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THE UNIVERSITY OF OKLAHOMA

GRADUATE COLLEGE

THE EFFECTS OF DIFFERENTIAL SCHEDULES OF REINFORCEMENT UPON ACQUISITION AND EXTINCTION IN A TWO-CHOICE PROBABILITY LEARNING SITUATION

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degree of

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Norman, Oklahoma

1971

THE EFFECTS OF DIFFERENTIAL SCHEDULES OF REINFORCEMENT UPON ACQUISITION AND EXTINCTION IN A TWO-CHOICE PROBABILITY LEARNING SITUATION

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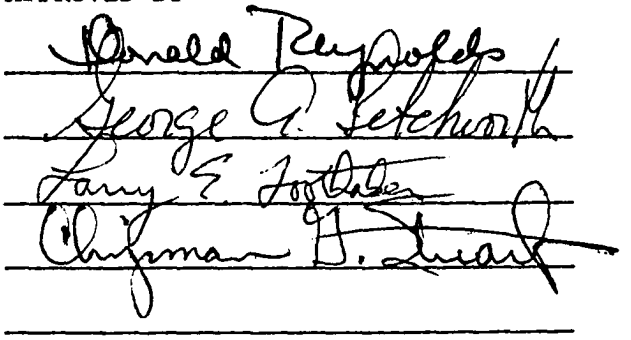

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In memory of my mother

and

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that they could afford me
the proper education they so
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THE EFFECTS OF DIFFERENTIAL SCHEDULES OF REINFORCEMENT UPON ACQUISITION AND EXTINCTION IN A TWO-CHOICE PROBABILITY LEARNING SITUATION

CHAPTER I

INTRODUCTION AND PROBLEM

While the emphasis in the 1940's and early 1950's was on animal learning, there has been in the past fifteen years a resurgence of theory and research about human learning. The reasons for this resurgence are many, complex, and often inexplicit. One significant motive has been the realization that human learning not only "encompasses the varieties of processes observable in animal learning, but goes beyond them, perhaps largely because of the capacities for verbal modes of symbolic, 'mediating' behavior in human beings."[1] Another reason is attributed to the recognition by many government, military, industrial, and social agencies of "the need for fundamental knowledge about human performance capabilities and limitations and. . . the optimal procedures for training men to meet performance requirements."[2]

There are many categories of human learning. These types are clusters of research activity rather than rational schemes of

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[1] W. K. Estes, "Probability Learning." In A. W. Melton (editor), Categories of Human Learning, Academic Press, New York, 1964, p. 326.

[2] Ibid.

classification.[3] One such cluster is probability learning.

Probability learning describes a situation where on each of a series of trials, a subject makes a choice from an experimenter-defined set of alternative responses, then receives a signal indicating whether the choice was correct.[4] The distinguishing feature in this setting is the occurrence of a random sequence of events. This characteristic permits no information by which the subject can precisely predict which event will occur.

The simplest form of probability learning is the two-choice arrangement. On each trial the subject is to predict which one of two events (E_1 and E_2) is going to occur. The experimenter decides according to a certain pattern (schedule) whether to show E_1 or E_2 on a given trial. He might choose the probability of an E_1 on the nth trial, for example, to (a) be a constant, (b) increase or decrease in some systematic manner as trials proceed, (c) vary depending on the response at the $(n-1)^{th}$ trial, and (d) vary depending on the response or reinforcing event that occurred a few trials back in the sequence.[5]

If A_1 and A_2 denote the subject's two predictive responses such that the occurrence of $E_i (i = 1,2)$ implies that $A_i (i = 1,2)$ was correct on a certain trial, then independently of how the sequence of events is generated, the general prediction is that the long-term average proportion of A_1 responses should come to equal the average proportion of E_1 events

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[3] Ibid., p. 89.

[4] Ibid., p. 89.

[5] E. R. Hilgard and G. H. Bower, Theories of Learning, Appleton-Century-Crofts, New York, 1966, p. 348.

over the same number of trials.[6]

Much research has been conducted in the area of acquisition vs. extinction in the two-choice situation. Studies of this nature have often taken a dual approach. One such approach is the accumulation of factual material the interpretation of which (in terms of concepts and assumptions) may lead to a "situational" or "generalized" theory.[7] The other uses "the probability learning situation as a convenient testing ground for general theories."[8] It must be pointed out, however, that this twofold methodology is frequently camouflaged by the shading of the two approaches into one another.

The phenomena of reinforcement have stimulated much investigating and theorizing.[9] Of considerable importance is the phenomenon of partial reinforcement, which not only plays a successful role in the establishment and maintenance of a conditioned response,[10] but also in the influence upon resistance to extinction. "Extinction," argues Skinner, "is the only appropriate measure of conditioning."[11]

The influence of partial reinforcement on resistance to extinction can be explained by several theories. Some of these are:

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[6] Ibid.

[7] Estes, "Probability Learning," op. cit., p. 90.

[8] Ibid.

[9] The standard text in this area is Schedules of Reinforcement by Ferster and Skinner (see (130)).

[10] Pavlov (141) demonstrated that salivation in a dog was induced with food reinforcement on every third trial.

[11] B. F. Skinner, "Resistance to Extinction in the Process of Conditioning," Journal of General Psychology, 1933, 9, p. 420.

1. Stimulus-generalization theory,

2. Discrimination theory,

3. Expectancy theory,

4. Secondary reinforcement theory, and

5. Response-Unit theory.

A brief account of each is discussed below.

Stimulus-Generalization Theory. The greater resistance to extinction, which follows partial as compared to full reinforcement, has been explained in terms of stimulus-generalization. The interpretation utilizes only stimulus-response concepts.[12] It claims that cues[13] conditioned on reinforced trials preceded by non-reinforced trials are more characteristic of extinction cues than those conditioned on reinforced trials preceded by reinforced trials.[14] As the amount of training increases (during partial reinforcement), these cues which are characteristic of extinction, become directly conditioned to the response.[15] Since a response evoked by a reinforced stimulus is stronger than that evoked by a generalized stimulus, one expects the conditioned response (during extinction) to be stronger (more resistant to extinction)

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[12]Stimulus-response learning theories (sometimes identified as classical conditioning theories) assume that reinforcement strengthens a conditioned response and non-reinforcement extinguishes it. This can be interpreted to mean that partial reinforcement should produce a weaker response which would extinguish faster than would be the case with full reinforcement.

[13]A cue is a stimulus that guides the response and determines which response will occur (see (134), p. 81).

[14]This process is called generalization decrement.

[15]Other cues not characteristic of extinction become conditioned also.

in the former case than in the latter.[16]

According to the "Hull-Sheffield" hypothesis, the greater resistance to extinction of a learned response following partial reinforcement than after full reinforcement, is attributed to the fact that the stimulus after-effect of a non-reinforced trial becomes conditioned to the instrumental response, whereas under full reinforcement such conditioning does not exist. Since extinction involves the after-effect on every trial (except the first), one expects a subject to have greater excitatory strength for a response after partial reinforcement than after full reinforcement and, therefore, more trials are required to extinguish in the first case than in the latter.

In applying the principle of stimulus-generalization to interpret the effects of partial reinforcement, one assumes "that there must be a large enough number of occurrences of non-reinforcement followed by reinforcement during training for a stable response to be conditioned to the extinction cues."[17] In Humphrey's experiment (58), for example, Groups III and IV[18] were each given seven reinforcements only. "It is unlikely," argues Sheffield, "that a very strong response could be conditioned to the extinction cues in so few trials."[19]

Discrimination Theory. To detect the onset of extinction depends upon one's ability to learn the reinforced patterns during acquisition.

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[16]V. F. Sheffield, "Extinction as a Function of Partial Reinforcement and Distribution of Practice," Journal of Experimental Psychology, 1949, 39, p. 513.

[17]Sheffield, "Extinction as a Function," p. 522.

[18]See p. 17.

[19]Sheffield, "Extinction as a Function," p. 522.

Better learning of a pattern implies that a deviation from that pattern will become more noticeable, and therefore, the rate of extinction is enhanced.[20]

Extinction following random reinforcement is not necessarily accelerated by increased amounts of training because of the unpredictability of the pattern and therefore the impossibility of learning the pattern.

Expectancy Theory. Conditioned responses are determined by the degree of one's expectation that reinforcement will occur. The shift from full reinforcement to full non-reinforcement makes it easy for the subject to expect no reappearance of reinforcement during extinction. After partial reinforcement, however, extinction is prolonged by the subject's expectation that reinforcement will be periodic as it was during training and consequently be reintroduced.[21]

Interpretation of the effects of partial reinforcement in terms of Humphrey's expectancy theory is not rigorously stated and therefore is somewhat ambiguous. Paralleling the same argument of the theory one might conclude "that after being habituated to infrequent reinforcements, the subject finds it easy to get used to the idea that there will be none at all, but after being habituated to uniform reinforcement, the subject finds it hard to believe that there will be no more reinforcements."[22]

Secondary Reinforcement Theory. The effect of change in the

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[20] E. J. Capaldi, "The Effect of Different Amounts of Training on the Resistance to Extinction of Different Patterns of Partially Reinforced Responses," Journal of Comparative and Physiological Psychology, 1958, 51, pp. 367-368.

[21] Sheffield, "Extinction as a Function," pp. 511-512.

[22] Ibid., p. 523.

afferent consequences of a response upon its resistance to extinction is explained in terms of secondary reinforcement--a neutral stimulus which acquires reinforcing properties as a result of repeated association with primary reinforcement. From this point of view, the extinction of a response would inevitably be retarded by stimuli which have been contiguous with reinforcement during training.[23] In other words, greater amounts of training should result in greater accumulation of secondary reinforcement, which in turn, should oppose the process of extinction.[24]

The secondary reinforcement theory, by the nature of its definition, "not only cannot explain the differential effect on resistance to extinction obtained with massed and spaced training trials, but also it cannot account for the basic difference in extinction between partial and 100 percent reinforcement with massed training trials."[25]

Response-Unit Theory. A response is redefined to mean a pattern of behavior rather than a single act.[26] In other words, the total number of responses leading up to reinforcement are viewed as a unit. Therefore, the more often such units are reinforced, the more resistant to extinction they become.[27]

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[23]M. E. Bitterman, W. E. Feddersen, and D. W. Tyler, "Secondary Reinforcement and the Discrimination Hypothesis," American Journal of Psychology, 1953, 66, p. 456.

[24]Capaldi, "The Effect of Different Amounts of Training," p. 367.

[25]Sheffield, "Extinction as a Function," p. 525.

[26]O. H. Mowrer and H. Jones, "Habit Strength as a Function of the Pattern of Reinforcement," Journal of Experimental Psychology, 1945, 35, pp. 294-295.

[27]This follows from the basic assumption of stimulus-response learning theories (see footnote 12).

From the response-unit theory one might easily predict that spacing of training trials would make it difficult for a sequence of behavior to be reinforced as a "unit" and would therefore cause a breakdown in the usual advantage of partial reinforcement in extinction.[28]

Statement of the Problem

The present study proposes to test the effects of differential schedules of reinforcement upon acquisition and extinction in a two-choice probability learning situation. It examines the effects of different reinforcement schedules upon acquisition and extinction and also their effects on extinction in the presence and absence of certain cues during extinction.

The specific objectives of this study are as follows:

1. To determine the effects of reinforcement on acquisition and the resistance to extinction in a two-choice probability learning paradigm.
2. To determine if differences exist in the resistance to extinction in a two-choice probability learning paradigm under the following conditions:
   a) when cues present during training are also present during extinction, and
   b) when those cues which are present during training are absent during extinction.
3. To test certain deductions of five theories[29] which attempt to account for extinction following partial reinforcement.

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[28] Sheffield, "Extinction as a Function," p. 524.

[29] See page 4.

Delimitations of the Study

This study was limited in the following ways:

1. The samples were composed of volunteer undergraduate students (American and of both sexes) between the ages of eighteen and twenty-two enrolled at the University of Oklahoma, and inferences may be made only to similar groups.
2. A two-choice situation was used, and therefore inferences may be made only to similar situations.
3. Reinforcement schedules were used, and therefore inferences may be made only to similar schedules.

Statistical Hypotheses

The following null hypotheses were formulated:

H_o-1 Among six schedules of reinforcement - 100 FR, 67 FR, 33 FR, 0 FR, 67 VR, and 33 VR each will have the same effect upon acquisition.

H_o-2 Among six schedules of reinforcement - 100 FR, 67 FR, 33 FR, 0 FR, 67 VR, and 33 VR each will have the same effect on resistance to extinction.

H_o-3 There will be no difference in resistance to extinction (a) when extinction is conducted, "light on," versus (b) when extinction is conducted, "light off."

Summary

The basic principle underlying probability learning in a two-choice situation can best be stated as follows: Independently of how a sequence of events is generated, the long-term average proportion of

positive (A_1) responses will eventually come to match the average proportion of positive (E_1) events.[30]

Among the many factors that influence both acquisition and extinction are reinforcement schedules. Many studies have been conducted to explain the relationship between reinforcement and acquisition and between reinforcement and resistance to extinction. Some of these studies have given sustenance to existing theories; others have either defied the existing theories, the consequence of which has led to the formation of new ones, or else, have denied them all forms of support.

Amidst all these controversies, therefore, additional research needs to be done on the effect of different schedules of reinforcement upon acquisition and resistance to extinction. A two-choice situation represents the simplest form of the probability learning paradigm. This study examined the effects of different reinforcement schedules upon acquisition and extinction as well as their effects on extinction in the presence and absence of certain cues during extinction.

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[30] A positive event is taken to mean the event which is chosen by the experimenter to be the positive reinforcer.

CHAPTER II

REVIEW OF RELATED LITERATURE

A survey of the literature indicates that the effects of reinforcement on acquisition and extinction can best be determined within the nature and scope of an individual experiment or study and by a thorough knowledge of all the factors which are either concurrent with reinforcement or related to it.

Due to the diversity of such factors, total experimental control is virtually impossible. Partial experimental control, on the other hand, may leave several if not many factors free to act and interact often causing considerable error in the results obtained.

Error is the concomitant of every scientific endeavor. Thus, by controlling the major factors that contribute to the maximum discrepancy, the experimenter can minimize this error. This chapter presents a review of the studies that have been concerned with the major aspects relevant to schedules of reinforcement and their effects upon acquisition and extinction. It also includes (whenever made available by the researchers) the theoretical interpretation of the pertinent issues and findings.

Acquisition is reflected in several different response measures, the most common of which are: (a) probability of occurrence, expressed

as the percentage of trials on which a given subject produces a conditioned response (CR); (b) latency, the time between the presentation of a signal and the occurrence of a CR; (c) response speed, the reciprocal of some time measure such as latency; (d) rate of responding, the number of CR's produced in some standard period of time; (e) response magnitude, some measure which reflects the vigor of a response on trials when it occurs; and (f) resistance to extinction, the resistance to the decrement in a conditioned response as a result of presenting the conditioned stimulus unaccompanied by the usual reinforcement.[31]

Effects of Amount of Reinforcement on Acquisition and/or Resistance to Extinction

In an experiment by Hovland (50), the galvanic skin reaction was conditioned to tonal stimuli in four groups[32] of 32 human subjects each. The four groups were given 8, 16, 24, and 48 paired presentations of electric shock and oscillator tone respectively. In each group half the subjects were conditioned to a weak tone, and half to a strong tone. These two intensities were 150 J.N.D.'s[33] apart. The intensity of tone not used in conditioning was employed as the stimulus to test for generalization.

Hovland's study revealed that the acquisition curve based on the means of the groups (dependent variable) plotted against the varying numbers of reinforcements (independent variable) showed continuous negative

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[31] See (133), p. 82.

[32] Equated on the basis of initial magnitude of unconditioned responses to shock stimuli.

[33] J.N.D. (Just Noticeable Difference) is the smallest difference which can be discriminated (see (139), p. 278).

acceleration.[34] There was a positive relationship between the dependent and independent variables. The conditioned responses extinguished more slowly the further the conditioning process had advanced. The group given 48 reinforcements showed an initial rise in the extinction curve. This, explains Hovland, is "due to a 'disinhibition' of the 'inhibition of reinforcement.' When a large number of reinforcements are given there is an adaptation by the subject to the stimulation. This effect is labeled 'inhibition of reinforcement.' Omission of the reinforcement during testing then acts as a 'disinhibitor' and the response becomes augmented."[35]

Generalized responses, on the other hand, extinguished more rapidly with greater amounts of reinforcement.[36]

Williams (121) used four groups of thirty-five 60-100-day-old male albino rats each. During training in a free responding lever press apparatus, and in a 100% RE situation, one group was allowed to obtain 5 pellets of food; a second group, 10 pellets; a third group, 30 pellets; and a fourth group, 90 pellets. A period of five minutes during which no responses were made was chosen as arbitrary criterion of extinction. Rate of response was obtained by dividing the total time by the number of responses. The results of this study show that the rates of response were highest for the 5-pellets group and lowest for the 90-pellets group,

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[34]Negative acceleration means that the curve changes more rapidly at the beginning than at the end.

[35]C. I. Hovland, "The Generalization of Conditioned Responses. IV. The Effects of Varying Amounts of Reinforcement Upon the Degree of Generalization of Conditioned Responses," Journal of Experimental Psychology, 1937, 21, p. 272.

[36]Humphreys, in a similar experiment, found that following 100% reinforcement responses to the reinforced tones were significantly higher than generalized responses (see (57), p. 371).

indicating that the greater the reinforcement, the greater is the resistance to extinction.

". . . The greater the intensity of the excitatory process," says Pavlov, "the more intense must be the inhibitory process to overcome it, and therefore the greater number of unreinforced repetitions necessary to bring about complete extinction."[37] William's finding seems to support this argument.

Harris and Nygaard (43) conducted an experiment on 175-255-day-old albino rats similar to that of Williams. In this study, however, they extended the number of reinforcements to 360 prior to extinction to examine the possibility of a decrease in the function. Three groups (A, B, C) received 45, 90, and 360 reinforcements respectively. The finding (confirming Williams' results) revealed that the number of responses to extinction is a monotonic increasing function of the number of reinforcements.

Zeaman (124) gave seven groups of white rats (of Wistar strain) well-spaced training on a simple straight and elevated runway. They were given .05, .20, .40, .60, .80, 1.60, and 2.40 grams of food reinforcement respectively.[38] When response latencies reached stable asymptotes, Groups II, III, V, and VI were extinguished with massed trials. Groups I and VII had their respective amounts of reinforcement reversed, and were given 8 additional daily trials with the opposite amounts. Following acquisition, the 40 animals of the .60 gm. group were divided into five

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[37] I. P. Pavlov, Conditioned Reflexes. (Translated by G. V. Anrep), Oxford University Press, 1927, p. 61.

[38] The Ss were left in the goal-box until the food was eaten and then removed. Fehrer (32) found that postreinforcement delay in the goal-box contributed to a rise in resistance to extinction. This may be explained by secondary reinforcement in the goal-box.

groups (A, B, C, D, E) equated for weight and average log latency on the last six days of acquisition, and given .05, .20, .60, 1.20, and 2.40 gms. respectively. These groups were also subjected to massed extinction trials. The results revealed that greater resistance to extinction is positively related to the amount of reinforcement on the acquisition trials. Related to this finding is a study by Hulse and Firestone (53) which showed a positive correlation between resistance to extinction and variability of absolute amount of reinforcement.

Zeaman suggests that extinction should be regarded as a reduction in amount of reinforcement which results in a reduction in habit strength.[39] This seems somewhat contrary to Hull's view which attributes extinction not to the reduction of ${}_{S}H_{R}$[40] by non-reinforced elicitations but to the accumulation of the two kinds of inhibition - I_R and ${}_{S}I_{R}$.[41]

Learning theorists generally assume that the more times a response has been reinforced, the more non-reinforcements are required for its extinction. This argument was tested in two experiments performed by North and Stimmel (86).

They showed that a group of 60-day-old male albino rats given a

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[39] Dufort and Kimble (26) later showed that extinction can be attributed to a decrease in the amount of reinforcement to zero. Whether the effect of changing the amount of reinforcement was on performance or learning was not determined.

