| Before Change |        | After Change |     |     |           |     |     |     |
|---------------|--------|--------------|-----|-----|-----------|-----|-----|-----|
| S             | Color  | 1            | 2   | 3   | Change to | 1   | 2   | 3   |
| 19            | Blue   | 628          | 815 | 914 | Yellow    | 980 | 523 | 602 |
| 20            | Yellow | 242          | 343 | 337 | Blue      | 351 | 193 | 286 |

colors used in this experiment. Similar findings have been reported by Elliot (1928) and Tolman and Honzik (1930) who have shown that reinforcement change leads to an immediate and obvious change in performance during learning.

### Summary

Four experimentally sophisticated pigeons were conditioned to respond to colored bread in a Skinner Box. Initially all Ss showed signs of extinction. Reconditioning was attempted but two Ss died. The remaining two Ss were reconditioned and after they stabilized in their responding were switched to a second color bread. Both showed an initial increment, followed by a marked decrement, followed by a recovery of responding on successive days. This seems to indicate that pigeons can readily discriminate between dyed breads of different colors. The death of the other Ss is explained on the basis of drastic cue-change from their previous food.

## CHAPTER IV

### EXPERIMENTAL PROCEDURES: MAJOR EXPERIMENTS

#### Subjects

The Ss used in this experiment were eighteen pigeons of the Lemberger strains consisting of homers, tumblers and rollers of unknown sex, and ranging in age from six months to one year. All Ss were deprived of food for approximately twenty-one to twenty-two hours prior to each experimental session and were at approximately 80 per cent plus or minus 3 per cent of their twenty-four hour deprived weight during the experimental sessions. As can be seen, drive was carefully controlled and all Ss can be considered under conditions of very high drive. Subjects were fed nothing but crushed stale white bread from the time of their arrival at the laboratory until the onset of the experimental conditions. The time varied between one to three months. At this time they were fed only stale white bread in their home cages. Several animals died during deprivation as well as over the course of the experiment. A partial explanation will follow later in this chapter.

#### Apparatus

The apparatus consisted of a unit of three Skinner



Boxes. Each box was semi-sound-proofed, and was divided into two compartments. One box housed S and had a circular window at head height to which S was to peck. The other compartment contained the food mechanism which could be activated on a 100 per cent reinforcement schedule or an aperiodic (A.P.R.) schedule, or by a hand switch controlled by E. The window, when pressed, activated a counter recording the number of pecks. The food compartment contained a seven and one-half watt bulb enabling the translucent window to be clearly visible in the darkened box containing S.

#### Preliminary Training

All Ss were placed in the experimental part of the Skinner box after having been dropped to 80 per cent plus or minus 3 per cent of their twenty-four hour deprived body weight and sustained at that level for three days. They were then trained to eat crushed stale white bread from the food magazine with the tray open. While they ate from the magazine they were habituated to the sound of opening and closing the tray. By the method of successive approximations Ss were trained to peck until they received twenty reinforcements for successful window pecks. The experimenter held a hand microswitch so that the act of "getting closer" to the key could be reinforced. On at least three more experimental days, Ss made twenty reinforced responses in the

Skinner boxes until they were able to make these responses in less than five minutes. On the next day Ss received twenty reinforced responses with the sound-proofed lid closed.

### Experimental Method

On the day following the preliminary training, Ss were simultaneously shifted to a three minute A.P.R. schedule and reinforced with colored bread. Each experimental session lasted eighteen minutes. If Ss didn't respond they received hand reinforcements as indicated above. If they showed no signs of learning, the final stage of pre-training was repeated but they received colored bread instead of white bread. After this second pre-training, if learning was not apparent, S was fed the colored bread in his home cage and an attempt was made to condition him after the colored bread obtained reinforcement value.

### Experiment I

The subjects were divided into three groups with an N of six each. Group I Ss were reinforced only with one color of bread. This group served essentially as the control group and was sub-divided into groups of two. Subjects I-1 and I-2 were reinforced with yellow bread; I-3 and I-4 obtained red bread; and I-5 and I-6 blue bread. Group II Ss were

reinforced randomly by two colors of bread. Group II was also sub-divided into three groups. Subjects II-1 and II-2 were reinforced with yellow and blue breads; II-3 and II-4, red and yellow; and II-5 and II-6 received blue and red. Group III was reinforced on random orders of red, yellow, and blue breads. All Ss were run until on three successive days each S did not vary more than 10 per cent of his median level of responding in those three days, with the provision that conditioning lasted at least twelve days. After the criteria of conditioning were met, extinction was begun. Extinction sessions lasted eighteen minutes and sessions were run daily until on two successive days Ss responded at 10 per cent or less of the median level of responding in the last three days of conditioning. All Ss were fed in their home cages one-half to two hours after the experimental session. If an S successfully completed experiment I he was used in the statistical analyses. The only Ss that did not successfully complete experiment I died during experiment I.

### Experiment II

After the criterion of extinction was met in experiment I, Ss were assigned to another group randomly and the experiment was repeated (see Table VI). The same criterion of conditioning and extinction held. Similarly if an S died during the course of this experimental round, that S was not

TABLE VI

ASSIGNMENT OF BIRDS TO GROUPS IN  
THE THREE EXPERIMENTS

| Group | Food | S     | Experiment I<br>Leg Number | Experiment II<br>Leg Number | Experiment III<br>Leg Number |
|-------|------|-------|----------------------------|-----------------------------|------------------------------|
| I     | Y    | I-1   | 42                         | 29*                         | 38*                          |
|       | Y    | I-2   | 31                         | 32                          | 26                           |
|       | R    | I-3   | 47                         | 50*                         | 39*                          |
|       | R    | I-4   | 34                         | 40                          | 43                           |
|       | B    | I-5   | 64                         | 56                          | 41                           |
|       | B    | I-6   | 36                         | 53                          | 66                           |
| II    | YB   | II-1  | 50                         | 36                          | 34*                          |
|       | YB   | II-2  | 43                         | 47*                         | 40                           |
|       | RY   | II-3  | 41                         | 66                          | 29*                          |
|       | RY   | II-4  | 56                         | 38*                         | 31                           |
|       | BR   | II-5  | 53                         | 42                          | 64                           |
|       | BR   | II-6  | 39                         | 26                          | 32**                         |
| III   | RYB  | III-1 | 40                         | 31                          | 36**                         |
|       | RYB  | III-2 | 29                         | 34*                         | 50*                          |
|       | RYB  | III-3 | 32                         | 41                          | 42                           |
|       | RYB  | III-4 | 26                         | 39*                         | 53                           |
|       | RYB  | III-5 | 38                         | 64                          | 56                           |
|       | RYB  | III-6 | 66                         | 43                          | 47*                          |

Y - Yellow

R - Red

B - Blue

\* Animal died before completion of Experiment II.

\*\* Animal died before completion of Experiment III.

used in the statistical analyses.

### Experiment III

After the criterion of extinction was met in experiment II, Ss were assigned to the group they had not yet been in. This experiment was repeated as was experiment II (see Table VI).

#### Preparation of the Food

The stale white bread was prepared daily. One to four day old white bread was placed approximately two feet over a heating unit for twelve to twenty-four hours. Essentially this made a large toaster except that the bread kept its natural white color. After the bread was dried so that it was fully hard to touch and brittle, it was placed in glass containers and crushed with a plunger-type device until the bread was broken up into fairly uniform crumb consistency.

The colored bread was prepared as needed in exactly the same manner as was the stale white bread. One day prior to the drying procedure, the bread was dyed either red, yellow or blue with McCormick food dye, a tasteless and non-caloric substance. The dye was placed in a glass container and tap water was added until the color satisfied E. White bread was then dipped in the container. Then the bread was

hand-squeezed to remove the excess water and dye. Twelve hours later the drying process began in exactly the same manner as was the white bread.

#### Vitamin Supplement

During the course of the experiment it became apparent that something in Ss' diet accounted for the unusually high death rate beside the long-term high deprivation and the food change. Many of the Ss who died showed symptoms of a vitamin A blindness. It appeared that they became blind due to an avitaminosis A, couldn't see the food and therefore starved to death since they could not find it to eat it. Only one S seemed to die of any other type disorder and that was a respiratory ailment. Cod-liver oil contains a great deal of vitamin A. Once every two weeks all of the Ss received an oral dosage of five to six drops of cod-liver oil after an experimental session. No other S died after the vitamin supplement. It was decided that giving the cod-liver oil on widely separated days would not lead to a change in performance due to "feeding" S.

## CHAPTER V

### RESULTS

#### Experiment I

The design of the experiment presented in Chapter IV is basically suited to analysis of variance. However, as a result of the small number of Ss in each group, classical statistics are not applicable. In addition, the data is markedly skewed in particular instances. Non-parametric analyses of variance as developed by Kruskal and Wallis (1957) were applied to all the data since parametric assumptions do not apply.

Table VII summarizes all the data for every third day during the original conditioning round. This was carried out until the twelfth day. On the twelfth day, some Ss met the conditioning criterion so that after that day the number in each cell varies. The only other comparisons where N would be equal are at the median of the criterion of conditioning and on the number of days to condition. Table VIII presents similar data for each S on the first round of extinction. A glance at the means and medians on each critical day for each group reveals the above-mentioned skew contra-indicating the use of classical statistical methods. The results of Kruskal-Wallis rank analyses of variance ( $X_H^2$  tests) are found in Table IX.