[40] ${}_{S}H_{R}$ ≡ habit strength.

[41] I_R ≡ reactive inhibition; the evocation of any reaction generates reactive inhibition (see (132), p. 155).

${}_{S}I_{R}$ ≡ conditioned inhibition; stimuli associated with the cessation of a response become conditioned inhibitors (see (132), p. 155).

large number of reinforcements (90 or 135) in a straight runway apparatus extinguished more rapidly than another group given 45 reinforcements. This result is attributed to the fact that after habit strength reaches its maximum level, frustration due to nonreward could be a major factor in extinction.

Ison (60) studied the relationship between the number of reinforced acquisition trials (N_g) and resistance to extinction of a running response in a straight alley. Six groups (A, B, C, D, E, F), 13 Ss each, of 100-day-old male hooded rats received 10, 20, 40, 60, 80, and 100 rewarded trials respectively. The Ss were given 5 trials per day and the minimum inter-trial interval was 18 minutes. The four criteria of extinction were delays of 10, 20, 40, and 120 seconds. Extinction was carried to a minimum of 80 trials and continued until S took 120 seconds or more to enter the goal box. Four measures were reported--(a) the number of trials to the various extinction criteria, (b) running speed in early extinction, (c) number of avoidance responses made in extinction, and (d) the number of trials to the first avoidance response.

The results were as follows:

1. (a) and (b) were negatively related to N_g,
2. relation of (b) to N_g was non-monotonic,
3. (c) was positively related to N_g, and
4. (d) was negatively related to N_g.

The assumption that the intensity of frustration elicited on non-reinforced trials varies positively with the number of prior reinforcements, and the further assumption that the strength of frustration-instigated avoidance response is also positively related to frustration intensity are supporting

evidence for the positive relationship between the number of avoidance responses and N_g and the negative relationship between trials to the first avoidance response and N_g.

In a bar-pressing apparatus, Dyal and Holland (27) studied the effect of number of reinforcements on resistance to extinction. Eighty 69-83-day-old male albino rats were randomly assigned to four groups (A, B, C, D) which received 10, 90, 180, and 360 reinforced training trials respectively. A lapse of five minutes without a response was the criterion of extinction. The mean number of bar-presses to extinction for Groups A, B, C, and D were 104.5, 159.1, 194.1, and 221.3 respectively.

The implication of such a result is that resistance to extinction is an increasing negatively accelerated function of the number of reinforced acquisition trials.

Effects of Amount and Level of Training on Acquisition and/or Resistance to Extinction

In a bar-pressing experiment with 60-100-day-old male albino rats, Humphreys (58) used four groups (20 rats in each group):

Group I received 18 reinforcements out of 52 trials,

Group II received 18 reinforcements out of 18 trials,

Group III received 7 reinforcements out of 18 trials, and

Group IV received 7 reinforcements out of 7 trials.

Comparison of the number of responses during 10-minute extinction periods showed (1) that Groups I and II (also III and IV) performed quite differently with an advantage for Group I over Group II and Group III over Group IV, and (2) that Groups II and III were practically identical. In the first case, the number of reinforcements was the same but the number

of trials different. In the second case, the number of trials was the same, but the number of reinforcements different. This indication can mean that partial reinforcement is effective only when the number of reinforcements is kept constant. It can also mean that the strength of conditioning in a Skinner-box situation is determined by the number of practice trials rather than by the number of reinforcements. The results, however, are in disagreement as far as the form of the extinction curve following random reinforcement is concerned; and further research is therefore necessary to clarify this point. In a subsidiary part of the experiment, Humphreys used two sub-groups (40 Ss each) selected equally from the four main experimental groups. During training, a buzzer was activated to produce a noise each time the bar was pressed. One group was extinguished in the presence of the buzzer while the other was extinguished in its absence. The results substantiated Bugelski's finding[42] concerning "sub-goal reinforcement."[43]

A corollary of RE theory is that greater amounts of training result in greater negative transfer; this was investigated by Capaldi and Stevenson (19). In this study 29 naive rats (of Wistar strain) were

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[42]Bugelski (8) in a similar experiment to that of Humphreys' (see (58)), found that those animals who did not hear the click during extinction extinguished much faster than those which heard it. "It appears fairly certain," he argues, "that the presence of the click during extinction was a partial or 'sub-goal' reinforcement to the animals and that its absence added more frustration to that resulting from the absence of the food reward" (see (8), p. 132). White (117) explains the effect of the click on resistance to extinction by the "completion hypothesis" which can be expressed as follows: "The completion of a fractional anticipatory reaction tends to reinforce recent and concomitant S-R connections." "Completion," here, "means the transition from an incipient reaction to the complete reaction of which it was previously a part (in Hull's symbolism, the transition from r_g to R_g)" (see (117), p. 399).

[43]Sub-goal reinforcement is the reinforcing effect of a stimulus which always precedes the goal response (see (58), p. 104).

trained in a simple T-maze, where one arm (with its goal box) was painted black, and the other arm and goal box painted white. The main alley was painted gray. The arms were also interchangeable. During training, the rats were taught to discriminate between black and white. This was done by randomly selecting 15 rats and reinforcing them following entry into the white goal box. The other 14 were reinforced following entry into the black goal box.

All animals were initially trained to a criterion of 7 correct responses out of 8 trials (Criterion 1). After reaching this criterion, they were divided into 3 groups of 10, 10, and 9 rats respectively. Group I received no more than the initial training. Training for Group II was continued until 8 additional consecutive correct responses were made (Criterion 2), and for Group III until 35 consecutive correct responses were made (in addition to meeting criteria 1 and 2). Reversal training[44] was begun for each group upon meeting its criterion. The experimental procedure was the same as that of original training. The criterion for reversal training was eight consecutive correct responses.

The analysis indicated (before reversal training began) that the rats reinforced in the black goal box learned the color discrimination in significantly fewer trials than those reinforced in the white goal box. Neither the difference in training trials among the groups nor the interaction between group and cue were significant. The results for the reversal trials, however, showed that Groups I and II did not differ significantly from each other, but that there were significant acquisition and

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[44]This was done by interchanging the arms.

extinction differences in favor of Group III over both Groups I and II,[45] i.e., Group III learned and extinguished faster than Groups I and II.

One may conclude, therefore, that a change in a situation is more readily discriminated, and extinction is faster following overtraining than it is following undertraining or slight overtraining.

A number of studies have investigated the effect of amount of training on resistance to extinction under conditions of 100% reinforcement (see (121), for example). Little attention, however, was given to situations dealing with partially reinforced responses.

Capaldi (11) had fifty-two naive Wistar-strain rats, randomly divided into four groups of 13 animals each. Group I was given alternating reinforcement for 7 days (A-7). Group II was given alternating reinforcement for 14 days (A-14). Groups III and IV were given 50% random reinforcement for 7 and 14 days respectively (R-7, R-14). The apparatus consisted of a straight runway and a goal box. The animals were trained to traverse the runway and jump to the white goal box. They were all given five reinforced and five non-reinforced trials per day. Extinction began on the day following the last day of training. The intertrial interval was 20 seconds for both training and extinction. If the animals did not reach the goal box within 90 seconds, it was removed for 20 seconds

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[45] Birnbaum (4) using bright (B) and dark (D) discrimination with 400 overtraining trials found evidence of the ORE (over-training reversal effect) with B but not with D in original learning. D'Amato and Jagoda (24) and Erlebacher (29), using spatial and brightness discrimination respectively, failed to demonstrate any effect of overtraining on reversal. Hill, Spear, and Clayton (48), in one experiment and some comparisons in two others, have shown a reverse ORE. While Capaldi (12) observed an ORE following position response training, the mean number of trials to reversal criterion on a position discrimination reported by Clayton (20) was not significantly affected.

and then given another extinction trial. Two successive incomplete trials of this kind constituted the criterion of extinction.

The results indicated that the A-14 group was less significantly resistant to extinction than any of the other groups. The A-7, R-7, and R-14 groups, however, did not differ from each other. It was noted that (during training) the A-14 animals ran faster on the reinforced trials than on the non-reinforced trials. This pattern of differential running did not occur in any of the other three groups. It was argued that the A-7 group did not learn the pattern. The failure of the R-14 group to discriminate was taken to imply that overtraining is not likely to be efficacious under a schedule of random reinforcement.

The general picture derived from the results lends support to the "Discrimination Hypothesis."

Reid (93) asserted that as a rat learns to make a specific choice discrimination, he is also learning a set of stimuli of which the specific stimulus is a member.[46] This assertion served as the point of departure for Murillo and Capaldi (84) to determine the effects of over-learning trials on resistance to extinction. Eighty-eight undergraduate students (men and women) were divided into four groups of 22 Ss each. They were trained using a regular pattern of events--two negative trials followed by one positive trial. The apparatus consisted of a partition which obscured the subject's view of the experimenter, and a tray which could be pushed toward or drawn away from the subject. In the tray was placed a well covered with a lid, and in this well (under the lid), a piece of green velvet cloth could be placed. The subject was to guess whether

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[46] See (93), p. 107.

the piece of cloth was under the lid or not.[47] The four groups were given either 12, 24, 48, or 60 acquisition trials. The criterion of acquisition was seven consecutive correct responses in which case the subject was considered a "learner." Immediately following the last acquisition trial, extinction was begun, i.e., all trials were negative. The criterion of extinction was 8 consecutive negative responses. The results of the experiment revealed that "nonlearners" were considerably more resistant to extinction than "learners." Speed of learning, however, was not offered as the reason for this reduction in resistance to extinction. It was suggested that resistance to extinction was reduced by increased training only if such training included overlearning trials. The theoretical explanation follows from Reid's demonstration: Learning more than the specific stimulus requires a fairly large amount of overtraining in the original situation to help build the habit strength necessary for discrimination.

When viewed together, the results of Murillo and Capaldi (84) and of Williams (121) suggest that a ∩-shaped function describes the relationship between amount of training and resistance to extinction. Senko, Champ, and Capaldi (98) tested this functional relationship. The same apparatus and instructions were used as in the study of Murillo and Capaldi (84). One hundred forty-four (undergraduate men and women) Ss were assigned to 8 groups (18 Ss in each). Each group received 0, 1, 3, 6, 12, 20, 40, or 80 100% reinforced acquisition trials immediately followed by 20 extinction trials.

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[47]The trial that included the cloth in the well was considered to be the positive trial. Absence of the cloth from the well on a certain trial made the trial negative.

The analysis indicated that resistance to extinction increased significantly from the 0- to the 1-trial group, decreased significantly from the 6- to the 12-trial group, and the difference between the 20- and 40-trial groups was not very reliable. The statistical findings certainly supported the ∩-shaped functional relationship hypothesis.

If, as was concluded in the Murillo and Capaldi study (84), that reduced resistance to extinction occurred only after the event pattern was well learned, then how can one explain the reduction in resistance to extinction in this study beginning with the 6-trial group? The explanation for the discrepancy might well hinge upon the difference in the two schedules of reinforcement used in both experiments (33-1/3 % vs. 100%).

The study by Grant and Schipper (39) implies that the ∩-shaped functional relationship between amount of training and resistance to extinction is the result of two processes--reinforcement and discriminability of extinction. If true, this in turn argues Lewis (74), can imply that the point of inflection (i.e., the peak) of the ∩-shaped curve would need to vary with the degree of learning. During the first few acquisition trials, only the reinforcement is in operation and extinction at this point would result in relatively greater resistance to extinction for the 100% reinforced responses. At a later stage of acquisition, however, when both processes are in operation, the peak of the ∩-shaped function is reached. And finally, when the discrimination process takes over, the greatest resistance to extinction will occur under the low partial reinforcement schedules. Lewis and Duncan (76) using 3 to 21 acquisition trials, found no interaction between number of

acquisition trials and percentage of reinforcement during extinction. The larger number of acquisition trials, however, resulted in faster extinction.

Basing his argument on the assumption that the results of Grant and Schipper (39) and Lewis and Duncan (76) might not be reliable due to the allegedly few trials used, Bacon (1) studied the relationship between degree of acquisition training and the partial reinforcement effect using a wide range of number of acquisition trials. Ninety-six albino rats (of the Sprague-Dawley strain) were randomly assigned to sixteen experimental groups (six Ss each). The sixteen groups resulted from four acquisition levels (10, 30, 100, and 300 trials) combined factorially with four percentages of reinforcement[48] (30, 50, 70, and 100).

The apparatus consisted of a right-turn L-shaped alleyway. Following pretraining, the subjects were given 10 acquisition trials per day with the appropriate percentage of reinforcement, (an intertrial interval of one minute) until the appropriate number of acquisition trials was completed. A day after the completion of the acquisition phase, extinction began. There were thirty extinction trials given over three days.

The results were expressed in terms of running and licking speeds.[49] They showed that, during acquisition, the animals ran faster after more training, and in general licked at a faster rate after more acquisition trials and under a higher schedule of reinforcement. The 100- and 300-

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[48]Reinforcement was in the form of 1% saccharine permitted on a drinking tube.

[49]Starting speeds were essentially the same as running speeds.

trial groups were not any statistically different. If, during extinction, resistance to extinction is defined in terms of mean running speed, then the results are in support of the "reinforcement-discrimination" hypothesis of Grant and Schipper. If, on the other hand, resistance to extinction is defined as the rate of decrease in running speed, and if performance by the animals is above the operant level,[50] then regardless of the number of acquisition trials, resistance to extinction bears an inverse relationship with the percentage of reinforcement.

The discrepancy caused by the two resistance-to-extinction definitions can be attributed to the failure of the mean-running-speed to take into account the terminal acquisition running speed.[51]

Level of acquisition and resistance to extinction have been shown to be monotonically related.[52] King, Wood, and Butcher (70), however, report an inverse (non-monotonic) relationship between the number of reinforcements and resistance to extinction when three groups of pigeons (5 in each) received 300, 600, or 900 continuous reinforcements of a key-peck response in a Skinner box. In this study, as in an experiment by D'Amato, Schiff, and Jagoda (25), acquisition training was carried to 1600 reinforcements. It was hypothesized (a) that under non-discriminative training, the monotonic relationship between acquisition level and resistance to extinction would prevail; and (b) that under discrimination

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[50] According to Logan (137), rats in a runway situation do not reach a stable operant level until after at least 40 non-rewarded trials.

[51] The timers in the 67 inch long alley were situated at only 3 inches and 45 inches from the start box.

[52] See (43), for example. Note that the number of reinforced responses here was carried up to 360 only.

training, a significant decline in resistance to extinction with prolonged acquisition training, would be expected. Four groups of 53-94-day-old naive albino rats (approximately 12 in each) underwent simple (nondiscriminative) instrumental training (in the presence of a bright light) and were allowed 200, 400, 800, or 1600 reinforced responses (50 per day). The same numbers of reinforced responses were given to four corresponding groups which were trained on a successive brightness discrimination problem.[53] All groups were exposed to a five day extinction period (10 minutes each day in the intense light). The results of the trend analysis supported the hypothesis.

Hill and Spear (47) compared extinction after five different acquisition levels with both continuous and partial reinforcement. Ten groups (10 Ss each) of naive female albino rats (of the Sprague-Dawley strain trained in an enclosed straight runway) were given (8, 50%), (8, 100%),(16, 50%), (16, 100%), (32, 50%), (32, 100%), (64, 50%), (64, 100%), (128, 50%), and (128, 100%) training trials and reinforcement respectively. Acquisition was completed in one day for the groups receiving 8, 16, or 32 trials and 32 trials per day were given to the other groups until completion of training.

During extinction, 28 trials were given on the day following the last day of acquisition and 12 trials on the ensuing day. The intertrial interval in both acquisition and extinction phases was 30 seconds.

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[53]Successive brightness involved the alternation of S^D periods (45 seconds of the bright light) and S^Δ periods (varying between 33 and 65 seconds of dim light). In other words, the procedure employed with the discrimination group differed only in the insertion of occasional S^Δ periods.

The acquisition curve indicated that the 100% group ran faster early in acquisition and the 50% group ran faster later in acquisition. However, the results were not statistically significant. During extinction, the partial reinforcement effect was present but weak. Groups with more training started at a higher level but dropped more rapidly. In the 100% condition, the groups seemed to reach a common asymptote while in the 50% condition the initial differences were, to a certain extent, preserved.

The findings of this experiment tend to support the view that resistance to extinction bears a direct relationship with the number of acquisition trials.

The marked discrepancy between the results of North and Stimmel (86) and Hill and Spear (47) might be attributed to many reasons among which are: (a) the relative spacing of trials (20-40 minutes) in the former study compared to 20 seconds in the latter; (b) the difference in the daily food rations; and (c) the difference (perhaps)[54] in the magnitude of the rewards.

Extinction of the eyelid CR as a function of the number of acquisition trials was studied by Spence, Rutledge, and Talbott (105). One hundred Ss (men from an introductory course in psychology) provided four equal groups (IA, IB, IIA, and IIB). An acquisition trial involved the paired presentation of the CS[55] and UCS[56] with a 500-m sec.

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[54]The magnitude of the reward was not reported by North and Stimmel (86).

[55]The conditioned stimulus consisted of a tone 70 decibels in intensity.

[56]The unconditioned stimulus was an air puff of 2 psi (pounds per square inch) applied to the right eye.

(milli-second) interval between them. The intertrial interval averaged about 20 seconds. The experiment was conducted in two phases. Phase 1 consisted of giving Groups IA and IB 32 acquisition trials and IIA and IIB 64 acquisition trials. With no break in the continuity of the experiment, and immediately after the last acquisition trials, Phase 2 started. In this phase, Groups IA and IIA received 40 extinction trials in the absence of the UCS, while Groups IB and IIB received the same number of extinction trials with a 2500-m sec. interval[57] between the CS and the UCS. The extinction curves of these groups revealed a marked drop in response strength as a result of the shift to non-reinforcement, i.e., absence or delay of the UCS. The statistical results indicated that extinction was significantly and positively related to the number of acquisition trials. There was no significant difference in the rate of extinction between the groups extinguished in the absence of the UCS and those extinguished in its presence. This finding is in agreement with that of Reynolds (96). The significance of the relationship between extinction and number of acquisition trials was interpreted by the "Discrimination Hypothesis" using the concept of set.

Siegel and Wagner (103) (using an enclosed straight runway) evaluated the importance of age, amount of handling, and length of deprivation time schedule (before extinction) in a study of the effects of overlearning upon resistance to extinction. Forty-four 90-110-day-old naive male albino rats were divided into 3 groups. Group I consisted

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[57]The extended 2500- m sec. interval was used to test McAllister's (80) finding--that the level of conditioning varies with the CS-UCS interval. McAllister (80) claims that with a CS-UCS interval of 2500- m sec. conditions might be negligible (see (80), p. 422).

of 14 rats while 15 rats were assigned to each of Groups II and III. After 5 days of habituation, Group I received 184 acquisition trials while Groups II and III each received 64 acquisition trials. Groups I and II began acquisition training at the same time (i.e., the day following habituation), which makes them differ (prior to extinction) not only in the number of acquisition trials prior to extinction, but also in age, amount of handling, and time of deprivation. Group III was not started on runway training until Group I completed 120 acquisition trials. This helped equate Groups I and III with respect to age and length of deprivation time. An attempt was also made to equate the amount of handling in the two groups. While Groups I and II, therefore, differed in the number of acquisition trials as well as the three variables, Groups I and III differed only in the number of acquisition trials. The results showed that (a) resistance to extinction decreased with extended acquisition (corroborating previous findings by North and Stimmel (86)), and (b) the overlearning effect cannot be attributed to the variables of age,[58] handling, and deprivation.

"There is an indication" says Birch (2), "that the extended training extinction effect is more likely to be observed under a series of spaced extinction days than it is under a single day of massed extinction" (p. 315). To pursue this point, a 2 x 2 experimental design was employed consisting of two levels of acquisition (60 or 190 trials), and two

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[58] Kass (66) using 4-, 6-, 8-, and 11- year old children to determine the effect of age on resistance to extinction reported significant differences only between Ss at 4 and Ss at higher chronological age levels. This finding was explained in terms of developmental changes in the length of attention span (see (66), p. 251).

different extinction inter-trial intervals (24 hours and approximately 1 minute). Twelve 90-day-old naive male rats went into each of the 4 cells. The apparatus was an enclosed straight alley.

During acquisition training, five trials per day were given on the first 2 days and 10 per day thereafter. The inter-trial interval was about 1 minute. Extinction occurred with the food cup in the appropriate place but empty. Each subject received 16 extinction trials. In massed extinction, five trials were given per day with an inter-trial interval of 1 minute. Spaced extinction, on the other hand, was administered at one trial a day. It must be noted that a period of 48 to 72 hours separated blocks of five extinction trials in both massed and spaced situations. This allowed comparison of the training groups in terms of "temporary" extinction (existing within the sets of five trials) and "permanent" extinction (existing after the occurrence of spontaneous recovery).

Judging from the post-recovery mean response speed, the results showed that the 190 acquisition trials led to faster extinction than the 60 acquisition trials regardless of the extinction inter-trial interval. Under massed training, while there was a decrement decrease (in mean response speed within a 5-trial block) following 60 acquisition trials, there appeared to be an increase in decrement following 190 trials. The results were interpreted by the "Frustrative Non-reward" hypothesis.

If, under identical patterns of partial reinforcement, two groups of rats were given inter-trial reinforcement in such a way that in one case the inter-trial reinforcement followed a non-reinforced trial and preceded a reinforced trial (G1) and in the other case just followed a

reinforced trial regardless of what type of trial it preceded (G2), and if those two groups could be compared with a third one all the members of which received full reinforcement (G3), then one might expect (if inter-trial reinforcement interferes with the after-effect of non-reinforcement) that (G1) would not be more resistant to extinction than (G3). This is because stimuli characteristic of non-reinforcement in (G1) will not be allowed to become conditioned to the instrumental response, and this is exactly what happens in (G3). In (G2), where the inter-trial reinforcement may be given after a reinforced trial, the stimuli characteristic of extinction may be allowed to become conditioned to the instrumental response and, therefore, could resemble those of a typical partial reinforcement situation.

Using a straight alley runway, 12 subjects (100-day-old naive albino rats) in each of G1, G2, and G3, Capaldi, Hart, and Stanley (15) verified this expectation and consequently lent great support to the "Hull-Sheffield" hypothesis.

While only 30 training trials were given to G1, G2, and G3 (10 trials per day) by Capaldi et al. (15), Black and Spence (6), in a comparable study, extended the acquisition trials to 96 (8 trials per day for 12 days). The results of their experiment differed from those of Capaldi et al. (15). Unlike the findings of the latter study, the groups corresponding to G1 and G2 (i.e., the partially reinforced groups) behaved alike and were both more resistant to extinction than the continuously reinforced group corresponding to G3. This finding was interpreted by a modified[59] version of the "Hull-Sheffield" hypothesis

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[59]Capaldi modified the Hull-Sheffield hypothesis by assuming that a particular after-effect will persist indefinitely until replaced by another different after-effect (see (6), p. 559).

and the "Frustrative-Non-reward" hypothesis of Amsel, Wagner, and Spence (see footnote 93).

A study by Hergenhahn (45) examines three hypotheses:

1. After minimal training there is little or no difference in resistance to extinction between two groups having received 50% and 80% reinforcement.
2. After criterion level training the 50% reinforced group shows more resistance to extinction than the 80% reinforced group, and
3. After overtraining, both the 50% and 80% groups show reduced resistance to extinction.

In this experiment, subjects guessed whether or not a square would appear on a card. Depending on the group assignment the square appeared on 50% or 80% of the cards, and subjects received 10, 30, or 60 trials. Combining these two factors, the experimental design, therefore, included six groups. The criterion for extinction was 10 consecutive guesses of "no square." The results, though statistically non-significant, tended to confirm the first hypothesis. The second hypothesis was not confirmed; instead the 50% group extinguished faster. The third hypothesis was partially confirmed since there was a tendency for the 80% group to extinguish faster than the 50% group.

The confirmation of Hypotheses 1 and 3 can best be interpreted by the "Discrimination" hypothesis; and while Hypothesis 2 could have been predicted by the stimulus-response learning theories,[60] these theories

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[60] See footnote 12.

would fail to explain why the partial reinforcement effect which should have taken place under the present circumstances did not do so.

In their review of the pertinent literature, Jenkins and Stanley (63) arrived at the following empirical generalization: "All other things equal, resistance to extinction after partial reinforcement is greater than that after continuous reinforcement when behavior strength is measured in terms of single responses" (p. 222).

Ten years of additional extensive research in this area reviewed by Lewis (74) revealed that "this generalization still stands perhaps more firmly than ever" (p. 2). This conclusion, though supported by Lewis and Duncan's (76) study using human Ss, was not shared by Capaldi's (11) using rats; although resistance to extinction in the latter was reduced in the case of the alternating pattern. The discrepancy can be attributed to the fact that "Capaldi may not have given a sufficient[61] number of acquisition trials to decrease resistance for his irregularly rewarded group. Also, he presents no evidence that his groups were equal at the end of acquisition" (p. 8).

Aware of Lewis and Duncan's (76) criticism of Capaldi's (11) work, McCain, Lee, and Powell (81) studied the effects of overtraining upon resistance to extinction in the partial-reinforcement situation.

Two groups of ten and eleven 90-day-old naive rats respectively were trained in a straight alley closed maze with two L-shaped goal boxes. A cup of wet mash was placed in one goal box while an empty cup

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[61] A sufficient number of acquisition trials helps "establish a stable stimulus pattern; the more acquisition trials the stabler the pattern, and when extinction begins, the stimulus change will be greater" (see (74), p. 8).

was placed in the other. Prior to extinction, Group I received 60 trials and Group II received 200 trials. Both groups received 50% reinforcement. The subject (S) was first placed in the start-box. When S faced the start-box door, the door was raised, actuating a timer. As S crossed the treadle[62] which stopped the timer, a guillotine door was inserted to prevent retracing. When S failed to cross the treadle in 60 seconds it was guided to the goal-box, where it remained for 15 seconds on both reinforced and non-reinforced trials. S was then removed from the goal-box and placed on a waiting stand for a 15-second inter-trial interval. Three consecutive 60-second trials determined the criterion for extinction. The results indicated (1) that Group II extinguished[63] more rapidly than Group I, and (2) that significantly more Ss ran faster on trials following non-reinforcement than reinforcement.

The theoretical interpretation supported neither the "Discrimination" nor the "Frustration" hypotheses. The critical factor in resistance to extinction may be dependent upon the predictive quality of some cues instead of the percentage of reinforcement.

One hundred forty-four naive male albino rats (150-700 gms. in weight) were trained by Uhl and Young (114) in a modified Skinner box for sucrose reinforcement. A 3 x 3 x 3 factorial design included (a) 25-, 50-, and 75% partial reinforcement, (b) 13.5-, 27-, and 48% sucrose concentration, and (c) 90, 180, and 360 non-reinforced trials.

The results indicated that the total of responses during extinction was a positive linear function of the number of non-reinforced trials

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[62]The treadle covered the last 7½ inches of the runway.

[63]Based on median running times in blocks of 10 trials.

during acquisition. This could imply "that non-reinforcement is responsible for learned reactions in acquisition which transfer to conditions of extinction, and the PRE is a result of such transfer of training."[64]

Prolonged training reduced resistance to extinction.[65] This reduction resulted because subjects had a better chance of detecting reinforcement patterns during acquisition. When Capaldi (11) used Gellermann orders thus eliminating a perceived or discriminable pattern of reinforcement, extinction took relatively longer. This finding may mean that any factors that tend to improve the chances of detecting a pattern of reinforcement during acquisition, i.e., make it more discernible, would enhance the rate with which extinction takes place. Restle[66] claims that Ss given a high percentage of reinforcement learn to discriminate faster than those receiving a relatively low percentage of reinforcement. Hergenhahn and Potts (46) tested Restle's claim. Their experiment consisted of showing students 3- x 5-inch cards. A 1½-inch black square appeared on 40 cards while 35 cards were blank. Three experimental groups (10 students each) were given 50 training trials before extinction. For Group I, cards with and without squares were randomized in blocks of 10, and squares appeared on only 50% of

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[64] C. N. Uhl and A. G. Young, "Resistance to Extinction as a Function of Incentive, Percentage of Reinforcement, and Number of Non-Reinforced Trials," Journal of Experimental Psychology, 1967, 73, p. 564.

[65] See Hill and Spear (47), for example.

[66] See equations (19) and (8) (in this order) on pages 186 and 184 respectively of Restle (95).

the trials. Similarly, for Group II squares appeared on 80% of the trials. For Group III, however, squares appeared on 50% of the trials but alternated with the blank cards. Analysis indicated that the means differed significantly. Group III showed the least resistance to extinction compared to Group I which exhibited maximum resistance. The theoretical interpretation tends to support the "Discrimination" hypothesis and Restle's prediction.

Kass and Wilson (67) investigated resistance to extinction in a free operant situation as a function of percentage of reinforcement, number of training trials, and the presence or absence of a conditioned reinforcer. The apparatus simulated a slot machine with the addition of two red lamps mounted behind the upper half of a plastic dome. The lower half of the dome contained a large number of pennies. Displayed by two pegboards were a number of prizes that the subject could buy with the pennies he would win. Three hundred twenty elementary school children (6.2 - 7.8 years old) evenly divided by sex were randomly assigned (by sex) to the 20 cells of a 2 x 2 x 5 experimental design. The design employed (a) 16 Ss per cell, half of whom received a light stimulus during acquisition and extinction, and half received no light stimulus during both phases; (b) two schedules of reinforcement--100% and 33-1/3% (random); and (c) 3, 9, 21, 45, or 60 training trials. The first "2" of the design, therefore, represented "light" and "no light" or presence and absence of conditioned reinforcer; the second "2", the two schedules of reinforcement; and the "5", the five different numbers of training trials. Each S was allowed to play as long as he wanted provided he did not exceed 20 minutes or 400 trials. The finding of the study indicated that there

was statistical significance associated with the number of acquisition trials and percentage of reinforcement but no significant difference associated with the presence or absence of the conditioned reinforcer.[67] Resistance to extinction was inversely related to number of acquisition trials, with the 100% group extinguishing more rapidly.

The results can be explained in terms of the "Discrimination Theory." Maximum dissimilarity between training and testing was experienced by the group which received 60 reinforced acquisition trials. Minimum dissimilarity (maximum similarity), on the other hand, was experienced by those who received three training trials on the partial (33-1/3%) schedule.

Effects of Inter-trial Interval on Acquisition and/or Resistance to Extinction

"Yet another important factor in determining the rate of experimental extinction is the length of the pause between successive repetitions of the stimulus without reinforcement. The shorter the pause the more quickly will extinction of the reflex be obtained, and in most instances a smaller number of repetitions will be required."[68] The index of the rate of extinction as defined by Pavlov is the time elapsing between the start and end of the extinction trials.

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[67] In a 2 x 2 factorial design by Grossen (41) twenty-five 90-day-old naive male rats were given either 117 or 36 trials on either a patterned or unpatterned partial reinforcement schedule in a multiple runway. Analysis revealed that longer training significantly increased resistance to extinction for the unpatterned group but decreased it for the patterned group.

[68] I. P. Pavlov, Conditioned Reflexes. (Translated by G. V. Anrep), Oxford University Press, 1927, p. 52.

Guthrie claims (thus challenging Pavlov's theory) that the number of non-reinforced elicitations rather than the length of the inter-stimulation interval was the key factor in determining extinction. He argues that one is able to explain experimental extinction in terms of general conditioning theory. In Guthrie's opinion, the conditioned response is extinguished because the unconditioned stimulus is removed. In the absence of the unconditioned stimulus, the conditioned stimulus tends to become attached to other reactions occurring in response to extraneous stimulation.[69] Porter (90) tested Pavlov's theory by testing the effect of varying the length of the interval between successive non-reinforced conditioned stimuli upon the extinction of the conditioned eyelid responses. Thirty-nine adult human subjects participated in the experiment. Each subject received 75 training trials.[70] Fifty of these trials were given during the first session of the experiment while the remaining 25 trials were given 24 hours later. The interval between the onset of the CS and that of the UCS was held at 500 milliseconds. At the completion of the 75th trial each subject was randomly assigned to one of five extinction groups. During extinction the inter-stimulus intervals of these groups were 10, 20, 40, 80 and 180 seconds. The extinction phase began 30 seconds after the last training trial, and the trials were continued until either the subject failed to respond to two successive stimulations or 15 such presentations had been made. The results showed that the number of stimulations required to secure extinction of the CR is independent of the length of the inter-stimulus

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[69] See (90), p. 111.

[70] A trial consisted of the paired presentation of a visual (light) stimulus (conditioned stimulus) and a puff of air directed against the cornea of the left eye (unconditioned stimulus).

interval, thus not supporting Pavlov's position.

Humphreys et al. (59) studied the verbal expectations of three groups of 152, 50, and 67 college students respectively. The apparatus consisted of a circular vertical board 3 feet in diameter. Two lights (one red and one green) of equal intensity (60 watts) were placed on the extreme right and left sides of the board respectively. The lights were manipulated by switches behind the board and out of sight of the subjects. This apparatus served as an analogue to a conditioning experiment. After a signal, the left light (CS) was always turned on and, sometimes, followed (after 5 seconds) by the right light (UCS). The subjects were to guess whether or not the right light was to follow the left light. Their guesses, therefore, could be taken to represent the conditioned responses. Group I received 24 acquisition trials followed immediately by 24 extinction trials (1st extinction). After a 30-minute recovery interval the group received 20 more extinction trials (2nd extinction). All trials occurred at a 5-second rate. For Group II, conditions were the same as for Group I differing in the recovery interval which was set at 4 minutes. All trials occurred at a 10-second rate.

Group III received 24 acquisition trials which were followed by 15 extinction trials. There was no recovery period allowed for this group and all trials occurred at a 20-second rate. The results indicated (1) that there were no differences in the rate of acquisition and extinction of verbal expectations resulting from variation of the intertrial interval, and (2) that, although spontaneous recovery of verbal expectations did occur (within the limits of the time intervals used)

there was no evidence of progressive recovery.

It was pointed out that the progressive nature of spontaneous recovery in conditioning experiments is due to "decremental" rather than "expectancy" factors.[71]

Two experiments were performed by Gagné (33) to determine the effect of inter-trial spacing on the rate of acquisition and extinction of a conditioned operant response.[72] The response was measured in terms of the latent period--the time required by the rat to leave the starting box once the door is opened.

In the first experiment, six groups of white rats (8 rats in each) were given fifteen acquisition and five extinction trials. The trials in the first group were spaced at 1/2 minute, in the second at 1 minute, in the third at 2 minutes, in the fourth at 3 minutes, in the fifth at 5 minutes, and in the sixth at 10 minutes. The UCS was a pellet of food the weight of which was kept constant throughout the experiment. As the inter-trial interval increased the rate of acquisition decreased at first and then increased. The curves appeared to be approaching different limits. The extinction curves for the 1/2- and 1-minute groups exhibited significant depressions on the 2nd trial, beyond which these groups exhibited a faster rate than those of the long-interval groups.

In the second experiment five groups of twelve white rats each were given 8 acquisition and 5 extinction trials. The trials for the

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[71]Decremental and expectancy refer to those factors which are related to performance and learning respectively.

[72]The conditioned response was taken to be the running of rats from a starting box on one end of a three-foot elevated runway to a food box at the other end.

groups were spaced at intervals of 1/2, 1, 2, 3, and 5 minutes respectively. The subject was allowed to eat throughout the whole period (between trials) spent in the food box.[73]

The results indicate that as the inter-trial interval increased the rate of acquisition decreased. On the fourth trial of acquisition, differences between the points on any two non-adjacent curves were significant.

The extinction curves for the shortest-interval groups again exhibited a depression on the 2nd trial. The extinction curves seemed to approach different limiting latent period values. As the inter-trial interval increased, the limiting value for the extinction curve decreased.

A theoretical interpretation was given in terms of the concept of excitation and inhibition. In Experiment I, the "average stimulating effect"[74] of the unconditioned stimulus was cut to approximately one-half in progressing from the 1/2-minute to the 1-minute interval, to one-quarter in the 2-minute interval to one-sixth in the 3-minute interval, etc. . . . The effectiveness of the unconditioned stimulus, therefore, was sharply decreased at first, and then less and less sharply as the inter-trial interval was increased. One might expect the response strength to vary more between groups whose acquisition is measured at the 1/2-minute and 1-minute intervals than between groups whose acquisition is measured at the 5- and 10-minute intervals.

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[73]Allowing the rat to eat during the time spent in the food box was intended to "spread" reinforcement throughout the interval between trials (see (33), p. 215).

[74]Average stimulating effect of an unconditioned stimulus = amount of food/interval between trials (see (33), p. 203).

Another effect resulting from increasing the inter-trial interval is the dissipation of inhibition and the occurrence of spontaneous recovery, which tend to work against each other. Beyond the 2-minute interval, inhibition becomes replaced by spontaneous recovery which manifests itself in the form of increased rate of acquisition.

In Experiment II the "stimulating effect" of the UCS was kept constant by allowing the animal to eat throughout the interval spent in the food box. Therefore, increasing the inter-trial interval had only allowed more strength of response. This effect is revealed as an increased rate of acquisition for the groups with the longer inter-trial intervals.

In an experiment by Sheffield (100), 72 rats were trained to run down an alley for food. During training, half received reinforcement on every trial (100 percent) and half "randomly"[75] on 50% of the trials. Half of each group were trained with a 15-second inter-trial interval (massed) and half with a 15-minute interval (spaced). Each of the four training groups was divided for extinction, half were being extinguished with the 15-second interval and half with the 15-minute interval. In schematic form the design looked like this:

	Massed Training (15-sec. intervals)		Spaced Training (15-min. intervals)	
	Massed Extinction	Spaced Extinction	Massed Extinction	Spaced Extinction
100% Reinforcement	100%MM (9) A	100%MS (9) B	100%SM (9) C	100%SS (9) D

[75]The distribution of 15 reinforcements and 15 non-reinforcements in 30 training trials was as follows: (1) Five isolated single reinforcements and four isolated single non-reinforcements. (2) Two "two successive" reinforcements and two "two successive" non-reinforcements. (3) Two "three successive" reinforcements. (4) One "three successive" non-reinforcements and one "four successive" non-reinforcements.

	Massed Training (15-sec. intervals)		Spaced Training (15-min. intervals)	
	Massed Extinction	Spaced Extinction	Massed Extinction	Spaced Extinction
50% Reinforcement	50%MM (9) E	50%MS (9) F	50%SM (9) G	50%SS (9) H

Ten pre-training trials were given on the first day; 30 training trials on the second; and 30 extinction trials on the third. The results were as follows:

1. Performance on the last half of the acquisition trials by all four groups--100% reinforced, 50% reinforced, massed, and spaced was equivalent.
2. Groups A and B extinguished much faster than E and F. (After massed training, resistance to extinction was significantly lower for the 100% reinforced groups than for the 50% reinforced groups).
3. There was no significant difference in resistance to extinction between Groups (C & D) and (G & H). (After spaced training, the difference in resistance to extinction between the 100- and 50-percent reinforced groups was not significant). However,
4. a differential effect of partial reinforcement was found to be significant regardless of whether the training was massed or spaced. The results support the "stimulus-generalization" theory in explaining the effect of partial reinforcement on extinction.

Not only is there a relationship between rate of extinction and

the distribution of learning trials, but also between rate of extinction and the distribution of extinction trials. Seventy-two 90-day-old male albino rats were trained to run down an alley for food. Half were given 30 training trials with a 15-second inter-trial interval (massed) and half 30 training trials with a 15-minute interval (spaced). Each of these two training groups was divided for extinction, half being extinguished with the 15-second interval and half with the 15-minute interval. There were 30 extinction trials. The time to traverse the alley was the measure of the strength of response. Hence, Sheffield (101) reports that the rate of extinction was significantly higher when extinction was spaced than when extinction was massed. She also points out that, while spaced extinction was significantly faster after massed training, the difference, though in the same direction, was not significant after spaced training. Increased motivation resulting from the frustration produced by non-reinforcement might be an explanation for such results.