TABLE VII

NUMBER OF RESPONSES ON CRITICAL CONDITIONING DAYS  
IN EXPERIMENT I AND DAYS TO CONDITION

| Group  | Condi-<br>S tions | Day 1 | Day 3 | Day 6 | Day 9  | Day 12 | Condi-<br>tioning<br>Median | Days to<br>Condi-<br>tion |
|--------|-------------------|-------|-------|-------|--------|--------|-----------------------------|---------------------------|
| I      | 1 Y               | 451   | 278   | 756   | 559    | 533    | 533                         | 12                        |
|        | 2 Y               | 102   | 136   | 247   | 558    | 710    | 710                         | 14                        |
|        | 3 R               | 481   | 604   | 391   | 425    | 632    | 619                         | 13                        |
|        | 4 R               | 70    | 437   | 460   | 320    | 233    | 696                         | 20                        |
|        | 5 B               | 109   | 288   | 688   | 1473   | 1904   | 1854                        | 12                        |
|        | 6 B               | 165   | 211   | 709   | 676    | 1008   | 582                         | 15                        |
|        | Mean              |       | 229.7 | 325.7 | 541.8  | 668.5  | 836.7                       | 832.3                     |
| Median |                   | 137   | 283   | 574   | 559    | 571    | 658                         | 13.5                      |
| Range  |                   | 411   | 468   | 509   | 1153   | 1671   | 1321                        | 8                         |
| II     | 1 YB              | 308   | 838   | 788   | 789    | 639    | 1020                        | 22                        |
|        | 2 YB              | 300   | 336   | 514   | 700    | 979    | 1176                        | 17                        |
|        | 3 RY              | 245   | 526   | 828   | 359    | 920    | 890                         | 13                        |
|        | 4 RY              | 423   | 1439  | 3542  | 2913   | 3830   | 2396                        | 17                        |
|        | 5 BR              | 140   | 227   | 379   | 370    | 706    | 706                         | 12                        |
|        | 6 BR              | 258   | 183   | 244   | 578    | 741    | 964                         | 16                        |
|        | Mean              |       | 279.0 | 591.5 | 1049.2 | 951.5  | 1302.5                      | 1192.0                    |
| Median |                   | 273   | 431   | 651   | 639    | 831    | 992                         | 15.5                      |
| Range  |                   | 287   | 1256  | 3298  | 2554   | 3191   | 1690                        | 10                        |
| III    | 1 RYB             | 108   | 376   | 588   | 507    | 481    | 558                         | 15                        |
|        | 2 RYB             | 86    | 198   | 614   | 557    | 340    | 731                         | 15                        |
|        | 3 RYB             | 411   | 131   | 121   | 355    | 134    | 760                         | 22                        |
|        | 4 RYB             | 344   | 688   | 533   | 726    | 385    | 828                         | 17                        |
|        | 5 RYB             | 190   | 191   | 380   | 512    | 504    | 1000                        | 19                        |
|        | 6 RYB             | 207   | 256   | 794   | 1087   | 802    | 1323                        | 17                        |
|        | Mean              |       | 224.3 | 306.7 | 505.0  | 624.0  | 474.3                       | 866.7                     |
| Median |                   | 199   | 227   | 561   | 535    | 493    | 794                         | 16                        |
| Range  |                   | 325   | 557   | 673   | 732    | 640    | 765                         | 7                         |



TABLE VIII

NUMBER OF RESPONSES ON CRITICAL DAYS DURING  
EXTINCTION IN EXPERIMENT I

| Group  | S | Condi-<br>tions | Day 1  | Extinction<br>Criterion | Average Re-<br>sponse Rate | Days to<br>Extinguish |
|--------|---|-----------------|--------|-------------------------|----------------------------|-----------------------|
| I      | 1 | Y               | 502    | 37                      | 163.4                      | 7                     |
|        | 2 | Y               | 1229   | 11                      | 347.2                      | 9                     |
|        | 3 | R               | 565    | 30                      | 206.8                      | 4                     |
|        | 4 | R               | 364    | 1                       | 126.0                      | 3                     |
|        | 5 | B               | 1563   | 1                       | 450.0                      | 5                     |
|        | 6 | B               | 505    | 46                      | 194.3                      | 5                     |
| Mean   |   |                 | 788.0  | 21.0                    | 247.9                      | 5.3                   |
| Median |   |                 | 535    | 21                      | 200.5                      | 4.5                   |
| Range  |   |                 | 1199   | 45                      | 324.0                      | 6                     |
| II     | 1 | YB              | 1233   | 63                      | 575.7                      | 6                     |
|        | 2 | YB              | 912    | 47                      | 318.0                      | 4                     |
|        | 3 | RY              | 1060   | 57                      | 403.6                      | 5                     |
|        | 4 | RY              | 2322   | 12                      | 959.6                      | 5                     |
|        | 5 | BR              | 344    | 1                       | 139.6                      | 5                     |
|        | 6 | BR              | 547    | 10                      | 299.2                      | 5                     |
| Mean   |   |                 | 1069.7 | 31.7                    | 449.2                      | 5                     |
| Median |   |                 | 986    | 30                      | 360.8                      | 5.0                   |
| Range  |   |                 | 1978   | 62                      | 819.6                      | 2                     |
| III    | 1 | RYB             | 51     | 13                      | 82.6                       | 5                     |
|        | 2 | RYB             | 737    | 0                       | 256.5                      | 6                     |
|        | 3 | RYB             | 835    | 25                      | 403.8                      | 5                     |
|        | 4 | RYB             | 729    | 37                      | 301.4                      | 5                     |
|        | 5 | RYB             | 840    | 20                      | 420.4                      | 5                     |
|        | 6 | RYB             | 1840   | 53                      | 727.0                      | 6                     |
| Mean   |   |                 | 838.7  | 24.7                    | 365.3                      | 5.3                   |
| Median |   |                 | 786    | 23                      | 352.6                      | 5.0                   |
| Range  |   |                 | 1789   | 53                      | 644.4                      | 1                     |

TABLE IX

SUMMARY OF RANK ANALYSES OF VARIANCE FOR  
DATA IN TABLES VII AND VIII

|   |        | Groups |        |       | d.f. | $X^2_H$ | P   |
|---|--------|--------|--------|-------|------|---------|-----|
|   |        | I      | II     | III   |      |         |     |
| Day 1                                   | Mean   | 229.7  | 279.0  | 234.3 | 2    | 1.16    | .60 |
|   | Median | 137    | 273    | 199   |      |         |     |
|   | Range  | 411    | 287    | 325   |      |         |     |
| Day 3                                   | Mean   | 325.7  | 591.5  | 306.7 | 2    | 1.72    | .44 |
|   | Median | 283    | 431    | 227   |      |         |     |
|   | Range  | 468    | 1256   | 557   |      |         |     |
| Day 6                                   | Mean   | 541.8  | 1049.2 | 505.0 | 2    | .46     | .80 |
|   | Median | 574    | 651    | 561   |      |         |     |
|   | Range  | 509    | 3298   | 673   |      |         |     |
| Day 9                                   | Mean   | 668.5  | 951.5  | 624.0 | 2    | .43     | .81 |
|   | Median | 559    | 639    | 535   |      |         |     |
|   | Range  | 1153   | 2554   | 732   |      |         |     |
| Day 12                                  | Mean   | 836.7  | 1032.5 | 474.3 | 2    | 10.45   | .01 |
|   | Median | 571    | 831    | 493   |      |         |     |
|   | Range  | 1671   | 3191   | 640   |      |         |     |
| Condition-<br>ing Median                | Mean   | 832.3  | 1192.0 | 866.7 | 2    | 3.95    | .15 |
|   | Median | 658    | 992    | 794   |      |         |     |
|   | Range  | 1321   | 1690   | 765   |      |         |     |
| Days to<br>Condition                    | Mean   | 14.3   | 16.2   | 17.5  | 2    | 3.71    | .17 |
|   | Median | 13.5   | 15.5   | 16.0  |      |         |     |
|   | Range  | 8      | 10     | 7     |      |         |     |
| Day 1<br>Extinction                     | Mean   | 788.0  | 1069.7 | 838.7 | 2    | 1.06    | .59 |
|   | Median | 535    | 986    | 786   |      |         |     |
|   | Range  | 1199   | 1978   | 1789  |      |         |     |
| Average re-<br>sponses in<br>Extinction | Mean   | 247.9  | 449.2  | 365.3 | 2    | 1.82    | .42 |
|   | Median | 201    | 361    | 353   |      |         |     |
|   | Range  | 324.0  | 819.6  | 644.4 |      |         |     |
| Extinction<br>Criterion                 | Mean   | 21.0   | 31.7   | 24.7  | 2    | .71     | .71 |
|   | Median | 21     | 30     | 23    |      |         |     |
|   | Range  | 45     | 62     | 53    |      |         |     |
| Days to<br>Extinguish                   | Mean   | 5.3    | 5.0    | 5.3   | 2    | .74     | .62 |
|   | Median | 4.5    | 5.0    | 5.0   |      |         |     |
|   | Range  | 6      | 2      | 1     |      |         |     |

On the first day of conditioning there is little if any real difference between the experimental groups; this is particularly true between groups I and III. Comparing the means and medians on each critical day it is apparent that all groups showed learning over the course of the experiment. It is interesting to note the extreme group and subject variability. On the twelfth experimental day, the last day of conditioning on which the number of Ss in each group is constant, there is an appreciable difference among groups. Group III is performing at the lowest rate and Group II performing at the highest level. At the median of conditioning, however, Group III replaces Group I as the second highest group. Indeed, Group III showed the most marked increase between the twelfth day and the median at conditioning. There is a fairly significant difference between groups in terms of days to condition. Group I conditioned faster than did Groups II and III, and Group III took the longest to condition. Extinction measures show insignificant differences between groups although some trends seem to be present. On every extinction measure Group I was below Groups II and III. Groups II and III do not seem to differ on these measures and hence the low confidence levels on the  $X_H^2$  tests.

Mann-Whitney-Wilcoxon T tests were applied to the above data to see what groups generated the differences on some of the more significant measures on the basis of the  $X_H^2$

tests. On the twelfth day a  $p$  of .20 was found between Groups I and III. The difference between Groups II and III was significant at the 5 per cent level of confidence. No significant difference appeared between Groups I and II. In terms of days to condition a confidence level of better than 10 per cent is shown between Groups I and II but not between the other groups. A significant difference at the 10 per cent level appears between Groups I and III on the days to condition measure.

It is possible to combine Groups II and III and compare them to Group I. In other words, it is possible to compare the groups with any degree of reinforcement variation to the constant reinforcement group. Inspection of Table IX indicates that, for the most part, there would be no significant difference since Group III would average out the effect of Group II. Therefore this appropriate statistic was not used in this experimental round.

Another type of analysis was possible but was not performed. The differential effect of the colored food could have been tested. The reader is referred to the data of Group I presented in Table VII. With one exception, no S seems extremely deviant from the group median at the conditioning criterion. Therefore, it was concluded that any particular color did not have more or less reinforcement value to the Ss than any other color.

## Experiment II

Each group in experiment II was limited to  $N_s$  of four due to deaths following the first experiment or during the second experiment. If an  $\underline{S}$  died during the course of experiment II, it was completely eliminated from the statistical analysis.