Verbal expectation of 184 college students (from elementary psychology classes) were studied by Grant, Hornseth, and Hake (37) using Humphrey's technique.[76] The trifactorial experimental design investigated (1) the effects of the inter-trial interval during acquisition, (2) the effects of the inter-trial interval during extinction, and (3) the partial reinforcement effect comparing 100% reinforcement with 50% reinforcement. The results were as follows:

1. The work of Humphreys, Miller, and Ellson (59) was corroborated,

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[76] See apparatus and instructions in (59).

2. A clear-cut "partial reinforcement effect"[77] was obtained, and
3. The inter-trial interval had no consistent effect upon acquisition, extinction, or the partial reinforcement phenomenon.

The interpretation of this study was in terms of non-decremental or verbal factors as opposed to decremental[78] factors suggested by Humphreys et al. (59).

Stanley (107) sought to determine the effect of the spacing variable on the resistance to extinction by providing a situation where measures of vigor and correct response are available. In the first part of his experiment, extinction was by frustrating omission of food; in the second part, extinction was by non-frustrating removal of a primary drive--hunger. Forty male albino rats were used in Part I and sixty-four in Part II of the study. The apparatus was a T-maze. Electric timers controlled by the movement of hinged floors gave three response time scores: (1) starting time, i.e., the time elapsed between raising of the starting door and the S's entry into the stem, (2) time required to reach the choice point (including the starting time), and (3) total time elapsed until S reaches either goal box. The experimental design in Parts I and II resembled that of Sheffield's (100).

In Part I, the results indicated that when running time to either goal box (a measure of vigor or performance) is considered, spaced extinction was faster; however, when viewed with respect to number of correct runs to the previously rewarding goal box (a measure of the acquired habit), then massed extinction was more rapid. No theoretical explanation of the

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[77]Partial reinforcement as opposed to full reinforcement lowers the rate of acquisition but raises the resistance to extinction.

[78]See footnote 71.

results was given in view of the complex manner in which the motivating effects of frustration-produced drive and the reinforcement effects of its reduction interacted.

In Part II, there was no difference between massed and spaced extinction in terms of either measure score. The theoretical interpretation utilized Guthrie's "interference-by-new-learning"[79] extinction theory to explain the results of Part II. Those results were in accord with the expectation from Pavlov's theory of "internal inhibition" or Hull's theory of "reactive inhibition." It can, therefore, be concluded that generalization decrement is produced by shifting from one inter-trial interval during acquisition to another during extinction, a result contesting theories which assume that response decrement during extinction is a direct function of internal inhibition which dissipates with time.

Teichner (110) throws additional light on the relationship between the rate of extinction and (a) the inter-trial interval during learning of the response, and (b) the inter-trial interval in the extinction series. The study was conducted in two instrumental learning experiments. Each experiment involved the training of a group of 90-110-day-old male hooded rats with a single inter-trial interval and then subjecting subgroups of these Ss to experimental extinction using different inter-trial intervals. The results were as follows:

1. The longer the inter-trial interval the faster was the acquisition of the response strength.
2. Resistance to extinction was greater when the inter-trial

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[79] According to Guthrie, extinction always occurs through the learning of an incompatible response (see (132), p. 79).

intervals during conditioning and extinction were the same than when the inter-trial intervals were different.

3. Other things being equal, massed extinction was faster than spaced extinction.

A theoretical interpretation was possible when an appeal was made to Hull's theory of reactive inhibition (I_R). Reactive inhibition accumulates with the making of each response and dissipates in the time between responses. This intervening variable tends to depress response strength. With long inter-trial intervals greater amounts of inhibition should dissipate, and therefore, under such conditions, acquisition should be relatively rapid and extinction relatively slow.[80]

Is it to be expected that different species in different response systems should react differently to massing or spacing of acquisition trials? Sheffield (100, p. 523) claims that the hypothesis that can predict rat behavior in a runway should also predict the course of response in Humphreys' experiment (54). Grant, Schipper, and Ross (40) tested the implication of Sheffield's interpretation that the Humphreys' random-reinforcement effect in human eyelid conditioning is somewhat diminished with 50% spaced random reinforcement. The experimental design was identical to that of Sheffield's (100). Seventy-two men and women students from inductory classes in psychology were randomly assigned to the eight

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[80]See (110), p. 176. Underwood (115) claims that distributed practice enhances learning only when interference occurs in the response-learning phase. Distributed practice allows for extinctions of error tendencies and the assumption is that distributed practice leads to a more effective elimination of the deleterious effects of interference than massed practice. If interference is very high and the interval too long, however, forgetting will occur and the recovery of error tendencies will block or replace the correct response (see (115) p. 245).

groups (nine Ss in each). All Ss were given 60 acquisition trials on the first day, 30 acquisition trials were also given on the second day followed by 30 extinction trials. On massed trials the interval ranged from 5 to 15 seconds, averaging about 10 seconds. On spaced trials the interval ranged from 40 to 50 seconds averaging about 45 seconds. The major findings were as follows:

1. During acquisition, there were significantly less CR's in the 50% reinforcement group than in the 100% reinforcement group.
2. Significantly less resistance to extinction was found following 100% and spaced reinforcement than following 50% and massed reinforcement.
3. Following partial reinforcement, the heightened resistance to extinction was significantly less for massed than for spaced extinction trials.
4. Massed extinction was significantly faster following spaced acquisition. Similarly, spaced extinction was significantly more rapid following massed acquisition.
5. Following partial reinforcement, the heightened resistance to extinction was significantly greater in spaced extinction if the reinforcement trials had been massed, and in massed extinction if the reinforcement had been spaced.

The stimulus-generalization interpretation given by Sheffield (100) can hardly be adequate to explain the results of this experiment. What is needed here, perhaps, is to rectify some of the assumptions, hypothesizing that different human mechanisms (verbal, optical, etc. . .) may result in relatively different after-effects of stimulation. A shift in the

distribution of trials (i.e., from massed reinforcement to spaced extinction or from spaced reinforcement to massed extinction) should heighten the discriminability of the change from the reinforcement procedure. Therefore, a shift in the distribution of trials should facilitate extinction for the 100% group. If, on the other hand, the greater resistance to extinction following partial reinforcement is due to the similarity between the partial-reinforcement and extinction procedures, then anything that heightens the discriminability of the change in schedule might very well reduce the partial reinforcement effect. The findings of Grant et al. (40) do not support this analysis. Hence, without utilizing additional concepts, one can say that neither the "Expectancy" nor the "Discrimination" hypotheses are also able to predict or interpret the results.

Lewis (73) contributes empirical evidence on the effect and interaction of (1) two (15-second and 2-minute) inter-trial intervals in acquisition, (2) two (50% and 100%) reinforcement schedules, (3) two (15-second and 2-minute) inter-trial intervals in extinction, and (4) four (1-, 5-, 10-, and 60-minute) postextinction delay intervals before a spontaneous recovery test. The experiment, therefore, followed a 2 x 2 x 2 x 4 factorial design.[81] It utilized seventy-one 75-90-day-old naive male albino rats in an alley-type runway with running time taken as the response measure. The Ss were given 30 acquisition trials and 20 extinction trials, followed by a spontaneous recovery trial after 1, 5, 10, or 60 minutes of delay. The results indicated that:

1. During acquisition, running times were significantly faster

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[81] Cell values were unequal but proportional.

for 100% reinforcement than for 50% reinforcement. During extinction, however, they were significantly faster following 50% reinforcement than following 100% reinforcement.

2. Massed acquisition (with the 15-second inter-trial interval) led to faster running times during extinction than did spaced acquisition (with the 2-minute inter-trial interval).
3. If followed by spaced extinction intervals, partial reinforcement led to significantly greater resistance to extinction than if followed by massed intervals.
4. There was no significant interaction between percentage of reinforcement and the acquisition interval.
5. Spontaneous recovery was a significant function of (varied inversely with) the post-extinction delay interval. It was significantly greater following massed than spaced acquisition.

Theories of extinction making use of an inhibition factor are said to require that massed extinction trials result in faster extinction than spaced. Lewis (73) found confirmation for this position, and on the basis of the "frustration-drive" theory,[82] he helped explain part of the findings of this study. It seems safe to conclude that while non-reinforcement does lead to frustration, the evidence is far from conclusive that this frustration affects running time.

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[82]"Frustration-drive" theory maintains that extinction increases the frustration-drive state of the organism, and that under massed extinction, the frustration-produced drive does not dissipate between trials.

In a supplementary report Katz et al. (68) tested the relationship between the development of differential response to alternating partial-reinforcement schedules and inter-trial interval. Thirty 79-day-old male albino rats were randomly assigned to three equal groups which received 9 trials a day in a runway for 30 days with inter-trial intervals of 1/4, 2 or 20 minutes. A sucrose solution was used as reinforcement. Non-reinforcement was accomplished by denying the subject access to the reinforcement. The median starting, running, and goal time measures indicated little differential responding in the 20-minute group. The 1/4-minute group, however, showed marked superiority in developing the differential response. The assumption that the after-effects of both reinforcement and non-reinforcement dissipate with time is clearly supported by the results of this study. One might argue, nevertheless, in favor of employing better controls for potential goal-box cues in a situation like this. The use of a sugar solution as a reinforcer, for example, might underestimate the duration of after-effects when food reinforcement is used.

Effects of Schedule and Pattern of Reinforcement on Acquisition and/or Resistance to Extinction

Increase in resistance to extinction following partial reinforcement has been demonstrated by Humphreys (55) using the conditioned eyelid response in humans. Sixty-six college students were divided into three groups. Group I received 100% reinforcement for 96 trials (a puff of air to the cornea always followed a light), and 24 extinction trials. Group II received 50% reinforcement for 96 trials (the air-puffs followed

the light randomly[83] on one-half of the trials), and 24 extinction trials. Group III received 100% reinforcement on only 48 trials (out of 96 trials); the remaining 48 trials were rest periods replacing (corresponding to) the non-reinforced trials of Group II. Group III, also, received 24 extinction trials.

The results indicate that differences in the acquisition of conditioned responses were not significant. There was a significant difference in the extinction of conditioned responses between Group II and Groups I and III, but not between Group I and Group III (Group II responded at a significantly higher level over the extinction trials than either Group I or Group III). Neither the acquisition nor the extinction results are in accord with the stimulus-response learning theories which stress the frequency of occurrence of reinforcement or non-reinforcement. The results, however, tend to support the expectancy hypothesis.

A study by Jenkins and Rigby (62) concerned itself with measuring resistance to extinction (of the bar-pressing habit in rats) after a schedule of partial reinforcement as compared with continuous reinforcement.

The results of the experiment indicated that (1) during conditioning the rate of responding was the highest for the continuously reinforced groups, and (2) the partial reinforcement groups (on the average) emitted far more responses during extinction than the continuously reinforced groups.

The present findings failed to support Humphreys'[84] argument that the number of trials rather than the number of reinforcements is the

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[83] No more than two trials of any one kind were given in succession, and in each group of 12 there were 6 reinforced and 6 non-reinforced trials.

[84] See p. 17.

important factor in influencing resistance to extinction. In the present case, 2400 continuous reinforcements yielded only 100 responses in extinction; compare this number with 129 responses produced during extinction by just 90 periodically administered reinforcements.

In an experiment by Grant, Hake, and Hornseth (36), five groups (A, B, C, D, E) of 37 Ss (men and women students from an introductory psychology class) each, were trained with 0, 25, 50, 75, and 100 percent reinforced trials respectively. The apparatus consisted of two electric (60-W) bulbs mounted on the left and right sides of a black-painted 4-ft. square upright board. An electronic timing device was arranged to produce a 3-second flash on the left bulb at the termination of which the right bulb could be actuated for a 0.5-second flash. The Ss were to guess on each trial, during the flash of the left bulb, whether the right bulb would or would not flash on. Positive reinforcement, therefore, was the onset of the right light. The inter-trial interval was 10 seconds[85] and the independent variable was the proportion of reinforced trials during training.

It was found that (during a 60-trial training series) all groups gradually emitted positive responses at about the same rate at which positive reinforcements were being given.[86] During the 30-trial extinction series, however, the rates of extinction varied inversely with the rates at which positive reinforcements were given during the training series;

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[85] According to Humphreys et al. (59), massing of trials has no effect on verbal conditioning phenomena.

[86] A similar result has been reported by Gardner (34). For situations involving more than two choices, response proportions were significantly different from presented proportions (see (34), p. 185 and (102), p. 349).

i.e., the 100 and 25 percent groups showed the most and least rapid rates of extinction respectively. All intergroup differences during acquisition and extinction showed statistical significance.

Grant and Schipper (39) investigated the effect of different percentages of fixed-ratio reinforcement upon the acquisition and extinction of the conditioned eyelid response. In this study, the UCS[87] was a corneal air-puff and the CS[88] was a light. Five groups (A, B, C, D, E) of 14 human subjects each were conditioned with 0%, 25%, 50%, 75%, and 100% reinforcement respectively. Each subject received 92 training trials and 25 extinction trials. The order of reinforced and non-reinforced trials was random.

The results indicated (a) that the percent frequency of CR's[89] during acquisition increased as the percentage of reinforcement increased, and (b) that during extinction the percent frequency of CR's was greatest in the 50% and 75% groups. When the number of CR's per reinforced trial (dependent variable) for both acquisition and extinction was plotted against percent groups (independent variable), however, both curves showed maximum values between 50 and 75 percent. Grant and Schipper indicated that the maximum resistance to extinction about 50-75% reinforcement is due to two factors: (1) the strength of response increases with

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[87] UCS ≡ unconditioned stimulus: Is one which always elicits or produces a reflex-like response (see (139), p. 83).

[88] CS ≡ conditioned stimulus: Is one which is neutral in the sense that it does not produce a marked response at the outset of an experiment. After pairing of the CS and UCS, the CS will come to elicit a response which is similar to, but usually not identical with, the unconditioned response (see (139), pp. 82-83).

[89] CR ≡ conditioned response: That response which is elicited by the CS (see (139), p. 83).

an increase in the number of reinforced trials, and (2) the ease of discriminating the occurrence of extinction is relatively greater if extinction follows a training period of higher percentage of reinforced trials.[90]

Wagner (116) investigated the acquisition and extinction of locomotor performance in various segments of a straight runway (consisting of an entry box, start box, alley, and goal box) as a function of percentage of reinforcement (50% or 100%), magnitude of reward (.08 gm. or 1.0 gm. of wet mash), and number of acquisition trials (16 or 60). Sixteen hooded rats were assigned to each of the eight groups in the 2 x 2 x 2 experimental design. The inter-trial interval (for both acquisition and extinction) was 24 hours. There were 33 extinction trials. The acquisition results indicated that performance levels (mean speed in ft/sec.) of the 100% and 50% groups depended not only on the number of trials but on the segment of the alley. Taken over the first and second six inches of the alley, the response measure showed an initial superiority for the 100% Ss but an asymptotic superiority for the 50% Ss. When the response measure was taken over the last six inches of the alley, however, the superiority of the 100% Ss prevailed. The extinction results showed that nowhere did the difference in extinction performance (expressed as a proportion of the mean speed attained on that response measure over the last four acquisition trials) between the 50% and 100% groups appear to vary with the number of acquisition trials.[91] The

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[90] It should be noted that the findings of this study differ from the findings of Grant et al. (36), discussed above.

[91] No variation in resistance to extinction due to change in amount of training was also reported by Wike (see (118), p. 260).

results reflected, nevertheless, not only greater resistance to extinction of partially reinforced Ss but also less resistance to extinction of continuously reinforced Ss following large than small rewards.

The theoretical interpretation of the previous results runs as follows: The occurrence of nonreward at a moment when the subject is expecting a reward causes the elicitation of a primary frustration reaction (R_F). . . . Fractional parts, i.e., secondary frustration reaction (r_f), of this primary frustration reaction become conditioned in the classical manner to stimuli (s_f) preceding its elicitation. Occurrence of this fractional response in anticipatory form is denoted by ($r_f - s_f$).[92] The cues, s_f, from anticipatory frustration are principally connected to avoidance responses but these connections can be modified through training.[93] During the prefrustration acquisition trials, continuous reinforcement should lead to a higher anticipatory reward ($r_g - s_g$) than partial reinforcement and, therefore, a higher level of responding. Postfrustration performance depends upon the relative degree of ($r_g - s_g$) superiority of continuous reinforcement as compared to the ($r_f - s_f$) drive level superiority of partial reinforcement, as well as upon the degree of conditioning of s_f (under partial reinforcement) to the approach response. The asymptotic superiority of the 50% group stems from the fact that not only did the approach response become conditioned to the early alley cues plus s_f but also that the ($r_f - s_f$) advantage of the 50% group was higher than the ($r_g - s_g$)

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[92]Called anticipatory frustration.

[93]This is a rough outline of the "Frustrative Nonreward Hypothesis" attributed mainly to Amsel, Wagner, and Spence (see (132) p. 488).

advantage of the 100% group. The superiority (close to the goal) of the 100% group over the 50% group can be explained, however, by the less effective conditioning of the approach response (in the 50% group) by the goal box cues plus s_f, and hence more persistence of competing responses elicited by s_f. At the start of extinction, $(r_g - s_g)$ would be greater with large than with small magnitude of reward and, therefore, due to increased motivation, larger rewards should lead to a slower rate of extinction in the 50% than in the 100% group. Faster rate of extinction in the continuous group is attributed to the stronger competing responses elicited by the more intense s_f.

In an experiment by Grant, Riopelle, and Hake (38), 60 human subjects (men and women from an elementary psychology class) were assigned in equal numbers to four groups. The apparatus was similar to that used in Grant and Schipper's (39). The CS was light. The UCS was a corneal air puff. The experimental procedures were as follows:

	Group I Single reinforcement alternation (SA)	Group II Double reinforcement alternation (DA)	Group III Random reinforcement alternation (R)	Group IV 100% spaced reinforcement (100S)
Day 1 (Acquisition)	50 trials-25 trials with light and puff, and 25 with light alone	50 trials-26 trials with light and puff, and 24 with light alone	50 trials-26 trials with light and puff, and 24 with light alone	26 trials (spaced) with light and puff.
Day 2 (Acquisition)	21 trials-11 with light and puff, and 10 with light alone	22 trials-12 with light and puff, and 10 with light alone	21 trials-11 with light and puff, and 10 with light alone	11 trials with light and puff

	Group I	Group II	Group III	Group IV
Day 2 (Extinction)	30 trials with light alone.	30 trials with light alone.	30 trials with light alone.	30 trials with light alone.

All eyelid closures with latencies averaging .35 seconds during acquisition and .45 seconds during extinction were considered to be CR's. The major findings indicated that:

1. During Day 1 acquisition, random reinforcement led to the greatest magnitude of CR's.
2. During both acquisition and extinction on the second day, random and 100% reinforcement led to higher CR's than either the single or double alternation.
3. The (SA) and (DA) groups portrayed a significant reversal of the extinction trend. The (R) group with a high level of response extinguished rapidly.
4. Despite the fact that most of the Ss were aware of the (SA) and (DA) patterns, there was little evidence of the CR's following such sequences either during acquisition or extinction.

The theoretical interpretation suggested that some inhibitory process (the nature of which cannot be specified) was present especially in the alternation groups. It also pointed out that the upward trend during extinction was due to CR's being suppressed in frequency and magnitude during reinforcement.

Sheffield (100) found that (after spaced training) there was no significant difference between the 100- and 50-percent reinforced groups. Since it is difficult to assume that the after-effects following the 15-minute inter-trial intervals are anything but negligible, argue Crum,

Brown, and Bitterman (23), the lack of a significant difference between the two groups suggests that there are factors other than stimulus-generalization that must be taken into account if the effect of partial reinforcement on resistance to extinction is to be fully understood.

Rats (of the Wistar strain) were trained to traverse a runway, one group receiving immediate reward on every trial, while a second group was rewarded immediately on half the trials, and (to eliminate the possibility of differential afferent after-effects) a 30-second delay of reinforcement was substituted for non-reinforcement on the remaining half. The results of the study indicated that under such a delayed condition of reinforcement resistance to extinction was significantly greater than that found following continuous and immediate reinforcement. The results suggest the importance of events that take place during the trials on which immediate reinforcement is not provided rather than those that follow them.

A careful attempt was made by Scott and Wike (97) to duplicate the work done by Crum, Brown, and Bitterman (23). The results of this investigation revealed that immediate reinforcement produced less resistance to extinction than partial delay of reinforcement--a fact that verified the previous finding of Crum et al..

To further test the stimulus-generalization theory, Longenecker, Krauskopf, and Bitterman (79) studied the extinction of a conditioned galvanic response of human subjects to shock following (a) 50% alternating reinforcement and (b) 50% random reinforcement.

Despite the parity in the levels of conditioning produced by the two conditions of reinforcement, the random group extinguished more

slowly than the alternating group.

This finding is undoubtedly the opposite of what is expected from the theory of stimulus-generalization.[94] It tends to support the theory of serial patterning.[95]

Tyler, Wortz, and Bitterman (112) trained two groups of 90-120-day-old naive albino rats (on a runway) under two conditions of 50% reinforcement (random and alternating).

The random group showed significantly greater resistance to extinction than the alternating group; a fact which again supports the concept of serial patterning and opposes predictions based on the theory of stimulus-generalization.

Grosslight, Hall, and Murnin (42) point out that the pattern in partial reinforcement (the arrangement of reinforcements and non-reinforcements in a sequence) has a tangible effect on resistance to extinction. A modification of the Humphreys (54) light expectancy procedure was employed with 172 students (of both sexes) from an elementary psychology class. The training period consisted of 33 trials, followed by 10 extinction trials. Three treatments consisted of (1) 100% reinforcement (RR), (2) partial reinforcement with non-reinforcement termination (RN), and (3) partial reinforcement with reinforcement termination (NR). The number of reinforcements in (2) and (3) was the same.

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[94] In the alternating group (since every reinforced trial follows an unreinforced trial), every reinforced response is made to an afferent compound that does not have the after-effects of reinforcement. In the random group, however, a number of reinforced responses are made to this compound while the after-effects of reinforcement are present.

[95] Rate of extinction is inversely related to the similarity between pattern of events in training and extinction.

The trial-by-trial analysis for the (NR) and (RN) groups (during training) showed no fundamental differences. The extinction light expectancy for the (NR) group, however, was significantly larger than that for both the (RN) and (RR) groups. The (RR) group showed the least resistance to extinction.

A possible explanation of this finding can be offered through the greater "resemblance" between acquisition and extinction for the (RN) group than for the (RR) group. Whether this explanation can be interpreted by the "Stimulus-generalization" theory, the "Discrimination" theory, both or neither, is a moot point.

In a series of experiments using 90-120-day-old black hooded rats and a double-alley maze, Logan, Beier, and Kincaid (78) studied the effects of varied delay and varied magnitude of reinforcement upon resistance to extinction. It was noted that: (a) the rate of extinction (under either massed or widely spaced practice) is decreased only if the delay of reinforcement is fairly large, and (b) resistance to extinction (under widely distributed practice) will vary directly with the magnitude of reinforcement.

The explanation for (a) and (b) is as follows: The extinction of an instrumental response, in the Hullian sense, is due (at least partially) to the loss of incentive motivation K. K, according to Spence, is assumed to be dependent on r_g--the fractional anticipatory goal response. The extinction of r_g, however, is a function of the number of unreinforced evocations of r_g. This number determines the extent to which r_g persists in occurring after the time of reinforcement has elapsed; the higher the number of unreinforced evocations of r_g is, the less likely that r_g would

persist, and the greater the resistance to extinction would be. Therefore, any training procedure which extinguishes r_g to the cues which occur (after the regular time of reinforcement) on non-reinforced trials, is assumed to increase the resistance to extinction.

Is the greater resistance to extinction exhibited after partial reinforcement due to reinforcement, non-reinforcement, or a combination of these two factors?

Employing a simple runway situation and involving the same experimental design, three experiments were run by Kendler et al. (69). In this study, three groups of 60-75-day-old naive male albino rats were used. Group (100) received 100% food reinforcement; Group (50) was reinforced on half the trials; and Group (50-50) was food-reinforced on half of the trials and water-reinforced on the other half. It must be pointed out that during training all Ss were hungry and thirsty. Twenty-five minutes before the extinction phase began all Ss were given water so that during extinction they were hungry but not thirsty. Groups (100) and (50-50) had the same pattern of reinforcement, and because of this it is expected that; if partial reinforcement is the key factor in determining the partial reinforcement effect, then the two groups should extinguish at the same rate. Such was not the case. Group (50) was more resistant to extinction than both Groups (100) and (50-50). There was no significant difference in extinction rate between the two latter groups.

The results suggest, therefore, that the partial reinforcement effect lies in explaining the effects of the non-reinforced training trials. A theoretical explanation[96] utilizing the concept of fractional

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[96]Another explanation of the partial reinforcement effect using the concept of fractional anticipatory goal responses is given by Wilson, Weiss, and Amsel (see (122), pp. 58-59).

anticipatory goal responses reads as follows: During training the goal-box responses of Group (50) differed on reinforced and non-reinforced trials. On reinforced trials, the dominant goal-box response was the consumption of food. On non-reinforced trials, a different type of response took place. One might call it a frustrated response.[97] It is assumed that such a response can be conditioned, in a classical manner, to stimuli in the goal-box and other parts of the apparatus. Cues produced by these frustrated responses would be, in turn, conditioned to the instrumental responses. During extinction frustrated responses occur for all groups. At the early stages of extinction they would work backwards into the earlier portions of the runway interfering with the consummatory responses learned by Group (100) and Group (50-50) but not with frustrated responses learned by Group (50). As a result the cues that have been conditioned to the instrumental response would be disrupted for the former groups but not for the latter group.

In a situation involving some risk-taking, Lewis and Duncan (77) measured resistance to extinction against percentage of reinforcement and amount of reward. Three hundred Ss were provided with enough disks to play an electric slot machine. For 150 Ss each disk was worth 1¢, for the others, 5¢. On a single trial, S could either lose or gain one disk. The machine paid off on 0%, 11%, 33%, 67%, or 100% of the first nine trials. These five percentages of reinforcement were combined in a factorial design with the two amounts of reward (1¢ and 5¢). After nine trials the extinction phase started, i.e., the machine stopped paying off. The Ss were at liberty to quit playing whenever they wished, at which

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[97] As opposed to a consummatory response.

time they were paid for all disks remaining. The total number of plays and S's expectancies (in numerical form) of winning or losing on each play constituted the response measures. The results were as follows:

1. Resistance to extinction decreased as the percentage of reinforcement increased.
2. There was no functional relationship between resistance to extinction and reward.[98]
3. Over the course of both acquisition and extinction trials, expectancies changed differentially as a function of percentage of reinforcement. During acquisition, expectancies decreased in the 0% and 11% groups but increased in the 33%, 67%, and 100% groups. During extinction, expectancies decreased in a manner that was directly proportional to the percentage of reinforcement.
4. There was no evidence of any significant change in the inverse relationship between percentage of reinforcement and resistance to extinction caused by risk-taking, despite the fact that resistance to extinction was significantly lower than that of an earlier comparable study.[99]

Hartman and Grant (44), keeping the number of reinforcements constant,[100] investigated the effect of intermittent random reinforcement

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[98] A previous study by Lewis and Duncan (75) revealed that there was an inverse relationship between percentage of reward and resistance to extinction. This relationship was attributed to the ease of discriminating between acquisition and extinction.

[99] See (76).

[100] In the study of Grant and Schipper (39), the number of reinforcements was not equalized (for each percentage of reinforcement) during the acquisition process.

(25%, 50%, 75%, and 100%) on acquisition, extinction, and spontaneous recovery of the conditioned eyelid response in four groups of 20 human subjects each (32 men and 48 women students from an elementary psychology class).

During the first experimental session, each S was given 40 reinforced trials followed immediately by 20 extinction trials. Approximately 24 hours later, another (10 minute) session of 20 unreinforced trials was given to each S to test for spontaneous recovery. The 25% group was given 160 acquisition trials with a mean inter-trial interval of 24 seconds, the 75% group was given 54 trials with a mean inter-trial interval of 36 seconds, and the 100% group was given 40 trials with a mean inter-trial interval of 48 seconds. In other words, the duration of the acquisition series and the number of reinforcements were the same for all groups. In each group the order of reinforced and non-reinforced trials followed a quasi-random sequence. For each group the number of inter-trial intervals during acquisition, extinction, and spontaneous recovery was the same. During the latter two, however, the mean inter-trial interval was set at approximately 30 seconds. The results were as follows:

1. The percentage of CR's (during acquisition) was a function of the percentage of reinforced trials. The percent frequency increased as the percentage of reinforcement increased.[101]
2. There was an inverse relationship (during extinction) between percentage of reinforcement and resistance to extinction. The highest percentage of reinforcement exhibited the lowest resistance to extinction.

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[101] The same result was found by Grant and Schipper (39).

3. The 50% and 75% groups showed greater spontaneous recovery than the 25% and 100% groups.
4. The form of the spontaneous recovery function for each group was not similar to that of its extinction counterpart, despite the fact that during the spontaneous recovery period the groups with the lowest percentage of reinforcement portrayed the greatest resistance to extinction.

It must be pointed out that the acquisition curves did not reach the asymptotes predicted by the Estes-Straughan model.[102] The 25% and 50% groups, for example, seemed to shoot higher than the 25% and 50% values. The discrepancy is due, perhaps, to the simplicity of the conditions envisioned by the model as compared to the more complex nature of the conditioned eyelid response.

To establish a theoretical framework for the phenomena of acquisition and extinction using the Estes[103] or Estes-Straughan probability model approach would no doubt lead to inadequacy in the results since these models do not take into consideration all the conditions involved. It is for this reason that more empirical data is needed so that ways in which those formulations can be modified might be indicated.

Myers (85) studied the effects of partial (primary and secondary) reinforcement upon an operant response of children. A box with the face of a clown painted on its front served as the apparatus. Upon pressing the clown's nose, a token was delivered from its mouth. The token was then inserted in the clown's ear and the nose was pressed again. This

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[102] See (31), equation (4), p. 226.

[103] See (30).

time a candy fell from its mouth.

The Ss were 140 children (70 boys and 70 girls) between the ages of 3 years 5 months and 6 years 3 months. These subjects were divided into 14 groups (10 Ss each) equated for mean age, school representation, and sex, but differing in acquisition and extinction procedures. Eight groups received 20 conditioning trials with various combinations of 50% and 100% (token and candy) reinforcement. For example, one of the 8 groups received 100% candy-50% token-100% token (100C-50T-100T); another received 50C-100T-100T; a third 100C-50T-0T; etc. . . Four groups received 100% token reinforcement for 10 conditioning trials. The 13th group received 20 training trials with 100% candy reinforcement. The last group was used as a control for the secondary reinforcing characteristics of the tokens. No candy reinforcement was allowed for this group.

Each training trial lasted about 10 seconds with a 2-3 second inter-trial interval. Extinction for all groups was without candy. Eight groups (including the last 2) were extinguished with "token"; the other groups (totalling 6) were extinguished with "no token." Each child received 40 5-second extinction trials. The results were as follows:

1. Groups given 100% candy (or token) reinforcement (during training) extinguished faster than those given 50% candy (or token) reinforcement.
2. When the number of token reinforcements was held constant, the 50% token reinforced groups were more resistant to extinction than the 100% token reinforced groups for half the number of trials.

3. There was no difference in resistance to extinction between the groups given 20 training trials with 100% token reinforcement and those given 10 trials with 100% token reinforcement.
4. Groups receiving "token" extinction were more resistant to extinction than those receiving "no token" extinction.
5. There was a significant difference in the number of responses (during extinction) between the control group (which never received candy conditioning) and those that received token extinction; the former gave fewer responses than the latter.

In an experiment by Boren (7), six groups (six Ss each) of 130-150-day-old male albino rats were trained in a bar-pressing apparatus on (0:1), (2:1), (5:1), (9:1), (14:1), and (20:1)[104] fixed-ratio schedules of reinforcement respectively, and were then extinguished. Extinction consisted of five daily 1-hour sessions during which food was not available. The study revealed that the rates of response, both at the end of training and the beginning of extinction, varied directly with the fixed ratio. During extinction, the number of responses made bore an approximately linear increasing relationship with the fixed ratio.

Yamaguchi (123) studied the relative effects of continuous, varied, and partial reinforcement on acquisition and extinction of a runway response. Four groups of thirteen 90-120-day-old male hooded rats were given 5-5 continuous reinforcement (5 units of reinforcement

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[104]This ratio (20:1) meaning that every twenty-first response is reinforced, was selected on the basis of pilot study by the experimenter to maintain rapid responding in most Ss. Moreover, performances (including magnitude of rates, consistency, and uniformity) under (20:1) ratio are not likely to change with more exposure to the schedule (see (130), p. 48).

on all trials), 8-2 varied-magnitude reinforcement (8 units on a random half and 2 units on the remainder of the trials), 9-1 varied-magnitude reinforcement (9 units on a random half of the trials and 1 unit on the other half), and 10-0 partial reinforcement (10 units on a random half of the trials and no reinforcement on the other half) respectively. All Ss received 40 acquisition trials (10 per day), and 30 extinction trials (following the last acquisition trial). The inter-trial interval for all trials was 25 seconds.

All groups showed similar acquisition performance but differed significantly in their resistance to extinction. In particular, the 9-1, and the 10-0 groups were more resistant to extinction than the continuous group. The extinction results of this study confirm those obtained by Logan et al. (78) and are in accord with their theoretical interpretation. The acquisition results, on the other hand, do not support their theory which claims that different magnitudes of reinforcement produce different r_g's--fractional anticipatory responses. When reinforcement magnitude is varied, the different r_g's compete and then result in an r_g equivalent to that produced by the average of those reinforcement magnitudes. Accordingly, one should expect better acquisition performance during partial than during varied-magnitude reinforcement. This was not what occurred in this study.[105] It might be conjectured that partial, varied, and continuous reinforcement schedules produce similar acquisition performance if the total amount of reinforcement is held constant. This, therefore, suggests that some modification of the theory of Logan et al. (78) is appropriate.

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[105]The acquisition curve for the 9-1 group, for example, was much higher than that of the 10-0 group.

In a study by Capaldi and Senko (17) three groups of 95-day-old Wistar strain rats were trained to traverse a straight-alley runway. All Ss received 12 trials per day and 33% reinforcement. For Group I (N = 8) reinforcement was irregular (random) and both reinforcement and non-reinforcement took place in a gray goal-box. Group II (N = 8) was comparable to Group I except that it was regularly reinforced--the two initial trials were non-reinforced, the third reinforced, and so on. Group III was also regularly reinforced; however, reinforcement occurred in a white goal-box, whereas non-reinforcement took place in both white and black goal-boxes. On the 15th day two groups were transferred to a single alternation (SA) pattern. Group I received 9 days of (SA) training; Group II, 7 days; and Group III was continued on the regular 33% pattern for an additional 7 days. The inter-trial interval was 20 seconds. The results showed that (a) the regular groups ran slowly following reinforcement and rapidly on the ensuing two trials, (b) after single alternation, immediate and consistent (SA) pattern running occurred, and (c) the color of the goal-box did not seem to give rise to distinctive after-effects. A theoretical explanation of the results cannot rely on the serial patterning version of the discrimination hypothesis, since in this case, partial reinforcement cannot be understood on a trial-by-trial basis but requires that responding be to the entire series of events. As far as can be determined, a patterning view cannot indicate (in the presence of a regular 33% pattern) whether a response will or not be appropriate. Furthermore, no specific predictions regarding transfer seem available from the patterning hypothesis.

What happens if (following conditioning on different schedules of reinforcement), instead of an extinction situation, a subject is confronted with a situation in which a response to any of several manipulanda is

reinforced?[106] McCray and Harper (82), in a study using kindergarten children, explored this question, finding that greater response variability was produced by a variable-ratio than by a regular or fixed-ratio schedule of reinforcement.

An important problem in the psychology of learning has been the description of the functional relationship[107] between delay of reinforcement and strength of learning. Such a relationship (based on empirical data or theoretical postulation) has always been found to be negatively accelerated and decreasing. Let it be assumed, therefore, that for all levels of habit strength, the reinforcing effect[108] of a constant amount of reward is a negatively accelerated and decreasing function of the interval of delay of reinforcement. It is predicted, under such an assumption, that (in a simple Y-maze situation) if, a group of Ss received a constant K seconds' delay of reinforcement for responses to one arm of the maze[109] and a variable delay of reinforcement to the other arm such that the delay is 2K seconds half of the time and 0 seconds the other half, then the Ss will develop a more favorable attitude towards the variable-delay side. This is, perhaps, the result of the more reinforcing effect of the K $(\frac{2K + 0}{2})$ seconds' variable delay than that of the K seconds'

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[106] Other studies (see (130), (63), and (74), for example, have shown stereotype of response (in conditioning) to be related to a regular schedule of reinforcement and (in extinction) to be related to variable-ratio schedules of reinforcement.

[107] Such a relationship is often referred to as the "gradient of reinforcement."

[108] It must also be assumed that the number of prior reinforcements at each stage of training is the same.

[109] The maze consisted of a start-box, runway and choice point, two delay chambers, and two goal-boxes. The delay chambers and goal-boxes were situated in both the left and right arms of the maze. For a full description of the apparatus (see (92), pp. 243-244).

constant delay. It is also predicted that, if two groups were trained under such conditions except that for one group the value of K is larger than that of the other, then the group with the larger K would develop the preference much faster. These two predictions have been tested by Pubols (91) in two separate experiments involving a total of 54 rats. In one experiment only the first prediction was verified, but in the other both were.

It was found that the number of trials required to arrive at a consistent preference for the variable-delay side is a negatively accelerated and decreasing function of the mean delay of reinforcement. In a different type of experiment, Logan reports: "When the delay of reward is varied irregularly between two equally likely values,

(a) among groups with the same shorter delay, average performance is higher the shorter the longer delay;

(b) among groups with the same longer delay, average performance is higher the shorter the shorter delay;

(c) among groups with the same average delay, average performance is higher the larger the variance in delays."[110]

Part (c) seems to be confirmed by the present findings of Pubols.

Levine (72) investigated the effects of random reinforcement (RR) on subsequent discrimination learning in two experiments. In Experiment I, human Ss were presented with a random sequence of two colors (e.g., purple or tan cards) and were asked to make one of two responses

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[110] F. A. Logan. Incentive, How the Conditions of Reinforcement Affect the Performance of Rats. Yale University Press, New Haven, 1960, pp. 73-74.

to each of the color-stimuli. In Phase I of the experiment (the RR phase) they were told "right" or "wrong" according to a prearranged random schedule whereby the words "right" and "wrong" were uncorrelated with any stimulus-response pairs. In the second phase (the discrimination phase) which appeared without comment, change of behavior, or any special announcement following Phase I, the world "right" was presented only when the correct response was made to the appropriate color. Either 0, 10, 30, or 60 RRs were made before the discrimination problem started and their effects upon discrimination learning was compared. To check whether the stimuli were being ignored half of the subjects were instructed to describe each stimulus before making the response. The results of Experiment I indicate that the 0-condition of the RR variable seemed to produce faster learning than either of the other three conditions. It was noted from the graph relating trials to criterion (independent variable) to RR (dependent variable) that the changes produced by RR occurred during the first 10 RR trials. Performance by those who were forced to observe the stimulus was slightly worse[111] than that of the other half.

The four RR amounts (in Experiment I) were presented in four different sequences counterbalanced to form a latin square.[112] This might have caused the function describing the effects of the RR variable to be influenced by the sequences in which the levels of this variable were presented. Accordingly, Experiment II used <u>independent</u> groups to compare the effects of 0, 4, 8, and 12 RRs. The 0-condition again produced faster learning than either of the other three conditions which did not

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[111] Although no statistical significance was observed.