Table X presents the data for the critical days in experiment II. Again appreciable variability across groups and across  $\underline{S}$ s appears. The extinction data is shown in Table XI and a summary of the  $X^2_{\underline{H}}$  tests is in Table XII. Learning is apparent for all groups. On the basis of confidence levels differential learning does not seem indicated. However, during conditioning, Group III tends to be higher than both Groups I and II. Group II begins on day 1 at a lower level than does Group I but at the conditioning criterion is responding at a higher level. In terms of the days to condition measure, a reversal seems apparent from the first round. Group I takes longer to condition than do Groups II and II, although not significantly so. Again in extinction, the groups show strong trends but they do not approach acceptable confidence levels. Group III performs at a higher level than does Group II and the latter in turn performs at a higher level than does Group I. It should be mentioned however that with  $\underline{N}_s$  of only four in each group, there would have to be almost no overlap between groups to

TABLE X

NUMBER OF RESPONSES ON CRITICAL CONDITIONING DAYS  
IN EXPERIMENT II AND DAYS TO CONDITION

| Group  | Condi-<br>S tions | Day 1 | Day 3 | Day 6  | Day 9  | Day 12 | Condi-<br>tioning<br>Median | Days to<br>Condi-<br>tion |
|--------|-------------------|-------|-------|--------|--------|--------|-----------------------------|---------------------------|
| I      | 1                 | Y     | *     | *      | *      | *      | *                           | *                         |
|        | 2                 | Y     | 547   | 770    | 1360   | 1237   | 1278                        | 1249                      |
|        | 3                 | R     | *     | *      | *      | *      | *                           | *                         |
|        | 4                 | R     | 768   | 447    | 399    | 646    | 544                         | 604                       |
|        | 5                 | B     | 320   | 1154   | 2323   | 1627   | 1289                        | 1244                      |
|        | 6                 | B     | 653   | 498    | 749    | 432    | 756                         | 677                       |
|        | Mean              |       | 572.0 | 717.3  | 1207.8 | 985.5  | 966.8                       | 943.5                     |
| Median |                   | 600   | 634   | 1055   | 942    | 1017   | 960                         | 16.5                      |
| Range  |                   | 448   | 707   | 1924   | 1195   | 745    | 645                         | 3                         |
| II     | 1                 | YB    | 529   | 958    | 1170   | 1297   | 833                         | 1013                      |
|        | 2                 | YB    | *     | *      | *      | *      | *                           | *                         |
|        | 3                 | RY    | 795   | 908    | 1333   | 1217   | 1476                        | 1501                      |
|        | 4                 | RY    | *     | *      | *      | *      | *                           | *                         |
|        | 5                 | BR    | 351   | 556    | 557    | 924    | 542                         | 590                       |
|        | 6                 | BR    | 451   | 982    | 720    | 914    | 926                         | 926                       |
|        | Mean              |       | 556.5 | 851.0  | 945.0  | 1088.0 | 944.3                       | 1007.5                    |
| Median |                   | 490   | 933   | 945    | 1071   | 880    | 970                         | 13                        |
| Range  |                   | 444   | 426   | 776    | 383    | 934    | 911                         | 3                         |
| III    | 1                 | RYB   | 568   | 979    | 1212   | 828    | 1247                        | 1247                      |
|        | 2                 | RYB   | *     | *      | *      | *      | *                           | *                         |
|        | 3                 | RYB   | 738   | 871    | 1076   | 1575   | 1276                        | 1186                      |
|        | 4                 | RYB   | *     | *      | *      | *      | *                           | *                         |
|        | 5                 | RYB   | 1253  | 1467   | 1175   | 1358   | 1501                        | 1460                      |
|        | 6                 | RYB   | 578   | 1021   | 1121   | 1195   | 1446                        | 1590                      |
|        | Mean              |       | 784.3 | 1084.5 | 1146.0 | 1239.0 | 1367.5                      | 1370.8                    |
| Median |                   | 658   | 1000  | 1148   | 1277   | 1361   | 1354                        | 14                        |
| Range  |                   | 685   | 596   | 136    | 747    | 254    | 404                         | 2                         |

\* Animal died.

TABLE XI

NUMBER OF RESPONSES ON CRITICAL DAYS DURING  
EXTINCTION IN EXPERIMENT II AND  
DAYS TO EXTINGUISH

| Group  | S | Condi-<br>tions | Day 1 | Extinction<br>Criterion | Average Re-<br>sponse Rate | Days to<br>Extinguish |
|--------|---|-----------------|-------|-------------------------|----------------------------|-----------------------|
| I      | 1 | Y               | *     | *                       | *                          | *                     |
|        | 2 | Y               | 214   | 16                      | 248.6                      | 8                     |
|        | 3 | R               | *     | *                       | *                          | *                     |
|        | 4 | R               | 298   | 16                      | 151.5                      | 6                     |
|        | 5 | B               | 2217  | 91                      | 657.5                      | 6                     |
|        | 6 | B               | 500   | 18                      | 204.0                      | 4                     |
| Mean   |   |                 | 807.3 | 35.3                    | 315.4                      | 6.0                   |
| Median |   |                 | 399   | 17                      | 178                        | 6.0                   |
| Range  |   |                 | 2003  | 75                      | 506.0                      | 2                     |
| II     | 1 | YB              | 469   | 0                       | 148.5                      | 4                     |
|        | 2 | YB              | *     | *                       | *                          | *                     |
|        | 3 | RY              | 1271  | 23                      | 505.6                      | 5                     |
|        | 4 | RY              | *     | *                       | *                          | *                     |
|        | 5 | BR              | 932   | 51                      | 351.2                      | 10                    |
|        | 6 | BR              | 803   | 70                      | 396.2                      | 5                     |
| Mean   |   |                 | 868.8 | 36.0                    | 350.4                      | 6.0                   |
| Median |   |                 | 868   | 37                      | 374                        | 5.0                   |
| Range  |   |                 | 802   | 70                      | 357.1                      | 6                     |
| III    | 1 | RYB             | 763   | 21                      | 361.4                      | 5                     |
|        | 2 | RYB             | *     | *                       | *                          | *                     |
|        | 3 | RYB             | 1320  | 50                      | 526.8                      | 6                     |
|        | 4 | RYB             | *     | *                       | *                          | *                     |
|        | 5 | RYB             | 1367  | 54                      | 617.4                      | 5                     |
|        | 6 | RYB             | 276   | 65                      | 360.7                      | 6                     |
| Mean   |   |                 | 931.5 | 47.5                    | 466.6                      | 5.5                   |
| Median |   |                 | 1042  | 52                      | 444                        | 5.5                   |
| Range  |   |                 | 1091  | 44                      | 256.7                      | 1                     |

\* Animal died.

TABLE XII

SUMMARY OF RANK ANALYSES OF VARIANCE  
FOR DATA IN TABLES X AND XI

|   |        | Groups |        |        | d.f. | $X_H^2$ | P   |
|---|--------|--------|--------|--------|------|---------|-----|
|   |        | I      | II     | III    |      |         |     |
| Day 1                                   | Mean   | 572.0  | 556.5  | 784.3  | 2    | 2.00    | .39 |
|   | Median | 600    | 490    | 658    |      |         |     |
|   | Range  | 448    | 444    | 685    |      |         |     |
| Day 3                                   | Mean   | 717.3  | 851.0  | 1084.5 | 2    | 2.81    | .25 |
|   | Median | 634    | 933    | 1000   |      |         |     |
|   | Range  | 498    | 426    | 596    |      |         |     |
| Day 6                                   | Mean   | 1207.8 | 945.0  | 1146.0 | 2    | .46     | .80 |
|   | Median | 1055   | 945    | 1148   |      |         |     |
|   | Range  | 1924   | 776    | 136    |      |         |     |
| Day 9                                   | Mean   | 985.5  | 1088.0 | 1239.0 | 2    | .50     | .77 |
|   | Median | 942    | 1071   | 1277   |      |         |     |
|   | Range  | 1195   | 383    | 747    |      |         |     |
| Day 12                                  | Mean   | 966.8  | 944.3  | 1367.5 | 2    | 2.35    | .33 |
|   | Median | 1017   | 880    | 1361   |      |         |     |
|   | Range  | 745    | 934    | 254    |      |         |     |
| Condition-<br>ing Median                | Mean   | 943.5  | 1001.5 | 1370.5 | 2    | 2.89    | .24 |
|   | Median | 960    | 970    | 1354   |      |         |     |
|   | Range  | 645    | 911    | 404    |      |         |     |
| Days to<br>Condition                    | Mean   | 16.0   | 13.3   | 13.5   | 2    | 1.43    | .49 |
|   | Median | 16.5   | 13.0   | 14.0   |      |         |     |
|   | Range  | 3      | 3      | 2      |      |         |     |
| Day 1<br>Extinction                     | Mean   | 807.3  | 868.8  | 931.5  | 2    | .58     | .75 |
|   | Median | 399    | 868    | 1042   |      |         |     |
|   | Range  | 2003   | 802    | 1091   |      |         |     |
| Average Re-<br>sponses in<br>Extinction | Mean   | 315.4  | 350.4  | 466.6  | 2    | 1.89    | .42 |
|   | Median | 178    | 374    | 444    |      |         |     |
|   | Range  | 506.0  | 357.1  | 256.7  |      |         |     |
| Extinction<br>Criterion                 | Mean   | 35.3   | 36.0   | 47.5   | 2    | .96     | .63 |
|   | Median | 17     | 37     | 52     |      |         |     |
|   | Range  | 75     | 70     | 44     |      |         |     |
| Days to<br>Extinguish                   | Mean   | 6.0    | 6.0    | 5.5    | 2    | .47     | .79 |
|   | Median | 6.0    | 5.0    | 5.5    |      |         |     |
|   | Range  | 2      | 6      | 1      |      |         |     |



generate acceptable confidence levels.

As was indicated in the results of experiment I, it is a justifiable procedure to combine Groups II and III and to compare them to Group I on the  $X^2_H$  tests. Table XIII reports the summary of these derived data. Again the confidence levels are not significant by the usual standards. However, in terms of means and medians there seems to be a real and consistent difference between the constant and varied reinforcement groups. The combined varied reinforcement group performs on a higher level than does the constant group. Only the days to condition measure is highly significant. Nonetheless a small effect does appear.

All the animals used in experiment II had been previously used in experiment I. It is quite possible that effects do not seem apparent in the second round due to the differential contamination of results by the performance in the first experiment. If each S's performance on the second round could have been predicted by the level of performance in the first, the results might be contaminated. A Spearman rank correlation of .75 and a Kendall correlation of .64 were obtained. It seems justifiable to conclude that experiment II is contaminated to some degree by the effects of experiment I.