[112] A latin square is an arrangement in which each treatment occurs once only in each row and column (see (129), p. 278).

differ significantly amongst themselves. Defining θ[113] to be the proportion of relevant cues, Restle (94) argues that "if a(k, n) is the probability that irrelevant cue k has been adapted[114] at the beginning of the nth trial, then $a(k, n + 1) = a(k, n) + \theta [1 - a(k, n)]$ is the probability that it will be adapted by the beginning of the next trial."[115] This implies that if there are no relevant cues (a condition resulting from the random character of the reinforcement sequence in the RR phase), then $\theta = 0$, and $a(k, n + 1)$ becomes equal to $a(k, n)$. This is equivalent to saying that S, after a large number of RR trials, will be no more apt to ignore color than after the first RR. This formulation is not supported by the results of Levine's study (72) which clearly reveal a neutralization effect.

Bush and Mosteller (10) assume the existence of a "discrimination operator"[116] (denoted by D) only when relevant cues are present. The present results do not seem to support such an assumption. Of special importance is the assumption by Restle (94), and Bush and Mosteller (10) that once cues are neutralized, they are no longer available for conditioning. The results of Experiment II disprove such an assumption, a fact which suggests that (a) cue neutralization is independent of the

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[113] $\theta = \frac{r}{r + i}$, where r and i are the number of relevant and irrelevant cues respectively.

[114] "Adapted" here is synonymous to "neutralized."

[115] F. Restle. "A Theory of Discrimination Learning." Psychological Review, Vol. 62, 12, 1955.

[116] Can be interpreted as the analogue of stimulus neutralization (see (10), p. 420).

existence of relevant cues and (b) the sampling probability of a neutralized cue (while diminishing) does not necessarily reach zero.

Humphreys (56) and Mowrer and Jones (83) ascribe the partial reinforcement effect (PRE) to the relative ease with which one can detect an abrupt transition to extinction following full reinforcement as compared to the gradual transition following partial reinforcement.[117] What happens to the PRE, then, if the location of some period of partial reinforcement within a larger sequence of fully reinforced trials (the total amount of training held constant) is varied?[118]

Using pigeons in an automatic key-pecking apparatus, Jenkins (61) studied resistance to extinction following different amounts of training with (a) partial reinforcement, (b) regular reinforcement, and (c) partial reinforcement followed by regular reinforcement. Resistance to extinction (i.e., number of responses in ten 40-trial sessions) increased with partially reinforced training up to 20 sessions and then leveled off, which clearly demonstrated the PRE. On the other hand, there was no change in resistance to extinction as a function of the amount of regularly reinforced training. However, under the partial-regular sequence of training (i.e., with the addition of regular reinforcement after partial reinforcement), resistance to extinction (though never significantly lower than under partial training alone) increased when the amount of prior partial training was <u>not</u> sufficiently extensive to produce a maximum resistance to extinction.

Two implications may be drawn from this study. First, the

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[117]This is known as the discrimination hypothesis.

[118]Since this would alter the amount of regular reinforcement between partial reinforcement and extinction.

abruptness of transition to extinction is not critically involved in the PRE; the effect on resistance to extinction is connected with how overtraining (in a discrimination task) facilitates the learning of a reversed discrimination.[119] Second, the increased resistance to extinction produced by the partial-regular training is a challenge to the dissonance theory[120] which claims that processes responsible for the change in the resistance to extinction are essentially involved with the non-rewarded trials.[121]

Two experiments were run by Hulse (52) to study experimentally conditioned licking by 85-day-old naive male albino rats (of the Sprague-Dawley strain) as a function of (a) ratio of reinforcement, and (b) shifts in the concentration of a saccharin reinforcer.

A shift in the concentration of saccharin (under partial reinforcement) brought about an immediate change in the rate of licking in the direction of the shift; under continuous reinforcement, however, a decrease in the response rate was the usual reaction. This suggests that, since partial reinforcement provides discrimination training for reinforcement stimuli and continuous reinforcement does not, behavior is more likely to be under the control of the former than the latter.[122]

The effect of reinforcement pattern on the conditioned eyelid response was studied by Passey and Wood (87). Four groups of 10 human Ss each acquired conditioned eyelid responses to a tonal stimulus (CS). The same mean intensity of reinforcing air puffs (UCS) was given to each of

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[119] See (3).

[120] See definition, p. 184.

[121] See (136), p. 54.

[122] See (52), p. 459.

the four groups over a 50-trial training series. The patterns of such reinforcement, however, differed amongst the groups and consisted of ascending, constant, variable, and descending magnitudes respectively. Paralleling the reinforcement patterns the slopes of the acquisition curves were also ascending, constant, variable, and descending, with the ascending group showing the steepest curve. The groups showed no difference in sex or number of anticipatory responses.

Sutherland, Mackintosh, and Wolfe (109) tested the relative effects on extinction of continuous reinforcement (CR) followed by partial reinforcement (PR) and of PR followed by CR with sufficient[123] PR trials.

Five groups of 90-day-old female hooded rats (8 Ss each) were trained in a straight alleyway. Each group was given different training. Group P received 60 PR trials only; Group P-C received 60 PR trials followed by 100 CR trials; Group C-P received 100 CR trials followed by 60 PR trials; Groups C-60 and C-160 had no PR training and received 60 and 160 CR training trials respectively. All groups received the same treatment during extinction. The mean number of trials to extinction for each group was as follows:

Group	Mean Number of Trials to Extinction
P	82
P-C	77
C-P	33
C-60	17
C-160	17

The statistical analysis of the results indicated that there was no

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[123] Jenkins (61) used 10 blocks of CR and 3 blocks of PR. The 3 blocks of PR might not have been sufficient to produce a clear-cut PR effect.

significant difference in resistance to extinction between Group P and Group P-C, i.e., between Ss given PR training only and those given CR after PR. Giving CR before PR, however, reduced resistance to extinction quite significantly.

The theoretical interpretation assumes a two-stage model of learning. The subject must learn which features of the stimulus situation to attend to (stage 1) and then which responses to make (stage 2). The strength with which one of those features is attended to depends on "the consistency with which its different outputs are differentially correlated with subsequent events of importance to the animal."[124] Under PR (as opposed to CR training) no feature will yield an output consistently correlated with subsequent important events and, therefore, the subject would continually seek new features. This causes the response to be conditioned to the outputs from many features with the eventual result of increased resistance to extinction. When S receives both PR and CR training, the number of trials to extinguish will be largely determined by the earlier of the two schedules of reinforcement.[125] Thus given PR before CR, the model predicts greater resistance to extinction than if the order is reversed.

The results confirm those of Jenkins but are in disagreement with the discrimination and dissonance theories.[126]

Capaldi and Spivey (18) studied resistance to extinction on the runway in 3 groups of twelve 90-day-old male rats each. Each group

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[124] See (109), p. 56.

[125] Since enough training trials are given, it is assumed that subsequent training under a schedule of reinforcement will not weaken the response connections caused by a preceding and different schedule.

[126] See (136), p. 33.

received 27 partial delay acquisition trials in which delayed and immediate reinforcement alternated.[127] For Group I, delayed and immediate reinforcement alternated; for Group II, partial delay was random; and for Group III, reinforcement was immediate. The results showed that resistance to extinction was greatest in Group I and least in Group III.

An after-effects hypothesis modified to apply to delay of reinforcement suggests that, following a small number of partial delay acquisition trials, resistance to extinction increases as the number of transitions from Delay to Immediate trials (DI transitions) increases.

It must be pointed out that under partial reinforcement (a) following small numbers of acquisition trials (27 for example), the single alternation (SA) group was more resistant to extinction than the random (R) group (see (14)); (b) following moderate training (70 trials) the (SA) and (R) groups were equally resistant to extinction (see (11)); and (c) following prolonged training (over 100 trials), the (SA) group was less resistant to extinction than the (R) group (see (11), and (112)). A parallel exists for extinction following delay of reinforcement. The results of Capaldi and Spivey (18), Wike et al. (119) using 110 acquisition trials, and Wike et al. (120) using 210 acquisition trials, coincide respectively with those of (a), (b), and (c) above.

Twelve groups of six 85-day-old Wistar strain naive male albino rats each were trained by Hothersall (49) to make a lever-pressing response under different schedules of continuous and partial reinforcement and were then extinguished. It was found that continuous reinforcement preceding partial reinforcement led to a great decrease in resistance to

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[127] Capaldi and Hart (14) used the same reinforcement schedules with non-reinforced in lieu of delayed trials.

extinction--a result which confirmed the finding of Sutherland et al. (109).

Explanations of the partial-reinforcement effect are of two kinds: Intratrial and Intertrial. Intratrial explanations attribute the PRE to learned mechanisms that develop on each trial during acquisition and consequently influence later acquisition and extinction trials. Intertrial interpretations, on the other hand, ascribe the PRE to stimulus after-effects of reinforcement from one trial to the next.[128]

Considerable amount of experimental research by Wilson, Weiss, and Amsel (122), and Jenkins (61) has shown that the inter-trial mechanisms, no matter how plausible, cannot alone account for the partial-reinforcement phenomena. A recent study by Capaldi and Senko (17), however, has demonstrated carried-over after-effects of reinforcement and non-reinforcement from one trial to the next even at 24-hour intertrial intervals.

An experiment by Surridge and Amsel (108) investigated the stimulus after-effects hypothesis[129] by involving three reinforcement conditions run at a 24-hour intertrial interval: (a) single alternations of reward and non-reward, (b) random 50% pattern of reward and non-reward, and (c) continuous reward. These schedules were run under conditions of extreme control so that any effects on the $(n + 1)^{th}$ trial by the nth trial would not be due to extraneous factors of stimulation. Three groups of 90-day-old male Wistar albino rats (11 Ss each) received

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[128] See (108), p. 361.

[129] See (100).

a total of 192 training trials and 44 extinction trials, 1 trial per day in a straight alley.

No evidence of differential performance on reward and non-reward trials for either the (SA) or the (R) groups was seen. Large differences were found in extinction, however, between these two groups and the continuously reinforced group--the latter extinguishing much faster than the former. The differences at the end of acquisition are claimed to account for the slight extinction differences between the (SA) and (R) groups. It is reasonable to conclude from such results, therefore, that carried-over effects are not a factor that should enter into explaining the PRE in an experimental situation such as this.

Theios and McGinnis (111) claim that if, in the data of Sutherland et al. (109), an adjustment[130] is made for the effects of differential acquisition asymptotes, then partial reinforcement preceding continuous reinforcement (P-C) should not lead to greater resistance to extinction than partial reinforcement following continuous reinforcement (C-P). This claim was tested in an experiment bearing similar conditions to those of Sutherland et al.. Continuous reward resulted in a higher rate of response during acquisition and a lower resistance to extinction during extinction than did partial reward.

The results (after the adjustment was made) strongly indicated that not only did (P-C) not lead to greater resistance to extinction than (C-P) but the very opposite (i.e., (C-P) leading to greater resistance to extinction than (P-C)) was found true. The theoretical interpretation is consistent with that of the PRE involving conditioning of

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[130]Extinction speed was expressed as a proportion of S's speed on the last day of training.

the response to stimuli from either non-reward, competing responses, or anticipatory frustration.

Delay of reinforcement under extended acquisition may produce a crossover effect that bears great resemblance to extended acquisition under partial reinforcement. To provide data on this effect, Sgro, Dyal, and Anastasio (99) conducted a study in which 3 groups of thirty 90-100-day-old naive female Sprague-Dawley rats each (after being trained to asymptote[131]) were given delays of 0, 7.5, and 15 seconds respectively, in a straight runway, for 126 trials, under a 24-hour inter-trial interval. Each acquisition group was divided into four extinction groups which received 24 trials of extinction with a 24-hour inter-trial interval. These groups differed only in the amount of time in which the delay door remained closed. The times were 0, 7.5, 15, and 30 seconds. The acquisition results indicated that the longer the delay of reinforcement is the slower is the speed. The extinction data failed to show that constant delay of reinforcement under extended acquisition increased resistance to extinction.

It can be concluded, therefore, that any similarity between delay of reinforcement and partial reinforcement cannot be established from the results of this study.

Forty differential instrumental conditioning trials interspersed with twenty choice trials were given by Pennes and Ison (88) to forty-seven 90-day-old male albino rats with either full reinforcement or 50% reinforcement on the positive stimulus and 0% reinforcement on the

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[131]Performance was considered asymptotic when in a block of 24 trials there was no significant increase in speed.

negative stimulus. Following this, the Ss were given either 15 extinction or 30 reversal trials.

The results indicated that while speed to the negative stimulus was high under PR, speed to the positive stimulus was virtually unaffected by PR. This is due to the attenuating effect of PR upon the inhibitory process associated with the incorrect response rather than the effect upon the excitatory process associated with the correct response.[132] It was also observed that PR led to increased resistance to extinction in either extinction or reversal. Approach to the formerly correct stimulus was weaker for extinction than for reversal--a fact which is explainable by Pavlov's principle of positive induction.[133]

The modified after-effects hypothesis holds that following a non-reinforced trial an extinction-like cue (an after-effect of non-reinforcement, S^N) is assumed to be available for conditioning on the next trial. If on this subsequent trial (i.e., in the presence of S^N) a response is reinforced, then the tendency to respond will be increased. As the number of occasions on which a reinforced trial is preceded by a non-reinforced trial (i.e., N-R transitions) is increased, the strength of such conditioning is increased.

During extinction, S^N, which is present on every trial except the first, has the capacity to elicit responses similar to those elicited during acquisition. Hence, resistance to extinction which is an increasing function of such capacity should also be an increasing function of N-R transitions. This hypothesis was supported by Capaldi and Hart (14), and

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[132] See (88), p. 219.

[133] See (141), p. 188. Positive induction refers to the intensification of excitation under the influence of inhibition (see (133), p. 34).

Bacon, (1) although the results of the latter were interpreted in terms of the two-factor hypothesis of Grant and Schipper (see (39)) which states, that following a small number of training trials, resistance to extinction is an increasing function of the number of reinforcements. To investigate whether resistance to extinction is a function of the number of N-R transitions or percentage of reinforcement, Spivey (106) employed a design in which 30% and 70% reinforcement were combined factorially with 1-NR and 3-NR transitions. This gives a 30% reinforcement schedule containing 1-NR transition and a 70% schedule containing 3-NR transitions (as used by Bacon (1)) plus a 30% schedule containing 3-NR transitions and a 70% schedule containing 1-NR transition (as a control). A fifth group given full reinforcement was added for further control.

The results indicated that resistance to extinction was a function of N-R transitions and was independent of percentage of reinforcement--a fact which added further support to the modified after-effects hypothesis.

Eight groups of twenty 67-132-day-old naive male Sprague-Dawley rats each were given 30 rewarded (R) trials in a runway on Day 1. Four N-brief-R groups received either 1, 5, 15, or 30 non-rewarded (N) trials on Day 2, followed after a brief 15-second interval by 15 R trials. On Day 2 also, four N-long-R groups each received 15 R trials followed (23 hours later) by 1, 5, 15, or 30 N trials. On Day 3, all 8 groups received 15 R trials[134] followed <u>immediately</u> by 30 N trials. The inter-trial interval between any two trials was 15 seconds. The data accumulated

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[134]These 15 R trials given on Day 3 helped bring the performance of all 8 groups to the same level prior to the final 30 N trials which were regarded as a formal extinction session.

by Jensen and Hill (64) indicated that extinction speeds[135] were directly related to the size of the N block and inversely related to the time between the N and R blocks. Stimulus after-effects of non-reinforced trials, argues Capaldi, persist indefinitely, or at least a long time, unless explicitly wiped out.[136] The present finding clearly shows that Capaldi's argument is not supported. The after-effects did not persist at full strength for as long as 24 hours.

Two experiments were conducted by Koteskey and Stettner (71) to compare the effects of (a) the number of non-reinforcements, (b) the number of non-reinforced-reinforced (NR) sequences, and (c) the length of run of successive non-reinforcements upon resistance to extinction. In Experiment I, 5 groups of eight 90-day-old naive male albino Sprague-Dawley rats each were run varying conditions (a), (b), and (c) independently. Group RNN received 33% reinforcement with runs up to four successive non-reinforced trials but did not receive a reinforced trial after a non-reinforced trial. Group NRR received 67% reinforcement with a reinforced trial always given after a block of non-reinforced trials. There was never more than two non-reinforced trials in succession. Group NNR received 33% reinforcement with up to four non-reinforced trials in succession and a reinforced trial always following a block of non-reinforced trials. Group NRN received 33% reinforcement with no more than 2 non-reinforced trials in succession. Only one half of the blocks of non-reinforced trials were followed by a reinforced trial. Group RRR was the control group and was continuously (100%) reinforced.

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[135] Speed is the reciprocal of response duration.

[136] See (64), p. 396.

In Experiment II, three groups of 8 rats (same age, sex, and strain as in Experiment I) each were run to a higher level of acquisition. Group NNR and NRR each received at least one reinforced trial following each block of non-reinforcements and an equal number of NR sequences. The length of run and percentage of reinforcement varied in the two groups.

The results of both experiments indicated that resistance to extinction varied only with the number of NR sequences.[137] In his "sequential analysis" of partial reinforcement schedules, Capaldi (13) considers different N-lengths of non-reinforcement as essentially different stimulus conditions. With such analysis, the present finding appears to be at odds with Capaldi's conclusions. The inconsistency is due to the fact that the long inter-trial intervals (15 and 20 minutes) in this study might have reduced the importance of the N-length. While these results are interpretable by the frustration hypothesis, they seem rather incompatible with both the discrimination and dissonance theories.

Cotler and Nygaard (21) evaluated the effects of partial and continuous reinforcement sequences upon the resistance to extinction of humans engaged in a choice task. Eighty-four male and female undergraduate students in psychology were randomly assigned to one of four groups (PCC, CPC, CCP, or CCC). In groups PCC, CPC, and CCP, partial reinforcement (during acquisition) was given prior to, in the middle of, and

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[137] Gonzalez and Bitterman (35) report that neither total number of non-reinforcements nor percentage of reinforcement but number of successive non-reinforcements in training that significantly affects resistance to extinction. Capaldi and Minkoff (16) report a similar finding only under short (15 second) inter-trial intervals. Under 15-minute inter-trial intervals the results of (16) and (35) are inconsistent.

following consistent reinforcement respectively. Group CCC receiving only full reinforcement was used for comparison. Acquisition data showed that by altering the schedule of reinforcement it was possible to change S's response level. Extinction data indicated that resistance to extinction was higher in the three partially-reinforced groups than in the continuous group. During the first 30 extinction trials, the CCP group showed a significantly greater resistance to extinction than any of the other groups. However, during the last 20 extinction trials, there were no reliable differences amongst the four groups.

The results of this experiment (using human subjects) are consistent with the findings of Theios and McGinnis (111) but not with those of Sutherland et al. (109) (both studies using rats). Though not statistically significant, there was a tendency of the PCC group to separate from the other groups during later extinction and make a larger mean of responses. It is interesting to note that this is precisely what would have been predicted by the "two-stage model of learning hypothesis" of Sutherland et al..

In two separate experiments, Coughlin (22) investigated the effect of percentage of reinforcement on (a) resistance to extinction, and (b) the frustration effect.[138] He used male albino rats in a straight double runway apparatus for both studies. Testing for the effect of percentage of reinforcement upon resistance to extinction, the rats were reinforced on 0%, 12½%, 25%, 50%, 75%, and 100%. In the second study dealing with the relationship between frustration effect and percentage reinforcement, the rats were reinforced on either 25%, 50%, or 75% of the trials.

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[138]Frustration effect is defined here as the difference in speed following non-reward as opposed to that following reward.

The results of the experiments showed that both the frustration effect and resistance to extinction are an inverted U-shaped function of the percentage of reinforcement.

This suggests that the animals that show the maximum response vigor due to nonreward, as measured by the frustration effect, turn out to be the most persistent when all reward has been withdrawn.[139] The theoretical explanation of the results can be achieved within the framework of the "frustration hypothesis."[140]

Summary

Several factors affect acquisition and/or resistance to extinction. Among these factors are (1) amount of reinforcement, (2) amount and level of training, (3) inter-trial interval, and (4) schedule and pattern of reinforcement.

Amount of Reinforcement

In a galvanic skin reaction test using human Ss, Hovland (50) found that conditioned responses extinguished more slowly the further the conditioning process advanced. Similar results were found by Williams (121), Harris and Nygaard (43), and Dyal and Holland (27), all using rats in a lever-pressing apparatus; and by Zeaman (124) using rats in a simple straight runway.

In contrast with the above finding, North and Stimmel (86) and Ison (60), using rats in a straight alley, found that the larger the number of reinforcements the faster is the rate of extinction.

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[139] Amsel views the frustration effect and resistance to extinction as reflecting respectively two dimensions of behavior--vigor and persistence (see (125), p. 14).

[140] See footnote 93.

Amount and Level of Training

Using rats in a simple T-maze, Capaldi and Stevenson (19) found that resistance to extinction was reduced by increased training. This finding was supported by Lewis and Duncan (76) using an electric slot machine and human Ss; Siegel and Wagner (103) and Birch (2) using rats in a straight runway; and McCain, Lee and Powell (81) using rats in a straight-alley maze with two L-shaped goal-boxes. In contrast, Hill and Spear (47) using rats in a straight runway, and Spence, Rutledge and Talbott (105), conditioning the eyelid response of human Ss, found that resistance to extinction bears a direct relationship to the number of acquisition trials.

Prolonged training reduces resistance to extinction because subjects have a better chance of detecting reinforcement patterns during acquisition. Many studies have confirmed this. Using rats in a straight runway, Capaldi (11) reported that when a perceived or discriminable pattern of reinforcement was eliminated, extinction took relatively longer. Similar results were obtained by Grossen (41) using rats in a multiple runway, Hergenhahn and Potts (46) using human Ss in a two-choice guessing situation, and King, Wood and Butcher (70) measuring key-peck responses in a Skinner box. Murillo and Capaldi (84) used human Ss in a two-choice guessing situation and found that resistance to extinction was reduced by increased training only if such training included over-learning trials. They suggested that a ∩-shaped function describes the relationship between amount of training and resistance to extinction. Using human Ss and a similar apparatus, Senko, Champ and Capaldi (98) confirmed this ∩-shaped functional relationship. Using human Ss in a

two-choice guessing situation, Hergenhahn (45) found that after over-training, there was a tendency for an 80%-reinforced group to extinguish faster than a 50%-reinforced group. Kass and Wilson (67) used school children and a simulated slot machine and reported a similar result in which a 100%-reinforced group extinguished faster than a 60%-randomly-reinforced group. Using rats in a modified Skinner box, Uhl and Young (114) reported that the total of responses during extinction was a positive linear function of the number of non-reinforced trials during acquisition.

Inter-trial Interval

Measuring the conditioned eyelid responses in human Ss, Porter (90) found that the number of stimulations required to secure extinction of the CR is independent of the length of the inter-stimulus interval. Humphreys, Miller and Ellson (59) and Grant, Hornseth and Hake (37) used similar apparatus in studying the verbal expectations of human Ss and found that there were no differences in the rate of acquisition and extinction resulting from variation in the inter-trial interval. In Part II of his experiment, Stanley (107) used rats in a T-maze and reported that there was no difference between massed and spaced extinction in terms of two-measure scores

In a bar-pressing apparatus using rats, Gagné (33) found that as the inter-trial interval increased, the rate of acquisition increased and the rate of extinction decreased. A similar result was reported by Lewis (73) who used rats in an alley-type runway. Using rats in an instrumental learning situation, Teichner (110) confirmed Gagné's result,

and also reported that resistance to extinction was greater when the inter-trial intervals during conditioning and extinction were the same than when the inter-trial intervals were different; a result which is similar to that obtained by Grant, Schipper and Ross (40) testing human eyelid reactions.

Sheffield (100), using rats in an alley, reported that only after massed training was resistance to extinction significantly lower for a 100%-reinforced group than for a 50%-reinforced group. Following spaced training, no significant difference existed between a 100%-reinforced and a 50%-reinforced group.

Schedule and Pattern of Reinforcement

Partial reinforcement as opposed to continuous reinforcement leads to an increase in resistance to extinction. This statement was supported by several studies: Humphreys (55) testing the conditioned eyelid response in humans; Jenkins and Rigby (62) testing the bar-pressing habit in rats; Grant, Hake and Hornseth (36) using human Ss in a two-choice guessing situation; Wagner (116) using rats in a straight runway; Jenkins (61) using pigeons in a key-pecking apparatus; Pennes and Ison (88) using rats in an instrumental conditioning situation; and Myers (85) studying the extinction of an operant response in children following partial and regular primary and secondary reinforcement procedures.

Grant and Schipper (39) and Hartman and Grant (44) testing the conditioned eyelid response in human Ss, and Lewis and Duncan (77) using a slot machine, each reported that the percentage of CR's during acquisition increased as the percentage of reinforcement increased. Grant and

Schipper (39) and Hartman and Grant (44) differ somewhat; the former indicated a maximum percent frequency of CR's in 50%- and 75%-reinforced groups during extinction and the latter showed an inverse relationship between resistance to extinction and percentage of reinforcement. Lewis and Duncan (77) also reported that no functional relationship existed between resistance to extinction and reward.

Longenecker, Krauskopf and Bitterman (79) conditioning a galvanic skin response of human Ss, and Tyler, Wortz and Bitterman (112) using rats in a runway, report that groups given random reinforcement extinguished more slowly than those given alternating reinforcement. A similar result was reported by Capaldi and Spivey (18) using rats in a runway. They showed that only after prolonged training was the single-alternation group (SA) less resistant to extinction than the random (R) group. Surridge and Amsel (108), using rats in a straight alley, concluded that the continuously rewarded group extinguished much faster than either the single-alternation group or the random group.

Levine (72) investigated the effects of random reinforcement on subsequent discrimination learning by presenting human Ss with a random sequence of two colors. The results indicated that the 0-condition of the randomly reinforced variable seemed to produce faster learning than either of the other conditions.

In a two-choice situation using human Ss, Grosslight, Hall and Murnin (42) claim that the arrangement of reinforcements and non-reinforcements in a sequence affected resistance to extinction. Their (NR) group was more resistant to extinction than either the (RN) or the (RR) groups, with the (RR) group exhibiting the least resistance to

extinction. Sutherland, Mackintosh and Wolfe (109) using rats in a straight alley, and Hothersall (49) using rats in a lever-pressing apparatus, found that giving continuous reinforcement before partial reinforcement reduced resistance to extinction significantly. Under similar experimental conditions, Theios and McGinnis (111) contested the claim of Sutherland et al. (109) showing that if an adjustment is made for the effects of differential asymptotes, partial reinforcement before continuous reinforcement does not reduce resistance to extinction.

Crum, Brown and Bitterman (23) and Scott and Wike (97) used rats in a runway and showed that under a delayed condition of reinforcement, resistance to extinction was significantly greater than following continuous and immediate reinforcement. However, Logan, Beier and Kincaid (78), using rats in a double-alley maze, and Yamaguchi (123), using rats in a runway, reported that rate of extinction (under either massed or widely spaced practice) is decreased only if the delay of reinforcement is fairly large. They also found that resistance to extinction (under widely distributed practice) varies directly with the magnitude of reinforcement.

Spivey (106), using rats in a straight alley, reported that resistance to extinction is a function of N-R transitions but is independent of percentage of reinforcement. Jensen and Hill (64) reported that extinction speeds were directly related to the size of the N-block and inversely related to the time between the N and R blocks, while Koteskey and Stettner (71) found that resistance to extinction varied only with the number of NR sequences. Both studies used similar experimental treatments to that of Spivey (106).

In conditioning an eyelid response in humans, Grant, Riopelle and Hake (38) found that even when most Ss were aware of the single-alternation (SA) and double-alternation (DA) patterns, there was little evidence of the CR's conforming to these patterns. This was true during both acquisition and extinction.

Kendler, Pliskoff, D'Amato and Katz (69), using rats in a simple runway, found that partial reinforcement was not the only factor in determining the partial reinforcement effect. The partial reinforcement effect also is influenced by the effects of the non-reinforced training trials.

In a bar-pressing apparatus using rats, Boren (7) reported that the rates of response, both at the end of training and the beginning of extinction varied directly with the fixed ratio.

McCray and Harper (82) with kindergarten children as Ss showed that greater response variability was produced by a variable-ratio than by a regular or fixed-ratio schedule of reinforcement.

A study by Capaldi and Senko (17), using rats in a straight-alley runway, demonstrated after-effects of reinforcement and non-reinforcement from one trial to the next even at 24-hour inter-trial intervals.

In a simple Y-maze situation, Pubols (91) gave rats constant delay of reinforcement for responses to one arm of the maze and variable delay of reinforcement for responses to the other arm, and showed that Ss developed a more favorable attitude towards the variable-delay side.

Hulse (52), conditioning a licking response in rats, found that under partial reinforcement, an increase in the concentration of the saccharin brought about an increase in the rate of licking. Under

continuous reinforcement, any change in the concentration of the saccharin led to a decrease in the response rate.

Passey and Wood (87) studied the effect of reinforcement pattern on the conditioned eyelid response of human Ss, and presented data showing that the slopes of the acquisition curves paralleled those of reinforcement patterns.

Sgro, Dyal and Anastasio (99), using rats in a straight runway, failed to show that constant delay of reinforcement under extended acquisition increased resistance to extinction. Therefore, any similarity between delay of reinforcement and partial reinforcement could not be established from the results of this study.

Cotler and Nygaard (21) evaluated the effects of partial and continuous reinforcement sequences upon resistance to extinction of humans engaged in a choice task. During the first 30 extinction trials, the CCP group showed significantly greater resistance to extinction than any of the PCC, CPC or CCC groups. However, during the last 20 extinction trials, there were no differences among the four groups.

The main findings which seem reasonably well-established from this review are as follows:

1. Conditioned responses extinguish more slowly as the number of reinforcements increases (Pro: 4 studies; Con: 2 studies).
2. Increased training reduces resistance to extinction (Pro: 11 studies; Con: 3 studies).
3. There are no differences in the rate of acquisition and extinction resulting from variation of the inter-trial interval (Pro: 4 studies; Con: 3 studies).

4. Partial reinforcement as opposed to continuous reinforcement leads to an increase in resistance to extinction (Pro: 7 studies; Con: 3 studies).
5. Groups given random reinforcement extinguish more slowly than those given patterned reinforcement (Pro: 4 studies; Con: 0 studies).

CHAPTER III

METHODOLOGY AND PROCEDURE

Subjects. See "Delimitations of the Study," p. 9.

Apparatus. The apparatus consisted of two 25-W electric bulbs mounted on the left and right sides (in the middle of the upper half) of a 3 x 4 foot upright wooden board. The board was painted black and the bulbs were 15 inches apart. The experimenter (E) and the subject (S) sat on opposite sides of (separated by) the board. The bulbs were actuated by a manual switch operated by E.

General Instructions. At the beginning of each session S was instructed to guess which of the two lights (left or right) was to be turned on.[141] The inter-trial interval was 10 seconds. No information (in addition to the "Instructions to Subjects") prior to, during, or after the session, was made available to S. Extinction was carried out (a) "with" and (b) "without" the light bulbs being actuated.[142]

Instructions to Subjects. "This is an experiment on Extra-Sensory Perception, or ESP. It has nothing to do with either personality or intelligence.

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[141] See "Instructions to Subjects." For the pattern which the experimenter followed in actuating the bulbs, see Appendix II.

[142] These two cases will henceforth be referred to as "light on" and "light off," respectively.

I am going to ask you to guess which of these two lights I am going to turn on. I will say the word "guess." You will say either "right" or "left" to indicate your guess. Sometimes you will guess correctly, and sometimes incorrectly. That is part of the experiment. Whenever your guess matches my guess, I will say the word "correct." When you hear me say "correct," make a mark on a piece of paper to tally your correct guesses. You may guess which light comes on, but not match my guess. In such a case, I will say nothing, and you will make no mark on the paper. At the end of this session, we will see how well you scored, that is, how well your guesses matched mine. Do you have any questions before we begin about how we will proceed?"

Between the conclusion of the training trials and the start of the extinction trials, there was a 2-minute rest period. For the "light on" Ss, E would only say: "Now let us continue," to initiate extinction. For the "light off" Ss, to initiate extinction, the following was read: "I want you to continue guessing, either "left" or "right" as before. This time, however, I will not be turning the lights on. Please try not to make any regular patterns in your guesses, for example, R-L-R-L-R-L, etc. . . . Do you have any questions before we begin?"

Description of the Research. The research was constructed in four separate studies.

Study #1. 36 Ss were randomly assigned to six groups (six Ss in each group).

One group received 100% fixed reinforcement (100 FR),

Another group received 67% fixed reinforcement (67 FR),

The third group received 33% fixed reinforcement (33 FR),

The fourth group received no reinforcement (0FR),

The fifth group received 67% variable reinforcement (67 VR),

And the sixth group received 33% variable reinforcement (33 VR).

All Ss received 60 acquisition trials. Extinction was carried out "light off." The criterion for "extinction" was the number of extinction trials which took S to guess (a) 3 "lefts" in a row, (b) 5 "lefts" in 10 consecutive trials, and (c) 10 "lefts" in 20 consecutive trials.[143] The criterion for "no extinction" was 360 extinction trials during which conditions (a), (b), and (c) had not all been met.

Study #2. 72 Ss were randomly assigned to 12 groups (six Ss in each group).

Six groups (I, II, III, IV, V, and VI) received 100FR, 67FR, 33FR, 0FR, 67VR, and 33VR respectively, and were extinguished "light on." The other six groups (VII, VIII, IX, X, XI, and XII) received 100FR, 67FR, 33FR, 0FR, 67VR, and 33VR respectively, but were extinguished "light off." All subjects received 60 training trials. The criteria for "extinction" and "no extinction" were the same as those of Study #1.

Study #3. 36 Ss were randomly assigned to six groups (6 Ss in each group). One group received 100FR, the second 67FR, the third 33FR, the fourth 0FR, the fifth 67VR, and the sixth 33VR.

Each subject received 60 trials plus as many trials as necessary to guess 8 "rights" in 10 consecutive trials.[144] No extinction trials were given to the subjects.

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[143] Irrespective of order, all 3 conditions (a), (b), and (c) had to be satisfied.

[144] Eight "rights" in 10 consecutive trials is equivalent to the probability of occurrence of R which is set at .8 (see pattern of actuating bulbs, Appendix II.

Study #4. This was a repetition of Study #2 with the exception that (a) all Ss received 90 acquisition trials,[145] and (b) during the last 40 trials (of the 90 trials) each S had to guess 8 or more "rights" in 10 consecutive trials. Data from those Ss who did not meet condition (b) were discarded.

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[145] 90 is the grand mean of the number of acquisition trials in Study #3.

CHAPTER IV

RESULTS AND DISCUSSION

This chapter presents an analysis of the data for each study, continuing with a summary of all four studies, and concluding with a general discussion relating the findings to the relevant hypothesis and theory.

Results

Study #1

A question to be answered in Study #1 is whether extinction does take place when reinforcement is stopped and lights are no longer turned on. In Table 2, the column labeled "No. of Ext. Trials" answers this question in the affirmative: yes, extinction does occur. With the exception of two (0% reinforced), all Ss did extinguish.

Table 3 lists the number of extinction trials which took each of the 36 Ss to extinguish under the specified schedule of reinforcement. It is interesting to note the type of symmetry that exists among the means ($\bar{X}$'s): The 67F and 33V groups extinguishing at about the same rate, as do the 33F and 67V groups. In terms of resistance to extinction, Groups 67F and 33V were the least resistant. Next in line were the 100F group, the 33F and 67V groups, and finally the 0F group.

A second question to be answered is does extinction occur in patterns directly related to schedules of reinforcement? A one-way analysis of variance (ANOVA), fixed effects (Table 4) indicates that there was no such pattern at the 5% level of significance.

The x's in Table 1 represent the trials at which the Ss were reinforced. The total number of reinforcements (RE's) are listed in Table 2--in the column labeled "No. of RE's." From Table 1, the number of transitions from reinforcement to non-reinforcement (or vice versa) for each S has been counted and listed in Table 2--in the column labeled "N-RE Transitions." Table 2 also shows the number of times each S said "Right" during the sixty acquisition trials, listed under "No. of R's;"[146] the number of times each subject said "Left" and matched an L on the "pattern of actuating the bulbs,"[147] listed under "No. of L-L;" the number of times each S said 3 or more "Lefts" in a row, listed under "Cluster of L;" and the "No. of $\frac{R's}{RE}$" which is the number of "Rights" divided by the number of reinforcements for each S.

Tables 5, 6, 7, and 8 list the "No. of RE's," the "No. of R's," the "No. of N-RE transitions," and the "No. of $\frac{R's}{RE}$" respectively under the six schedules of reinforcement. Table 5 shows that the $\bar{X}$'s for the 67F and 33F groups are almost identical with their counterparts--the 67V and 33V groups. The same situation exists in Tables 7 and 8. While no information can be gained from the $\bar{X}$'s of Table 6, the $\bar{X}$'s of Table 8 show distinct features amongst the schedules of reinforcement. Note that 100F carries the smallest numerical value, the 67F and 67V the next larger, and the 33F and 33V the largest.

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[146] R is shown elsewhere as CR--conditioned response.

[147] See Appendix II.

STUDY #1 (Acq. = 60 trials, 6 blocks; N = 36)

Table 1

S	Sch.	BL 1 1234567890	BL 2 1234567890	BL 3 1234567890	BL 4 1234567890	BL 5 1234567890	BL 6 1234567890
1	67F	xx x x	xx x x x	x xx x x	xx x x	xx x x x	x xx xx
2	0F						
3	100F	x x x	x xx x	x xxx	xx xx x	xx xx xxx	x xx xxx x
4	100F	x x xxx	x xx x	x x xxxx	xxx x x	xxxxx xx	x x xxxxx
5	0F						
6	67V	xx x	x x x	x xx x	xxx xx	xx x	x x xx x
7	33F	x x	x	x x	x x	x x	x x
8	0F						
9	33V	x x	x x	x		x x	x
10	33F	x x	x	x x	x x	x x	x x
11	33F	x x x	x x	x x	x x	x	x x x
12	67F	x x	xx x x	xx x	x xx	xx xx	xx xx
13	67F	xx x x	xx	x x x	x x x	x xx x	x xx
14	33F	x	x x	x x	x	x x	x x x
15	67V	xx	x x	x x	x x xx x	x xxx	x x x
16	67V	x x	x x	x x xx	x x	x x x xx	x xx xx
17	33F	x x	x x	x	x	x	x x
18	33F	x x	x	x	x x	x	x x
19	33V	x	x	x	x x	x	x
20	67V	xx x	x xx x	x x	x x xx	xxx xx	x xxx
21	67F	x x	x x x	xx x	x x x	x x	x
22	0F						
23	67V	x x x x	x x	x x	x x	xx x x	x x
24	67F	xx xx	xx	x x xx	xx xx	x x x	x x x xx
25	100F	xx xxx	xxxxxxx x	xxx xxxx	x x xxxx x	xxxx xxx	x x xxxxx
26	33V	x	x	x	x x	x	x
27	67V	x x	x x xx	x x	x x x	x x	x x
28	0F						
29	33V	x	x x	x	x x	x x	xx
30	0F						
31	33V	x x	x	x xx	x	x	xx
32	33V	x x	x x	xx	x x	x	x x
33	100F	x	xxxxxxx	x xxxx	xx xx x	xxxx xxx	x xx xx x
34	100F	xx x x	x xx x	xx x	x	xxxx x	x x xxx
35	67F	xx	xx	xx xx	xx	xx	xx x x
36	100F	xx xx	x xxxx x	xx xxx	x x x x x	xxx x xxx	x xx xxxxx

STUDY #1 (Acq. = 60 trials, 6 blocks; N = 36)