To remove the effect of the high correlation, change scores from the median of the first round to the median of the second round were computed. Table XIV includes all these

TABLE XIII

SUMMARY OF RANK ANALYSES OF VARIANCE COMPARING  
GROUP I TO THE COMBINED DATA OF GROUPS  
II AND III IN EXPERIMENT II

|   |        | Group I | Groups II<br>and III | d.f. | $\chi^2_H$ | P    |
|---|--------|---------|----------------------|------|------------|------|
| Day 1                                   | Mean   | 572.0   | 670.4                | 1    | .15        | .72  |
|   | Median | 600     | 573                  |      |            |      |
|   | Range  | 448     | 902                  |      |            |      |
| Day 3                                   | Mean   | 717.3   | 967.8                | 1    | 1.85       | .19  |
|   | Median | 634     | 969                  |      |            |      |
|   | Range  | 498     | 911                  |      |            |      |
| Day 6                                   | Mean   | 1207.8  | 1045.5               | 1    | .42        | .52  |
|   | Median | 1055    | 1146                 |      |            |      |
|   | Range  | 1924    | 776                  |      |            |      |
| Day 9                                   | Mean   | 985.5   | 1163.5               | 1    | .26        | .64  |
|   | Median | 942     | 1206                 |      |            |      |
|   | Range  | 1195    | 747                  |      |            |      |
| Day 12                                  | Mean   | 966.8   | 1155.9               | 1    | .46        | .50  |
|   | Median | 1017    | 1262                 |      |            |      |
|   | Range  | 745     | 959                  |      |            |      |
| Condition-<br>ing Median                | Mean   | 943.5   | 1186.0               | 1    | .72        | .42  |
|   | Median | 980     | 1217                 |      |            |      |
|   | Range  | 645     | 1000                 |      |            |      |
| Days to<br>Condition                    | Mean   | 16.0    | 13.4                 | 1    | 10.67      | .001 |
|   | Median | 16.5    | 14.0                 |      |            |      |
|   | Range  | 3       | 3                    |      |            |      |
| Day 1<br>Extinction                     | Mean   | 807.3   | 900.1                | 1    | .72        | .42  |
|   | Median | 399     | 868                  |      |            |      |
|   | Range  | 2003    | 1091                 |      |            |      |
| Average Re-<br>sponses in<br>Extinction | Mean   | 315.4   | 408.5                | 1    | .72        | .42  |
|   | Median | 178     | 379                  |      |            |      |
|   | Range  | 506.0   | 468.9                |      |            |      |
| Extinction<br>Criterion                 | Mean   | 35.2    | 41.8                 | 1    | .72        | .42  |
|   | Median | 17      | 51                   |      |            |      |
|   | Range  | 75      | 70                   |      |            |      |
| Days to<br>Extinguish                   | Mean   | 6.0     | 5.8                  | 1    | .66        | .46  |
|   | Median | 6.0     | 5.0                  |      |            |      |
|   | Range  | 2       | 6                    |      |            |      |

TABLE XIV

SUMMARY OF RANK ANALYSIS OF VARIANCE ON CHANGE  
 SCORE FROM EXPERIMENT I TO EXPERIMENT  
 II AT MEDIAN LEVEL OF RESPONDING

|        | Change Scores            |          |           |
|--------|--------------------------|----------|-----------|
|        | Group I                  | Group II | Group III |
|        | -47.66                   | 10.69    | -21.25    |
|        | -4.11                    | 11.84    | 33.26     |
|        | 8.24                     | 13.45    | 35.20     |
|        | 63.05                    | 74.05    | 75.63     |
| Mean   | 4.88                     | 27.51    | 30.71     |
| Median | 2.07                     | 12.65    | 34.23     |
| Range  | 110.71                   | 84.74    | 96.88     |
|        | $\chi^2_{H}$ equals 1.89 | p .41    |           |

data. The change score was derived by subtracting the median of each S's performance in the first experiment from S's performance in the second round. This was divided by S's first round performance and then multiplied by one hundred. A p value of .41 is obtained. Again a small but insignificant trend appears but the direction of the effect is consistent with the previous reported results.

### Experiment III

Only ten Ss survived through experiment III. This makes it practically impossible to generate significance on  $X_H^2$  tests unless there is little overlap between groups. Nonetheless the data will be reported to see if trends appear. Further there is the very real possibility of contamination of behavior by the time Ss reach the third experiment.

The hypothesized extreme contamination does not appear. A Spearman correlation of .40 and a Kendall correlation of .40 results between the ten remaining Ss in experiment III and their performance in experiment I. Similarly a Spearman coefficient of .36 and a Kendall coefficient of .49 result from a comparison of performance in experiments II and III.

Data similar to the previous findings on the preceding experiments are found in Tables XV, XVI, and XVII. Although

TABLE XV

NUMBER OF RESPONSES ON CRITICAL CONDITIONING DAYS  
IN EXPERIMENT III AND DAYS TO CONDITION

| Group  | Condi-<br>S tions | Day 1  | Day 3  | Day 6  | Day 9  | Day 12 | Condi-<br>tioning<br>Median | Days to<br>Condi-<br>tion |
|--------|-------------------|--------|--------|--------|--------|--------|-----------------------------|---------------------------|
| I      | 1 Y               | *      | *      | *      | *      | *      | *                           | *                         |
|        | 2 Y               | 1179   | 962    | 1596   | 1713   | 751    | 994                         | 22                        |
|        | 3 R               | *      | *      | *      | *      | *      | *                           | *                         |
|        | 4 R               | 1527   | 1154   | 1215   | 1544   | 2087   | 2087                        | 12                        |
|        | 5 B               | 877    | 1348   | 1064   | 1128   | 948    | 948                         | 12                        |
|        | 6 B               | 1480   | 1343   | 1056   | 1239   | 1184   | 1199                        | 12                        |
| Mean   |                   | 1265.8 | 1201.8 | 1232.8 | 1406.0 | 1242.3 | 1307.0                      | 16.5                      |
| Median |                   | 1330   | 1246   | 1140   | 1342   | 1066   | 1074                        | 12                        |
| Range  |                   | 650    | 386    | 540    | 585    | 1336   | 1139                        | 10                        |
| II     | 1 YB              | *      | *      | *      | *      | *      | *                           | *                         |
|        | 2 YB              | 604    | 769    | 492    | 229    | 396    | 1137                        | 20                        |
|        | 3 RY              | *      | *      | *      | *      | *      | *                           | *                         |
|        | 4 RY              | 1247   | 1449   | 1346   | 1148   | 1166   | 1046                        | 19                        |
|        | 5 BR              | 1176   | 1811   | 1440   | 1644   | 1965   | 1965                        | 13                        |
|        | 6 BR              | *      | *      | *      | *      | *      | *                           | *                         |
| Mean   |                   | 1009.0 | 1343.0 | 1092.6 | 1007.0 | 1175.7 | 1392.7                      | 17.3                      |
| Median |                   | 1176   | 1449   | 1346   | 1148   | 1166   | 1137                        | 19                        |
| Range  |                   | 643    | 1042   | 948    | 1415   | 1569   | 919                         | 7                         |
| III    | 1 RYB             | *      | *      | *      | *      | *      | *                           | *                         |
|        | 2 RYB             | *      | *      | *      | *      | *      | *                           | *                         |
|        | 3 RYB             | 1417   | 1800   | 734    | 1569   | 1586   | 1281                        | 15                        |
|        | 4 RYB             | 456    | 1072   | 1328   | 1450   | 1523   | 1523                        | 16                        |
|        | 5 RYB             | 654    | 1246   | 1387   | 1149   | 1789   | 2030                        | 16                        |
|        | 6 RYB             | *      | *      | *      | *      | *      | *                           | *                         |
| Mean   |                   | 842.3  | 1378.7 | 1149.7 | 1389.3 | 1632.7 | 1611.3                      | 15.7                      |
| Median |                   | 654    | 1264   | 1328   | 1450   | 1586   | 1523                        | 16                        |
| Range  |                   | 961    | 728    | 653    | 420    | 266    | 749                         | 1                         |

\* Animal died.

TABLE XVI

NUMBER OF RESPONSES ON CRITICAL DAYS DURING  
EXTINCTION IN EXPERIMENT III AND  
DAYS TO EXTINGUISH

| Group  | S | Condi-<br>tions | Day 1  | Extinction<br>Criterion | Average Re-<br>sponse Rate | Days to<br>Extinguish |
|--------|---|-----------------|--------|-------------------------|----------------------------|-----------------------|
| I      | 1 | Y               | *      | *                       | *                          | *                     |
|        | 2 | Y               | 607    | 21                      | 241.6                      | 8                     |
|        | 3 | R               | *      | *                       | *                          | *                     |
|        | 4 | R               | 1756   | 67                      | 600.0                      | 8                     |
|        | 5 | B               | 588    | 24                      | 234.3                      | 4                     |
|        | 6 | B               | 924    | 42                      | 304.7                      | 7                     |
| Mean   |   |                 | 968.8  | 38.5                    | 345.2                      | 6.8                   |
| Median |   |                 | 766    | 33                      | 273                        | 7.5                   |
| Range  |   |                 | 1168   | 46                      | 365.8                      | 4                     |
| II     | 1 | YB              | *      | *                       | *                          | *                     |
|        | 2 | YB              | 658    | 26                      | 241.0                      | 8                     |
|        | 3 | RY              | *      | *                       | *                          | *                     |
|        | 4 | RY              | 1360   | 27                      | 368.1                      | 10                    |
|        | 5 | BR              | 1377   | 117                     | 751.8                      | 4                     |
|        | 6 | BR              | *      | *                       | *                          | *                     |
| Mean   |   |                 | 1131.7 | 56.7                    | 453.6                      | 7.3                   |
| Median |   |                 | 1360   | 27                      | 368                        | 8.0                   |
| Range  |   |                 | 719    | 91                      | 510.8                      | 6                     |
| III    | 1 | RYB             | *      | *                       | *                          | *                     |
|        | 2 | RYB             | *      | *                       | *                          | *                     |
|        | 3 | RYB             | 1302   | 4                       | 416.6                      | 7                     |
|        | 4 | RYB             | 1281   | 113                     | 477.7                      | 3                     |
|        | 5 | RYB             | 1534   | 198                     | 483.4                      | 8                     |
|        | 6 | RYB             | *      | *                       | *                          | *                     |
| Mean   |   |                 | 1372.3 | 105.0                   | 459.2                      | 6.0                   |
| Median |   |                 | 1302   | 113                     | 478                        | 7.0                   |
| Range  |   |                 | 253    | 196                     | 66.8                       | 5                     |

\* Animal died.

TABLE XVII

SUMMARY OF RANK ANALYSES OF VARIANCE FOR  
DATA IN TABLES XV AND XVI

|   |        | Groups |        |        | d.f. | $\chi^2_H$ | P   |
|---|--------|--------|--------|--------|------|------------|-----|
|   |        | I      | II     | III    |      |            |     |
| Day 1                                   | Mean   | 1265.8 | 1009.0 | 842.3  | 2    | 2.30       | .33 |
|   | Median | 1330   | 1176   | 654    |      |            |     |
|   | Range  | 650    | 643    | 961    |      |            |     |
| Day 3                                   | Mean   | 1201.8 | 1343.0 | 1378.7 | 2    | .48        | .79 |
|   | Median | 1246   | 1449   | 1264   |      |            |     |
|   | Range  | 386    | 1042   | 728    |      |            |     |
| Day 6                                   | Mean   | 1232.8 | 1092.7 | 1149.7 | 2    | .02        | .99 |
|   | Median | 1140   | 1346   | 1328   |      |            |     |
|   | Range  | 540    | 948    | 653    |      |            |     |
| Day 9                                   | Mean   | 1406.0 | 1007.0 | 1389.3 | 2    | .36        | .84 |
|   | Median | 1342   | 1148   | 1450   |      |            |     |
|   | Range  | 585    | 1415   | 420    |      |            |     |
| Day 12                                  | Mean   | 1242.3 | 1175.7 | 1632.7 | 2    | 1.07       | .58 |
|   | Median | 1066   | 1166   | 1586   |      |            |     |
|   | Range  | 1336   | 1569   | 266    |      |            |     |
| Condition-<br>ing Median                | Mean   | 1307.0 | 1382.7 | 1611.3 | 2    | 1.62       | .47 |
|   | Median | 1074   | 1137   | 1523   |      |            |     |
|   | Range  | 1139   | 919    | 749    |      |            |     |
| Days to<br>Condition                    | Mean   | 16.5   | 17.3   | 15.7   | 2    | 1.67       | .45 |
|   | Median | 12     | 19     | 16     |      |            |     |
|   | Range  | 10     | 7      | 1      |      |            |     |
| Day 1<br>Extinction                     | Mean   | 968.8  | 1131.7 | 1372.3 | 2    | 1.21       | .55 |
|   | Median | 766    | 1360   | 1302   |      |            |     |
|   | Range  | 1168   | 719    | 253    |      |            |     |
| Average Re-<br>sponses in<br>Extinction | Mean   | 345.2  | 453.6  | 459.2  | 2    | 1.43       | .49 |
|   | Median | 273    | 368    | 478    |      |            |     |
|   | Range  | 365.8  | 510.8  | 66.8   |      |            |     |
| Extinction<br>Criterion                 | Mean   | 38.5   | 56.7   | 105.0  | 2    | .75        | .69 |
|   | Median | 33     | 27     | 113    |      |            |     |
|   | Range  | 46     | 91     | 196    |      |            |     |
| Days to<br>Extinguish                   | Mean   | 6.8    | 7.3    | 6.0    | 2    | .89        | .65 |
|   | Median | 7.5    | 8.0    | 7.0    |      |            |     |
|   | Range  | 4      | 6      | 5      |      |            |     |

never approaching acceptable confidence levels, similar directional effects appear. It should be indicated that one chance variation by any S might have "washed out" a more significant effect due to the small number of Ss. Nonetheless at the conditioning median, the Groups I, II, III, rank 1, 2, 3 respectively from low to high in keeping with the previously reported data. The same overall trends during conditioning and extinction appear. The days to condition effect disappears suggesting that the two previous and contradictory findings were but chance effects.

Groups II and III were combined and again compared to Group I on  $X_H^2$  tests (see Table XVIII). Initially on day 1, significance is approached in the opposite direction from the results at the conditioning criterion. This adds further support to the conclusion that reinforcement change leads to a higher performance level. The effect appears on both the conditioning and extinction measures.

A change score analysis similar to that performed in experiment II could have been used on the above data. This was not done since by the third experiment the derivation of these data would have been much too complex.

#### Combined Data

Although not technically justified, it is possible to combine all the data and treat all Ss in all experiments as



TABLE XVIII

SUMMARY OF RANK ANALYSES OF VARIANCE COMPARING  
GROUP I TO COMBINED DATA OF GROUPS II  
AND III AND EXPERIMENT III

|   |        | Group I | Groups II<br>and III | d.f. | $\chi^2_H$ | P   |
|---|--------|---------|----------------------|------|------------|-----|
| Day 1                                   | Mean   | 1265.8  | 925.7                | 1    | 2.23       | .15 |
|   | Median | 1330    | 915                  |      |            |     |
|   | Range  | 650     | 813                  |      |            |     |
| Day 3                                   | Mean   | 1201.8  | 1360.3               | 1    | .41        | .51 |
|   | Median | 1246    | 1357                 |      |            |     |
|   | Range  | 386     | 1042                 |      |            |     |
| Day 6                                   | Mean   | 1232.8  | 1121.2               | 1    | .00        | .99 |
|   | Median | 1140    | 1337                 |      |            |     |
|   | Range  | 540     | 948                  |      |            |     |
| Day 9                                   | Mean   | 1406.0  | 1198.2               | 1    | .18        | .69 |
|   | Median | 1342    | 1300                 |      |            |     |
|   | Range  | 582     | 1415                 |      |            |     |
| Day 12                                  | Mean   | 1242.3  | 1404.2               | 1    | .18        | .69 |
|   | Median | 1066    | 1555                 |      |            |     |
|   | Range  | 1336    | 1569                 |      |            |     |
| Condition-<br>ing Median                | Mean   | 1307.0  | 1497.0               | 1    | 1.00       | .34 |
|   | Median | 1074    | 1402                 |      |            |     |
|   | Range  | 1139    | 984                  |      |            |     |
| Days to<br>Condition                    | Mean   | 16.5    | 16.5                 | 1    | .92        | .36 |
|   | Median | 12      | 16                   |      |            |     |
|   | Range  | 10      | 8                    |      |            |     |
| Day 1<br>Extinction                     | Mean   | 968.8   | 1252.0               | 1    | 1.14       | .30 |
|   | Median | 766     | 1331                 |      |            |     |
|   | Range  | 1168    | 876                  |      |            |     |
| Average Re-<br>sponses in<br>Extinction | Mean   | 354.2   | 456.5                | 1    | 1.14       | .30 |
|   | Median | 273     | 447                  |      |            |     |
|   | Range  | 365.8   | 510.8                |      |            |     |
| Extinction<br>Criterion                 | Mean   | 38.5    | 80.8                 | 1    | 1.00       | .34 |
|   | Median | 33      | 70                   |      |            |     |
|   | Range  | 46      | 194                  |      |            |     |
| Days to<br>Extinguish                   | Mean   | 6.8     | 6.7                  | 1    | .00        | .99 |
|   | Median | 7.5     | 7.5                  |      |            |     |
|   | Range  | 4       | 4                    |      |            |     |

individuals. Admittedly, the data is correlated to a degree and therefore any statistic treating the data as independent is somewhat inappropriate. Nonetheless the data will be reported.

Table XIX is a summary of the combined analyses on what had previously seemed to be critical measures. The raw data for these analyses can be found in Tables XX, XXI, XXII, XXIII, and XXIV in the appendix. Again effects do seem apparent although they do not seem to be highly significant. On the twelfth day Groups II and III perform higher than Group I on both the mean and median but the great variability leads to no significance. However, Groups I, II, and III rank 1, 2, and 3 respectively from low to high. At the conditioning median, a p value of .25 is obtained. When one considers the appreciable variability, a highly consistent trend has to exist in order to obtain such a significant confidence level. The days to condition measure shows a slight trend over the three experiments although the confidence level suggests a chance effect. In terms of average responses to extinguish, moderately significant difference occurs. This may be a result of the differences that are apparent at the median of conditioning. The days to extinguish measure shows no real difference between the groups. Groups II and III show some slight tendency to extinguish faster than does Group I.

Since the data is obviously not independent, Friedman

TABLE XIX

SUMMARY OF RANK ANALYSES OF VARIANCE  
FOR COMBINED DATA

|   |        | Groups |        |        | d.f. | $\chi^2_H$ | P   |
|---|--------|--------|--------|--------|------|------------|-----|
|   |        | I      | II     | III    |      |            |     |
| Day 12                                  | Mean   | 989.8  | 1163.0 | 1016.5 | 2    | .02        | .99 |
|   | Median | 852    | 920    | 1247   |      |            |     |
|   | Range  | 1854   | 3434   | 1655   |      |            |     |
| Condition-<br>ing Median                | Mean   | 999.7  | 1179.2 | 1194.1 | 2    | 2.79       | .25 |
|   | Median | 829    | 1020   | 1247   |      |            |     |
|   | Range  | 1554   | 1806   | 1472   |      |            |     |
| Days to<br>Condition                    | Mean   | 14.7   | 15.5   | 15.5   | 2    | .76        | .69 |
|   | Median | 14.0   | 15.0   | 15.0   |      |            |     |
|   | Range  | 10     | 10     | 10     |      |            |     |
| Average Re-<br>sponses in<br>Extinction | Mean   | 294.9  | 419.8  | 418.1  | 2    | 5.24       | .08 |
|   | Median | 237.9  | 368.1  | 416.6  |      |            |     |
|   | Range  | 531.5  | 819.6  | 644.4  |      |            |     |
| Days to<br>Extinguish                   | Mean   | 5.9    | 5.9    | 5.5    | 2    | .44        | .94 |
|   | Median | 6.0    | 5.0    | 5.0    |      |            |     |
|   | Range  | 6      | 6      | 5      |      |            |     |

$\chi^2_R$  tests (Jenkins, 1956) were run on the data of Ss that went through all three experiments. The groups have an N of ten. The measures on the twelfth day, at the median of conditioning, and days to condition all reveal highly insignificant p values as does days to extinguish. The only value that approached significance was the average rate of responding in extinction yielding a p of .17.

#### Overview

It seems appropriate to stop and see what consistently appeared in all three experimental rounds. Throughout all the experiments, there is considerable subject and group variability. With one exception, Group III performed at a higher level than did Group II while Group I was the lowest responder at the twelfth day of conditioning and at the conditioning criterion. Any differences in the number of days to condition measure seem to be chance effects. Probably the strongest experimental effect is in terms of average responses in extinction. In every case Group I was lower than Group II and Group III was the highest average responders in extinction. None of the above findings were highly significant and only suggest trends. While there is a suggestion of experimental contamination over the three experiments due to previous experimental performance, it does not completely "wash out" the trends.

## CHAPTER VI

### DISCUSSION

Although the results are not highly significant, the findings are interesting and have to be accounted for because of their consistency. Essentially the same results are found in all three experiments in that the groups with more reinforcement variation tend to perform at a higher level during both conditioning and extinction than does the group under constant reinforcement. This immediately suggests that larger experimental groups would have led to more significant findings. A further finding is that rate of responding appears to be directly related to the degree of reinforcement variation.

When one considers the extent of the total stimulus situation that faced Ss, a very small part of the total stimulus complex was varied. (This line of reasoning is admittedly a posteriori). It is reasonable to assume that behavioral change is proportional to the degree of "importance" of the stimulus varied. A minor stimulus dimension (color) was varied.

The relatively small differences between groups can be accounted for in different terms. Recently, Jenkins, Pascal, and Walker (1957) reported that differences between experimental conditions are more apparent under low drive than under high drive. The data reported in the present

paper pertains to Ss under high drive conditions. It is suggested therefore that if the drive were lessened in terms of less deprivation, greater differences might have been apparent.

The findings in this experiment seem to negate a Hullian prediction. Since drive was carefully controlled in the sense of deprivation, and since drive-reduction was carefully controlled in the sense of caloric content, there should be no difference among groups. Differences do result, however.

A straight cue-change prediction does not account for the data. On the basis of the above, one would have to predict that more reinforcement variation would lead to lower response levels. This was not the case although it seemed to follow from the Hunter-Pascal pilot study. In that research, increased cue-change interfered with performance (see Chapter II.) It is possible that, initially, constant reinforcement might lead to less variability and a higher response level. Further, the greater the reinforcement variation, the longer it would take to perform at a higher rate than the constant group.

The "amount" or "bits" hypothesis may account for the final results. Simply stated, Ss in the varied reinforcement groups were getting more for their efforts in terms of greater stimulus variation. It is also possible to account for these findings on the basis of novel stimulation. As

Young (1959) clearly demonstrated, increased change in terms of the cue pattern upon reinforcement may lead to "better" performance.

In experiment I, the groups under conditions of reinforcement variation took more days to stabilize. However in experiment II, they took significantly less time to stabilize. There was no real trend in the last experiment. This strongly suggests that there were no real differences in terms of rate of conditioning. On the basis of experiment I, one might have concluded that greater reinforcement change leads to more variability and, hence, more time to reach the conditioning criterion. The differential effects could then be attributed to time rather than reinforcement variation. Time does not appear to have confounded these data. It is possible that the experiment was not carried far enough. Perhaps if the criterion of conditioning took longer to reach, a greater, or even a different effect might have resulted.

The strongest and most consistent finding is that the varied groups performed at a consistently higher level in extinction than did the constant group, and performance was roughly inversely predicted by the degree of reinforcement variation. While this effect is partially due to the differences in group performance during conditioning, its relatively high level of significance implies that greater reinforcement variation during conditioning leads to higher

response levels in extinction. Speed of extinction does not seem to be related to degree of reinforcement variation. This is partially consistent with the findings of McClelland and McGown (1953). They would predict the higher level of performance but they probably would have predicted greater time to reach the extinction criterion as well.

### Suggestions For Further Study

The results are consistent enough to show the need for further investigation in the general area of reinforcement variation. This research should be considered hypothesis generating. The most obvious need is to repeat the experiment with a larger number of Ss in each group. This would help decrease variability and would show if a small but consistent effect truly appears. Secondly, in a replication, the criterion of conditioning should take longer to reach and should be the same for all Ss. This would make any effect more apparent and would control for time to condition which could, in itself, lead to differences in extinction apart from the experimental treatment.

A similar experiment should be performed under lower drive conditions as has already been suggested. Sandler at the University of Tennessee has run a pilot study using a highly similar experimental design to the one in the present research. He controlled drive at 90 per cent of the Ss



twenty-four hour deprived weight. Furthermore, he controlled for the number of days to condition and extinguish. Essentially, he found highly significant differences over the first few days in terms of rate of responding with Ss receiving more reinforcement variation performing at a higher level. This effect is not apparent after the first few days. There seems also to be a real tendency for this group to extinguish more quickly. Sandler used very few Ss as this was a pilot study and he found great S variability. His results can only be considered as being suggestive for further research.

This research should suggest parallel studies on other organisms. For example, if reinforcement variation leads to an "elation" effect, why not use this procedure to condition psychotic human subjects who are so easily distracted? Invariably investigators complain of this difficulty. Another possibility is to use a similar procedure with children who are also highly distractable.

There is one possible hypothesis that needs discussion. The findings in the present experiment seem deviant in light of the previous cue-change studies. It is possible however that response strength is not linearly related to the degree of cue-change but curvilinearly related. In other words, mild cue-change may slightly impair responding but a slightly greater stimulus change may enhance responding.

More extreme stimulus change may severely interfere with performance. Certainly this is a testable hypothesis. This hypothesis has been suggested previously by Hebb (1949, 1955).

## CHAPTER VII

### SUMMARY

Three groups of experimentally naive pigeons at 80 plus or minus 3 per cent of their twenty-four hour deprived body weight were conditioned to different degrees of variation in the reinforcing stimulus of food (i.e., one, two, or three changes). All Ss were trained in the standard Skinner box to peck a window for food reinforcement of controlled nutritional value but of different colors. Subjects were reinforced on a three minute aperiodic schedule. After a criterion of conditioning was met, Ss were extinguished to a pre-arranged criterion. Upon completion of extinction, a second conditioning round was begun with each S appearing in a different experimental condition. After a second extinction, Ss were conditioned in the presence of the third degree of reinforcement variation and again extinguished. Three possible trends were suggested for the data.

The most consistent finding is that the more reinforcement variation, the higher the resulting level of responding. Three reinforcement changes lead to a higher response level than two changes which, in turn, produced more reacting than no change. Differences occurring in extinction partly reflect the conditioning effects. None of the findings were highly significant.

The results seem most consistent with the "bits" or amount of reinforcement and the novel stimulation hypotheses. A Hullian or a cue-change prediction could not account for the findings.

An experiment involving reinforcement variation on human Ss using the Hunter-Pascal Concept Formation Test was also reported. The results of this experiment are inconsistent with the other research reported here in that the more variation in reinforcement, the more performance was impaired.

Suggestions for further research have been indicated. Possible theoretical implications were also suggested.

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## APPENDIX

TABLE XX

PERFORMANCE OF ALL ANIMALS IN ALL THREE EXPERIMENTAL  
CONDITIONS ON TWELFTH DAY

| S  | Group I | Group II | Group III |
|----|---------|----------|-----------|
| 26 | 751     | 926      | 385       |
| 29 | *       | *        | 540       |
| 31 | 710     | 1166     | 1247      |
| 32 | 1278    | *        | 134       |
| 34 | 233     | *        | *         |
| 36 | 1008    | 833      | *         |
| 38 | *       | *        | 504       |
| 39 | *       | 741      | *         |
| 40 | 544     | 396      | 481       |
| 41 | 948     | 920      | 1276      |
| 42 | 533     | 542      | 1586      |
| 43 | 2087    | 979      | 1446      |
| 47 | 632     | *        | *         |
| 50 | *       | 639      | *         |
| 53 | 756     | 706      | 1523      |
| 56 | 1289    | 3830     | 1789      |
| 64 | 1904    | 1965     | 1501      |
| 66 | 1184    | 1476     | 802       |

\* Animal died.

TABLE XXI

MEDIAN CONDITIONING PERFORMANCE LEVEL  
OF ALL ANIMALS IN ALL THREE  
EXPERIMENTAL CONDITIONS

| S  | Group I | Group II | Group III |
|----|---------|----------|-----------|
| 26 | 994     | 926      | 828       |
| 29 | *       | *        | 731       |
| 31 | 710     | 1046     | 1247      |
| 32 | 1249    | *        | 766       |
| 34 | 696     | *        | *         |
| 36 | 582     | 1012     | *         |
| 38 | *       | *        | 1000      |
| 39 | *       | 964      | *         |
| 40 | 604     | 1137     | 558       |
| 41 | 948     | 890      | 1186      |
| 42 | 533     | 590      | 1281      |
| 43 | 2087    | 1176     | 1590      |
| 47 | 619     | *        | *         |
| 50 | *       | 1020     | *         |
| 53 | 677     | 706      | 1523      |
| 56 | 1244    | 2396     | 2030      |
| 64 | 1854    | 1965     | 1460      |
| 66 | 1199    | 1501     | 1323      |

\* Animal died.

TABLE XXII

DAYS TO CONDITION FOR ALL ANIMALS IN ALL  
THREE EXPERIMENTAL CONDITIONS

| S  | Group I | Group II | Group III |
|----|---------|----------|-----------|
| 26 | 22      | 12       | 17        |
| 29 | *       | *        | 15        |
| 31 | 14      | 19       | 12        |
| 32 | 14      | *        | 22        |
| 34 | 20      | *        | *         |
| 36 | 15      | 15       | *         |
| 38 | *       | *        | 19        |
| 39 | *       | 16       | *         |
| 40 | 16      | 20       | 15        |
| 41 | 12      | 13       | 14        |
| 42 | 12      | 14       | 15        |
| 43 | 12      | 17       | 14        |
| 47 | 13      | *        | *         |
| 50 | *       | 22       | *         |
| 53 | 17      | 12       | 12        |
| 56 | 17      | 17       | 16        |
| 64 | 12      | 13       | 13        |
| 66 | 12      | 12       | 17        |

\* Animal died.

TABLE XXIII

AVERAGE RESPONSES IN EXTINCTION FOR ALL ANIMALS  
IN ALL THREE EXPERIMENTAL CONDITIONS

| S  | Group I | Group II | Group III |
|----|---------|----------|-----------|
| 26 | 241.63  | 396.20   | 301.40    |
| 29 | *       | *        | 256.50    |
| 31 | 347.22  | 368.10   | 361.40    |
| 32 | 248.63  | *        | 403.80    |
| 34 | 126.00  | *        | *         |
| 36 | 194.25  | 148.50   | *         |
| 38 | *       | *        | 420.40    |
| 39 | *       | 299.20   | *         |
| 40 | 151.50  | 241.00   | 82.60     |
| 41 | 234.25  | 403.60   | 526.83    |
| 42 | 163.43  | 351.20   | 416.57    |
| 43 | 600.00  | 318.00   | 360.67    |
| 47 | 206.75  | *        | *         |
| 50 | *       | 575.67   | *         |
| 53 | 204.00  | 139.60   | 477.67    |
| 56 | 657.50  | 959.20   | 483.38    |
| 64 | 450.00  | 751.75   | 617.40    |
| 66 | 304.71  | 505.60   | 727.00    |

\* Animal died.

TABLE XXIV

DAYS TO EXTINGUISH FOR ALL ANIMALS IN ALL  
THREE EXPERIMENTAL CONDITIONS

| S  | Group I | Group II | Group III |
|----|---------|----------|-----------|
| 26 | 8       | 5        | 5         |
| 29 | *       | *        | 6         |
| 31 | 9       | 10       | 5         |
| 32 | 8       | *        | 5         |
| 34 | 3       | *        | *         |
| 36 | 4       | 4        | *         |
| 38 | *       | *        | 5         |
| 39 | *       | 5        | *         |
| 40 | 6       | 8        | 5         |
| 41 | 4       | 5        | 6         |
| 42 | 7       | 10       | 7         |
| 43 | 8       | 4        | 6         |
| 47 | 4       | *        | *         |
| 50 | *       | 6        | *         |
| 53 | 4       | 5        | 3         |
| 56 | 6       | 5        | 8         |
| 64 | 5       | 4        | 5         |
| 66 | 7       | 5        | 6         |

\*Animal died.



TABLE XXV

TOTAL RESPONSES DURING CONDITIONING FOR EACH  
SUBJECT ON EACH DAY IN EXPERIMENT I

| S  | C   | Days |      |      |      |      |      |      |      |      |      |      |
|----|-----|------|------|------|------|------|------|------|------|------|------|------|
|    |     | 1    | 2    | 3    | 4    | 5    | 6    | 7    | 8    | 9    | 10   | 11   |
| 42 | Y   | 451  | 460  | 278  | 372  | 229  | 756  | 534  | 562  | 559  | 536  | 517  |
| 31 | Y   | 102  | 228  | 136  | 111  | 292  | 247  | 419  | 137  | 558  | 621  | 603  |
| 47 | R   | 481  | 847  | 604  | 347  | 528  | 391  | 402  | 461  | 425  | 443  | 587  |
| 34 | R   | 70   | 86   | 437  | 116  | 342  | 460  | 355  | 233  | 320  | 280  | 105  |
| 64 | B   | 109  | 121  | 288  | 531  | 541  | 688  | 902  | 1131 | 1473 | 1751 | 1854 |
| 36 | B   | 165  | 237  | 211  | 356  | 407  | 709  | 588  | 490  | 676  | 769  | 833  |
| 50 | YB  | 308  | 618  | 838  | 721  | 780  | 788  | 626  | 671  | 789  | 623  | 958  |
| 43 | YB  | 300  | 265  | 336  | 577  | 581  | 514  | 389  | 663  | 700  | 779  | 738  |
| 41 | RY  | 245  | 183  | 526  | 746  | 654  | 828  | 338  | 492  | 359  | 672  | 890  |
| 56 | RY  | 423  | 1401 | 1439 | 2126 | 1438 | 3542 | 1704 | 2251 | 2913 | 2251 | 2616 |
| 53 | BR  | 140  | 153  | 227  | 286  | 331  | 379  | 410  | 310  | 370  | 649  | 728  |
| 39 | BR  | 258  | 497  | 183  | 340  | 399  | 244  | 591  | 616  | 578  | 661  | 748  |
| 40 | RYB | 108  | 58   | 376  | 242  | 303  | 588  | 686  | 964  | 507  | 796  | 841  |
| 29 | RYB | 86   | 21   | 198  | 72   | 220  | 614  | 457  | 591  | 557  | 512  | 825  |
| 32 | RYB | 411  | 0    | 131  | 129  | 424  | 121  | 595  | 284  | 355  | 151  | 540  |
| 26 | RYB | 344  | 431  | 688  | 426  | 354  | 533  | 451  | 625  | 726  | 635  | 657  |
| 38 | RYB | 190  | 122  | 191  | 348  | 292  | 380  | 385  | 434  | 512  | 417  | 633  |
| 66 | RYB | 207  | 310  | 256  | 512  | 544  | 794  | 1014 | 1195 | 1087 | 1579 | 843  |

TABLE XXV (continued)

TOTAL RESPONSES DURING CONDITIONING FOR EACH  
SUBJECT ON EACH DAY IN EXPERIMENT I

| S  | C   | Days |      |      |      |      |      |      |      |      |     |      |
|----|-----|------|------|------|------|------|------|------|------|------|-----|------|
|    |     | 12   | 13   | 14   | 15   | 16   | 17   | 18   | 19   | 20   | 21  | 22   |
| 42 | Y   | 533  |      |      |      |      |      |      |      |      |     |      |
| 31 | Y   | 710  | 718  | 651  |      |      |      |      |      |      |     |      |
| 47 | R   | 632  | 619  |      |      |      |      |      |      |      |     |      |
| 34 | R   | 233  | 775  | 164  | 506  | 838  | 541  | 696  | 761  | 663  |     |      |
| 64 | B   | 1904 |      |      |      |      |      |      |      |      |     |      |
| 36 | B   | 1008 | 570  | 643  | 582  |      |      |      |      |      |     |      |
| 50 | YB  | 639  | 886  | 853  | 636  | 1172 | 677  | 838  | 777  | 1020 | 933 | 1069 |
| 43 | YB  | 979  | 1240 | 1577 | 1083 | 1177 | 1176 |      |      |      |     |      |
| 41 | RY  | 920  | 856  |      |      |      |      |      |      |      |     |      |
| 56 | RY  | 3830 | 2270 | 2548 | 2233 | 2552 | 2396 |      |      |      |     |      |
| 53 | BR  | 706  |      |      |      |      |      |      |      |      |     |      |
| 39 | BR  | 741  | 665  | 964  | 908  | 1005 |      |      |      |      |     |      |
| 40 | RYB | 481  | 552  | 594  | 558  |      |      |      |      |      |     |      |
| 29 | RYB | 540  | 749  | 728  | 731  |      |      |      |      |      |     |      |
| 32 | RYB | 134  | 31   | 152  | 189  | 271  | 443  | 583  | 576  | 766  | 688 | 842  |
| 26 | RYB | 385  | 673  | 683  | 881  | 828  | 778  |      |      |      |     |      |
| 38 | RYB | 504  | 699  | 648  | 494  | 678  | 930  | 1000 | 1033 |      |     |      |
| 66 | RYB | 802  | 970  | 1151 | 1253 | 1452 | 1323 |      |      |      |     |      |

TABLE XXVI

TOTAL RESPONSES DURING EXTINCTION FOR EACH  
SUBJECT ON EACH DAY IN EXPERIMENT I

| S  | C   | Days |      |      |     |     |    |     |    |    |
|----|-----|------|------|------|-----|-----|----|-----|----|----|
|    |     | 1    | 2    | 3    | 4   | 5   | 6  | 7   | 8  | 9  |
| 42 | Y   | 502  | 168  | 174  | 124 | 127 | 12 | 37  |    |    |
| 31 | Y   | 1229 | 686  | 596  | 218 | 123 | 15 | 183 | 64 | 11 |
| 47 | R   | 565  | 191  | 41   | 30  |     |    |     |    |    |
| 34 | R   | 364  | 13   | 1    |     |     |    |     |    |    |
| 64 | B   | 1563 | 124  | 546  | 16  | 1   |    |     |    |    |
| 36 | B   | 505  | 203  | 23   | 46  |     |    |     |    |    |
| 50 | YB  | 1233 | 672  | 1006 | 439 | 41  | 63 |     |    |    |
| 43 | YB  | 912  | 208  | 105  | 47  |     |    |     |    |    |
| 41 | RY  | 1060 | 603  | 294  | 4   | 57  |    |     |    |    |
| 56 | RY  | 2322 | 1715 | 511  | 236 | 12  |    |     |    |    |
| 53 | BR  | 344  | 253  | 89   | 11  | 1   |    |     |    |    |
| 39 | BR  | 587  | 562  | 265  | 72  | 10  |    |     |    |    |
| 40 | RYB | 51   | 166  | 168  | 15  | 13  |    |     |    |    |
| 29 | RYB | 737  | 523  | 123  | 127 | 29  | 0  |     |    |    |
| 32 | RYB | 835  | 617  | 468  | 74  | 25  |    |     |    |    |
| 26 | RYB | 729  | 451  | 217  | 73  | 37  |    |     |    |    |
| 38 | RYB | 840  | 931  | 303  | 8   | 20  |    |     |    |    |
| 66 | RYB | 1840 | 1177 | 959  | 269 | 64  | 53 |     |    |    |

TABLE XXVII

TOTAL RESPONSES DURING CONDITIONING FOR EACH  
SUBJECT ON EACH DAY IN EXPERIMENT II

| S  | C   | Days |      |      |      |      |      |      |      |      |
|----|-----|------|------|------|------|------|------|------|------|------|
|    |     | 1    | 2    | 3    | 4    | 5    | 6    | 7    | 8    | 9    |
| 32 | Y   | 547  | 401  | 770  | 816  | 1301 | 1360 | 1325 | 1362 | 1237 |
| 29 | Y   | *    | *    | *    | *    | *    | *    | *    | *    | *    |
| 50 | R   | *    | *    | *    | *    | *    | *    | *    | *    | *    |
| 40 | R   | 768  | 532  | 447  | 545  | 418  | 399  | 432  | 598  | 646  |
| 56 | B   | 320  | 1145 | 1154 | 1090 | 870  | 2323 | 2301 | 1577 | 1627 |
| 53 | B   | 653  | 728  | 498  | 733  | 654  | 749  | 484  | 492  | 432  |
| 36 | YB  | 529  | 909  | 958  | 817  | 765  | 1170 | 1078 | 1405 | 1297 |
| 47 | YB  | *    | *    | *    | *    | *    | *    | *    | *    | *    |
| 66 | RY  | 795  | 823  | 908  | 1180 | 1403 | 1333 | 1432 | 854  | 1217 |
| 38 | RY  | *    | *    | *    | *    | *    | *    | *    | *    | *    |
| 42 | BR  | 351  | 716  | 556  | 629  | 618  | 557  | 729  | 712  | 924  |
| 26 | BR  | 451  | 636  | 982  | 287  | 735  | 720  | 700  | 943  | 914  |
| 31 | RYB | 568  | 1024 | 979  | 1303 | 1030 | 1212 | 1233 | 1253 | 828  |
| 34 | RYB | *    | *    | *    | *    | *    | *    | *    | *    | *    |
| 41 | RYB | 738  | 1197 | 871  | 1154 | 1307 | 1076 | 1399 | 1583 | 1575 |
| 39 | RYB | *    | *    | *    | *    | *    | *    | *    | *    | *    |
| 64 | RYB | 1253 | 1334 | 1467 | 1844 | 956  | 1175 | 1418 | 1422 | 1358 |
| 43 | RYB | 578  | 870  | 1021 | 1338 | 1051 | 1121 | 968  | 1182 | 1195 |

\*Animal died.

TABLE XXVII (continued)

TOTAL RESPONSES DURING CONDITIONING FOR EACH  
SUBJECT ON EACH DAY IN EXPERIMENT II

| S  | C   | Days |      |      |      |      |      |      |      |  |
|----|-----|------|------|------|------|------|------|------|------|--|
|    |     | 10   | 11   | 12   | 13   | 14   | 15   | 16   | 17   |  |
| 32 | Y   | 1324 | 916  | 1278 | 1232 | 1249 |      |      |      |  |
| 29 | R   |      |      |      |      |      |      |      |      |  |
| 50 | R   |      |      |      |      |      |      |      |      |  |
| 40 | R   | 530  | 652  | 544  | 524  | 612  | 604  | 594  |      |  |
| 56 | B   | 2196 | 1754 | 1289 | 1355 | 1125 | 1126 | 1271 | 1244 |  |
| 53 | B   | 498  | 572  | 756  | 653  | 525  | 630  | 712  | 677  |  |
| 36 | YB  | 1153 | 943  | 833  | 976  | 1013 | 1108 |      |      |  |
| 47 | YB  |      |      |      |      |      |      |      |      |  |
| 66 | RY  | 1504 | 1501 | 1476 |      |      |      |      |      |  |
| 38 | RY  |      |      |      |      |      |      |      |      |  |
| 42 | BR  | 790  | 688  | 542  | 590  | 631  |      |      |      |  |
| 26 | BR  | 959  | 849  | 926  |      |      |      |      |      |  |
| 31 | RYB | 1222 | 1325 | 1247 |      |      |      |      |      |  |
| 34 | RYB |      |      |      |      |      |      |      |      |  |
| 41 | RYB | 1629 | 1417 | 1276 | 1155 | 1186 |      |      |      |  |
| 39 | RYB |      |      |      |      |      |      |      |      |  |
| 64 | RYB | 1673 | 1190 | 1501 | 1414 | 1460 |      |      |      |  |
| 43 | RYB | 1448 | 873  | 1446 | 1590 | 1680 |      |      |      |  |

TABLE XXVIII

TOTAL RESPONSES DURING EXTINCTION FOR EACH  
SUBJECT ON EACH DAY IN EXPERIMENT II

| S  | C   | Days |      |      |     |     |     |     |     |    |    |
|----|-----|------|------|------|-----|-----|-----|-----|-----|----|----|
|    |     | 1    | 2    | 3    | 4   | 5   | 6   | 7   | 8   | 9  | 10 |
| 32 | Y   | 214  | 288  | 606  | 148 | 454 | 164 | 99  | 16  |    |    |
| 29 | Y   | *    | *    | *    | *   | *   | *   | *   | *   | *  | *  |
| 50 | R   | *    | *    | *    | *   | *   | *   | *   | *   | *  | *  |
| 40 | R   | 298  | 211  | 147  | 190 | 47  | 16  |     |     |    |    |
| 56 | B   | 2217 | 1207 | 144  | 268 | 18  | 91  |     |     |    |    |
| 53 | B   | 500  | 268  | 30   | 18  |     |     |     |     |    |    |
| 36 | YB  | 469  | 119  | 6    | 0   |     |     |     |     |    |    |
| 47 | YB  | *    | *    | *    | *   | *   | *   | *   | *   | *  | *  |
| 66 | RY  | 1271 | 770  | 435  | 29  | 23  |     |     |     |    |    |
| 38 | RY  | *    | *    | *    | *   | *   | *   | *   | *   | *  | *  |
| 42 | BR  | 932  | 691  | 417  | 434 | 33  | 556 | 187 | 153 | 58 | 51 |
| 26 | BR  | 803  | 545  | 470  | 93  | 70  |     |     |     |    |    |
| 31 | RYB | 763  | 682  | 326  | 15  | 21  |     |     |     |    |    |
| 34 | RYB | *    | *    | *    | *   | *   | *   | *   | *   | *  | *  |
| 41 | RYB | 1320 | 951  | 494  | 238 | 108 | 50  |     |     |    |    |
| 39 | RYB | *    | *    | *    | *   | *   | *   | *   | *   | *  | *  |
| 64 | RYB | 1367 | 522  | 1004 | 140 | 54  |     |     |     |    |    |
| 43 | RYB | 276  | 205  | 1352 | 174 | 92  | 65  |     |     |    |    |

\* Animal died.

TABLE XXIX

TOTAL RESPONSES DURING CONDITIONING FOR EACH  
SUBJECT ON EACH DAY IN EXPERIMENT III

| S  | C   | Days |      |      |      |      |      |      |      |      |      |      |
|----|-----|------|------|------|------|------|------|------|------|------|------|------|
|    |     | 1    | 2    | 3    | 4    | 5    | 6    | 7    | 8    | 9    | 10   | 11   |
| 26 | Y   | 1179 | 1205 | 962  | 1227 | 1449 | 1596 | 1720 | 1531 | 1713 | 1562 | 1386 |
| 38 | Y   | *    | *    | *    | *    | *    | *    | *    | *    | *    | *    | *    |
| 39 | R   | *    | *    | *    | *    | *    | *    | *    | *    | *    | *    | *    |
| 43 | R   | 1527 | 1716 | 1154 | 1163 | 1009 | 1215 | 1034 | 1058 | 1544 | 1968 | 2217 |
| 41 | B   | 877  | 1144 | 1348 | 1224 | 1394 | 1064 | 978  | 874  | 1128 | 856  | 965  |
| 66 | B   | 1480 | 1444 | 1343 | 1186 | 997  | 1056 | 1195 | 1001 | 1239 | 1318 | 1199 |
| 40 | YB  | 604  | 718  | 769  | 939  | 971  | 492  | 421  | 366  | 229  | 593  | 47   |
| 34 | YB  | *    | *    | *    | *    | *    | *    | *    | *    | *    | *    | *    |
| 31 | RY  | 1247 | 1366 | 1449 | 1787 | 1480 | 1346 | 1467 | 1489 | 1148 | 1954 | 1541 |
| 29 | RY  | *    | *    | *    | *    | *    | *    | *    | *    | *    | *    | *    |
| 32 | BR  | *    | *    | *    | *    | *    | *    | *    | *    | *    | *    | *    |
| 64 | BR  | 1176 | 1417 | 1811 | 1601 | 1515 | 1440 | 1539 | 1502 | 1644 | 1723 | 2003 |
| 42 | RYB | 1223 | 1800 | 1842 | 2226 | 734  | 1813 | 1688 | 1569 | 2084 | 2044 | 1586 |
| 36 | RYB | *    | *    | *    | *    | *    | *    | *    | *    | *    | *    | *    |
| 53 | RYB | 456  | 976  | 1072 | 1510 | 1440 | 1328 | 1562 | 1299 | 1450 | 1442 | 1658 |
| 56 | RYB | 654  | 998  | 1264 | 1153 | 1115 | 1387 | 1171 | 647  | 1149 | 1289 | 713  |
| 50 | RYB | *    | *    | *    | *    | *    | *    | *    | *    | *    | *    | *    |
| 47 | RYB | *    | *    | *    | *    | *    | *    | *    | *    | *    | *    | *    |

\* Animal died.





TABLE XXX

TOTAL RESPONSES DURING EXTINCTION FOR EACH  
SUBJECT ON EACH DAY IN EXPERIMENT III

| S  | C   | Days |      |     |     |     |     |     |     |     |    |
|----|-----|------|------|-----|-----|-----|-----|-----|-----|-----|----|
|    |     | 1    | 2    | 3   | 4   | 5   | 6   | 7   | 8   | 9   | 10 |
| 26 | Y   | 607  | 233  | 15  | 217 | 563 | 180 | 97  | 21  |     |    |
| 38 | Y   | *    | *    | *   | *   | *   | *   | *   | *   | *   | *  |
| 39 | R   | *    | *    | *   | *   | *   | *   | *   | *   | *   | *  |
| 43 | R   | 1756 | 1430 | 289 | 588 | 225 | 331 | 114 | 67  |     |    |
| 41 | B   | 588  | 305  | 20  | 24  |     |     |     |     |     |    |
| 66 | B   | 924  | 540  | 220 | 130 | 260 | 17  | 42  |     |     |    |
| 40 | YB  | 658  | 302  | 314 | 197 | 244 | 126 | 61  | 26  |     |    |
| 34 | YB  | *    | *    | *   | *   | *   | *   | *   | *   | *   | *  |
| 31 | RY  | 1360 | 742  | 450 | 314 | 227 | 31  | 238 | 191 | 101 | 27 |
| 29 | RY  | *    | *    | *   | *   | *   | *   | *   | *   | *   | *  |
| 32 | BR  | *    | *    | *   | *   | *   | *   | *   | *   | *   | *  |
| 64 | BR  | 1377 | 1358 | 155 | 117 |     |     |     |     |     |    |
| 42 | RYB | 1302 | 523  | 524 | 262 | 194 | 107 | 4   |     |     |    |
| 53 | RYB | 1281 | 39   | 113 |     |     |     |     |     |     |    |
| 36 | RYB | *    | *    | *   | *   | *   | *   | *   | *   | *   | *  |
| 56 | RYB | 1534 | 381  | 555 | 703 | 100 | 252 | 144 | 198 |     |    |
| 50 | RYB | *    | *    | *   | *   | *   | *   | *   | *   | *   | *  |
| 47 | RYB | *    | *    | *   | *   | *   | *   | *   | *   | *   | *  |

\* Animal died.