Table 2

S	Sch.	Number of R's BL 1	BL 2	BL 3	BL 4	BL 5	BL 6	No. of Ext. Trials	No. of R's	No. of RE's	No. of R's per RE	No. of L-L	Cluster of L (3 or more)	N-RE Transi-tions*
1	67F	5	8	7	9	9	8	20	46	28	1.64	5	1	28
2	0F	7	5	5	5	4	6	100	32	0	--	8	2	0
3	100F	4	6	6	7	9	8	40	40	30	1.33	3	1	30
4	100F	5	5	7	7	9	9	40	42	34	1.24	3	2	34
5	0F	5	5	6	3	7	8	360	34	0	--	9	3	0
6	67V	5	4	6	9	5	7	20	36	23	1.57	7	1	23
7	33F	4	6	8	6	8	8	30	40	11	3.64	4	1	11
8	0F	2	4	6	4	6	6	20	28	0	--	5	7	0
9	33V	5	6	4	4	5	4	20	28	8	3.50	7	4	8
10	33F	5	5	9	7	8	6	90	40	11	3.64	3	1	11
11	33F	7	7	7	6	6	9	160	42	13	3.23	7	1	13
12	67F	5	7	6	6	8	7	20	39	20	1.95	3	0	20
13	67F	5	5	5	5	7	6	30	33	19	1.74	7	4	19
14	33F	5	6	5	6	6	9	20	37	11	3.36	6	2	11
15	67V	4	4	4	7	7	5	100	30	18	1.67	8	3	18
16	67V	4	5	6	6	9	9	20	39	20	1.95	2	2	20
17	33F	5	6	5	5	4	7	20	32	9	3.56	6	2	9
18	33F	4	5	5	6	5	7	20	32	9	3.56	5	4	9
19	33V	4	2	5	6	5	3	30	25	7	3.57	7	4	7
20	67V	6	6	4	9	7	8	100	40	21	1.90	4	3	21
21	67F	3	5	6	6	5	3	20	28	15	1.87	6	6	15
22	0F	3	6	5	5	6	5	20	30	0	--	7	7	0
23	67V	6	4	4	4	5	6	40	29	16	1.81	7	4	16
24	67F	5	5	6	8	6	9	30	39	22	1.77	5	2	22
25	100F	6	9	10	9	9	9	40	52	41	1.27	2	1	41
26	33V	4	3	6	5	7	3	40	28	7	4.00	4	2	7
27	67V	5	8	4	5	7	5	60	34	16	2.13	3	3	16
28	0F	7	4	5	5	4	5	50	30	0	--	8	2	0
29	33V	4	4	7	7	8	5	20	35	10	3.5	5	5	10
30	0F	5	3	3	9	10	9	360	39	0	--	5	3	0

STUDY #1 (Acq. = 60 trials, 6 blocks; N = 36)

Table 2 (continued)

S	Sch.	Number of R's BL 1	BL 2	BL 3	BL 4	BL 5	BL 6	No. of Ext. Trials	No. of R's	No. of RE's	No. of R's per RE	No. of L-L	Cluster of L (3 or more)	N-RE Transi-tions*
31	33V	7	5	6	6	6	6	20	36	10	3.6	5	2	10
32	33V	6	9	6	6	5	6	20	38	11	3.45	6	3	11
33	100F	1	9	7	6	9	8	30	40	31	1.29	4	4	31
34	100F	5	5	4	3	6	7	40	30	22	1.36	4	4	22
35	67F	4	4	5	5	5	7	40	30	16	1.88	6	4	16
36	100F	5	7	5	7	9	9	30	42	35	1.20	5	1	35

*A change from reinforcement to non-reinforcement or vice versa is called a transition. For example, NNRNRRNNNRN has six transitions.

STUDY #1

TABLE 3

SCHEDULE OF REINFORCEMENT VS. NUMBER OF EXTINCTION TRIALS

	100F	67F	33F	0F	67V	33V
	40	20	30	100	20	20
	40	20	90	360	100	30
	40	30	160	20	20	40
	30	20	20	20	100	20
	40	30	20	50	40	20
	30	40	20	360	60	20
Σ =	220	160	340	810	340	150
$\bar{X}$ =	36.67	26.67	56.67	151.67	56.67	25.00

TABLE 4

Source	SS	df	MS	F
Treatments (between groups)	50,623	5	10,124.60	$\frac{10,124.60}{6,241.10} = 1.62$
Error (within groups)	187,233	30	6,241.10	
TOTALS	237,856	35		

$F_{.05}$ (5,30) = 2.53

$F_{.01}$ (5,30) = 3.70

STUDY #1

TABLE 5

SCHEDULE OF REINFORCEMENT VS. NUMBER OF REINFORCEMENTS

	100F	67F	33F	0F	67V	33V
	30	28	11	0	23	8
	34	20	11	0	18	7
	41	19	13	0	20	7
	31	15	11	0	21	10
	22	22	9	0	16	10
	35	16	9	0	16	11
$\overline{X}$ =	32.17	20	10.67	0	19.00	8.83

TABLE 6

SCHEDULE OF REINFORCEMENT VS. NUMBER OF R'S

	100F	67F	33F	0F	67V	33V
	40	46	40	32	36	28
	42	39	40	34	30	25
	52	33	42	28	39	28
	40	28	37	30	40	35
	30	39	32	30	29	36
	42	30	32	39	34	38
$\overline{X}$ =	41	35.83	37.17	32.17	34.67	31.67

STUDY #1

TABLE 7

SCHEDULE OF REINFORCEMENT VS. NUMBER OF N-RE TRANSITIONS

	100F	67F	33F	0F	67V	33V
	32	40	22	0	30	16
	28	24	22	0	27	12
	24	29	24	0	31	13
	23	28	21	0	23	17
	24	26	18	0	28	15
	31	17	17	0	29	18
$\bar{X}$ =	27.00	27.33	20.67	0	28.00	15.17

TABLE 8

SCHEDULE OF REINFORCEMENT VS. NUMBER OF R'S/RE

	100F	67F	33F	67V	33V
	1.33	1.64	3.64	1.57	3.50
	1.24	1.95	3.64	1.67	3.57
	1.27	1.74	3.23	1.95	4.00
	1.29	1.87	3.36	1.90	3.5
	1.36	1.77	3.56	1.81	3.6
	1.20	1.88	3.56	2.13	3.45
$\bar{X}$ =	1.28	1.81	3.50	1.84	3.60

A Pearson product-moment correlation coefficient was obtained for: number of RE's, number of R's per RE, number of L-L, clusters of L, and N-RE transitions, each vs. number of extinction trials. The respective correlation coefficients are -0.3368, 0.0274, 0.2701, -0.0704, and -0.4240. These results are listed in Tables A, B, C, D, and E found in Appendix IV.

Study #2

Study #2 compares extinction under the two conditions of "light on" and "light off." A two-way analysis of variance (fixed effects) was conducted on the data of Table 13. These data are rearranged in Table 11, and the results of the analysis are listed in Table 12. They indicate that a significant difference ($F = 13.79$) exists between extinction "light on" and extinction "light off." The results, however, again reveal that extinction did not occur in a pattern directly related to schedules of reinforcement. There was no "row" significance ($F = 1.39$). There was also no significant interaction between the six levels of reinforcement and the two levels of "light on" and "light off."

Tables 9, 10, 14, 15, 16 and 17 correspond respectively to Tables 1, 2, 7, 5, 6, and 8 of Study #1. The number of entries in the former tables, however, are double those of the latter. Notice the similarity (in magnitude) of the $\overline{X}$'s in Tables 14, 15, 16 and 17 of Study #2 and those of Tables 7, 5, 6, and 8 of Study #1 respectively.

Pearson product-moment correlation coefficients were obtained for RE, $\frac{R}{RE}$, L-L, cluster of L, and N-RE, each (with light and no light) vs. number of extinction trials.[148] The coefficients are (0.2311, 0.4057),

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[148] See Tables F, F', G, G', H, H', I, I', J, and J' in Appendix IV.

STUDY #2 (Acq. = 60 trials, 6 blocks; N = 72)

Table 9

S	Sch.	BL 1 1234567890	BL 2 1234567890	BL 3 1234567890	BL 4 1234567890	BL 5 1234567890	BL 6 1234567890
1	67F/L	xx xx	xx x	x xx	xx xx	x x xx	xx xx
2	0F/L						
3	67V/L	x x	x x	x xx x x	x xx	xx x	xx x
4	33F/N	x x	x	x x	x	x x	x x
5	100F/L	xx x xx	xx x	x xx	x x x x	x xx	xx x
6	0F/N						
7	33V/N	x	x	x x	x	x x	
8	100F/N	x x x	x x x	x x x x	x x xxx	xxx x	x x xxxx
9	67F/N	xx	x x	xx xx	xx	xx xx	x x
10	67V/L	xx x x	xxxx	x x	xxx x x	x x xxx	x x
11	67V/N	xx x	x x	xxx	x x x x	x x x x	x xxx
12	33V/L	x	x x	x x	x x	x x	x x
13	33F/N	x	x x	x	x x	x x x	x x
14	0F/L						
15	100F/L	xx xx	x xxxx x	xx xxx	x x x x x	xxx x xxx	x xx xxxxx
16	67V/N	xx	x x x	x xx	xxx xxx	xxx x	x x xx x
17	33V/N	x	x	x	x x	x	x
18	100F/L	x x xx	xx xx x	x x x x	xxx x xx x	xxxx xxx	x xx xxx
19	0F/N						
20	33V/N	x	x		x x	x x	x
21	33F/L	x	x	x x	x	x	x x
22	67F/L	x x	x x x	x	xx xx	xx xx	x x x
23	100F/N	x x x	xxx x	x x x	x x xx x	x xxx	x x x
24	33F/L	x x	x	x	x x	x x	x
25	67V/N	x x x	x xx	x x	x x x	x	x xx
26	100F/L	xx xx xxx	xxx x	xxx xxx	x xxxx	xxxx xxx	x xx
27	33V/N	x	x	x x	x	x x	x
28	100F/N	xx xx	xx xx x	x xx	xx x xx x	xx x xx	xx xx xx
29	0F/L						
30	67V/L	x x xxx	x x x x	x x x x x	xx x x	x xx x	xx x xx
31	100F/L	x x x	x x x x	x x xx	x x xx x	x x xx	x xx x xx
32	67V/L	xx xx	x x x	x x x	x x x	xxx xx	x x xx
33	67F/N	x x x	x x	x xx	xx x x	xx	xx xx
34	0F/N						
35	33F/L	x x	x	x x	x	x x	x

Table 9 (continued)

S	Sch.	BL 1 1234567890	BL 2 1234567890	BL 3 1234567890	BL 4 1234567890	BL 5 1234567890	BL 6 1234567890
36	OF/L						
37	33F/N	x x	x x	x	x x	x	x
38	33V/L	x	x x	x x	x	xx	x x
39	100F/N	x xx x	x xx	x x xx	xxx x x	xxxx xx	xx
40	67F/N	xx x	x xx	x x xx	x x x x	x x xx	x x x
41	67F/N	xx x x	xx x x	xx xx x	x xx x	x xx xx	xx xx x
42	67F/L	x x xx	xx	x x x	x xx	x x xx	x x
43	33V/L	x	x	x	x	x x	x
44	100F/L	xx x x x	xxx x x	xx x x	xxx xx x x	x xx xxx	xx xxx
45	67V/N	x x	x x x	x x x	x x x x	xxx x	xx xx
46	33F/N	x x	x	x x	x x	x	x x
47	33F/L	x x	x	x x	x x	x x	x x
48	67V/N	xx x	x xx	x xx xx	x x x	x x x	x x xx
49	33V/N	x x	x	x	x x	x	x
50	OF/L						
51	67F/N	xx x	x xx x	x x x	xx xx x	x xx	x x xx
52	33F/L	x x	x	x x	x x x	x	x x x
53	33V/L	x	x	x x	xx	x	x
54	67F/L	xx	xx	xx xx	x x x	x x x	x x xx
55	67V/L	xx x	x x x	x x x	x x x	x x x	x x x
56	33F/N	x x	x	x	x x	x	
57	33F/L	x	x x	x	x x	x	x x
58	OF/L						
59	100F/N	x x x	x xx x x	xx xxx	xxx xxx x	x xxx xx	x xx xxxxx
60	67F/L	x x	xx	x x x	x x x	x x x	x x
61	33V/L	x x	x x	x	x x	x	x x x
62	33V/L	x	x	x x	x	xx	x
63	33F/N	x x	x	x	x	x	x x
64	67V/L	x x x	x xx	x x x x	x xxx x	x xx xx	x x x
65	100F/N	xx x xx	xxxxxx x	x x x x x	xx xxxx x	x xxx xxx	x xx x xxx
66	67V/N	x x x	x x x x	x x	x x	xx x	x x x
67	OF/N						
68	33V/N	x x	x	x	x	xx	x x
69	67F/L	x x	x x	x x xx	xx x	x x x x	x x x
70	OF/N						
71	67F/N	xx x	x x x	x x	x x x	x x x x	x xx
72	OF/N						

STUDY #2 (Acq. = 60 trials, 6 blocks; N = 72)

Table 10

S	Sch.	Number of R's BL 1	BL 2	BL 3	BL 4	BL 5	BL 6	No. of Ext. Trials	No. of R's	No. of RE's	No. of R's per RE	No. of L-L	Cluster of L (3 or more)	N-RE Transi-tions*
1	67F/L	5	5	4	7	8	7	250	36	22	3.44	8	3	25
2	0F/L	5	4	3	6	4	4	60	26	0	1.73	7	6	0
3	67V/L	4	6	7	5	6	7	20	35	18	1.16	5	3	28
4	33F/N	6	5	5	5	5	7	220	33	10	4.25	8	2	20
5	100F/L	6	4	5	5	4	4	20	28	21	1.14	5	6	29
6	0F/N	3	6	4	4	5	7	20	29	0	--	6	5	0
7	33V/N	3	5	6	4	4	5	64	27	7	1.78	7	2	14
8	100F/N	4	5	5	6	5	7	40	32	25	1.12	5	0	31
9	67F/N	3	5	5	5	6	6	40	30	16	1.95	7	7	20
10	67V/L	7	8	6	8	7	7	230	43	22	1.83	3	1	27
11	67V/N	4	5	5	6	6	6	40	32	20	--	8	4	29
12	33V/L	4	6	8	7	8	8	110	41	11	3.22	4	2	22
13	33F/N	4	6	7	8	10	7	90	42	11	--	2	1	22
14	0F/L	4	4	4	5	3	5	60	25	0	3.44	8	3	0
15	100F/L	5	7	5	7	9	9	30	42	35	3.5	5	1	31
16	67V/N	3	8	6	10	9	9	360	45	23	1.29	2	2	27
17	33V/N	2	4	5	6	4	5	20	26	7	2.00	6	6	14
18	100F/L	5	6	6	9	9	7	360	42	33	1.81	3	1	36
19	0F/N	3	5	5	7	4	7	40	31	0	2.06	6	5	0
20	33V/N	6	3	0	8	6	6	50	29	7	4.29	4	3	13
21	33F/L	4	4	5	4	5	5	20	27	8	1.25	7	3	16
22	67F/L	5	4	4	7	6	6	360	32	17	1.80	5	3	26
23	100F/N	3	4	4	6	4	4	30	25	22	3.60	9	6	33
24	33F/L	5	3	6	5	6	6	20	31	9	3.55	7	5	18
25	67V/N	4	5	5	4	3	5	20	26	15	1.71	8	4	25
26	100F/L	7	5	7	7	7	4	190	37	32	3.63	7	5	23
27	33V/N	4	5	7	6	6	6	20	34	8	--	2	2	16
28	100F/N	5	6	4	6	6	6	100	33	29	1.77	8	2	32
29	0F/L	4	4	5	8	7	7	270	35	0	3.33	4	3	0
30	67/L	7	9	7	8	9	8	360	48	27	3.88	4	0	36

STUDY #2 (Acq. = 60 trials, 6 blocks; N = 72)

Table 10 (continued)

S	Sch.	Number of R's BL 1	BL 2	BL 3	BL 4	BL 5	BL 6	No. of Ext. Trials	No. of R's	No. of RE's	No. of R's per RE	No. of L-L	Cluster of L (3 or more)	N-RE Transi-tions*
31	100F/L	4	5	4	5	4	7	360	29	26	1.12	9	3	40
32	67V/L	8	7	6	7	7	8	360	37	18	2.06	2	1	30
33	67F/N	5	5	5	6	5	7	80	33	18	1.83	5	4	25
34	0F/N	5	3	5	5	4	6	79	28	0	--	8	5	0
35	33F/L	4	6	5	4	5	5	360	29	9	3.22	9	2	17
36	0F/L	4	3	4	4	7	8	20	30	0	--	7	5	0
37	33F/N	6	6	4	6	5	4	20	31	9	3.44	7	3	17
38	33V/L	5	6	5	7	6	6	20	35	10	3.5	6	4	17
39	100F/N	5	4	6	6	7	3	70	31	24	1.29	5	6	27
40	67F/N	6	7	6	8	8	7	50	42	21	2.00	1	2	34
41	67F/N	6	7	9	8	9	10	110	49	27	1.81	3	3	34
42	67F/L	6	5	6	7	7	6	360	37	18	2.06	2	2	27
43	33V/L	5	4	4	6	5	6	27	30	7	4.29	3	1	14
44	100F/L	6	7	4	9	8	6	40	40	32	1.25	4	2	35
45	67V/N	4	5	4	7	9	7	340	36	20	1.80	7	2	32
46	33F/N	5	4	6	8	6	7	40	36	10	3.60	5	4	20
47	33F/L	5	6	5	7	8	8	100	39	11	3.55	7	3	21
48	67V/N	5	6	7	6	6	6	43	36	21	1.71	8	2	29
49	33V/N	6	4	5	4	6	4	20	29	8	3.63	6	4	15
50	0F/L	5	7	6	9	7	8	360	42	0	--	2	0	0
51	67F/N	5	7	6	9	6	7	30	39	22	1.77	4	3	30
52	33F/L	5	6	5	9	7	8	270	40	12	3.33	5	2	23
53	33V/L	3	6	6	5	4	7	360	31	8	3.88	5	3	14
54	67F/L	5	3	7	5	5	7	360	32	18	1.78	7	4	26
55	67V/L	5	5	5	5	5	7	140	32	18	1.78	7	3	34
56	33F/N	5	5	3	6	3	4	73	26	6	4.33	4	5	11
57	33F/L	3	6	4	6	5	6	70	30	9	3.33	8	2	18
58	0F/L	5	4	4	5	4	6	20	28	0	--	5	4	0
59	100F/N	3	6	6	8	8	10	60	41	34	1.21	5	3	29
60	67F/L	3	5	5	6	4	5	44	28	15	1.87	6	3	28

STUDY #2 (Acq. = 60 trials, 6 blocks; N = 72)

Table 10 (continued)

S	Sch.	Number of R's BL 1	BL 2	BL 3	BL 4	BL 5	BL 6	No. of Ext. Trials	No. of R's	No. of RE's	No. of R's per RE	No. of L-L	Cluster of L (3 or more)	N-RE Transi-tions*
61	33V/L	6	8	6	7	8	8	90	43	11	3.91	1	0	21
62	33V/L	4	4	6	7	6	6	360	33	8	4.13	3	4	13
63	33F/N	6	3	5	4	7	7	80	32	8	4.00	4	6	16
64	67V/L	5	5	7	9	9	8	360	43	23	1.87	3	2	35
65	100F/N	5	9	6	9	9	9	330	47	38	1.24	2	0	34
66	67V/N	5	6	4	5	5	6	50	31	17	1.82	6	3	32
67	0F/N	6	5	6	6	4	5	20	32	0	--	6	4	0
68	33V/N	6	5	5	3	7	5	20	31	9	3.44	8	3	15
69	67F/L	2	6	7	5	8	6	210	34	18	1.89	5	4	29
70	0F/N	5	5	4	6	6	4	20	36	10	3.60	7	2	20
71	67F/N	5	5	6	6	6	6	80	34	18	1.88	5	0	32
72	0F/N	6	7	6	7	7	6	80	39	0	--	5	2	0

*A change from reinforcement to non-reinforcement or vice versa is called a transition. For example, NNRNRRNNNRN has six transitions.

STUDY #2

TABLE 11

NOTE: ENTRIES IN CELLS ARE NUMBERS OF EXTINCTION TRIALS

	Lt.			No Lt.		Σ
	20		190	40	70	
100F	30		360	30	60	
	360		40	100	330	1,630
		(1,000)			(630)	
	250		360	40	110	
67F	360		44	80	30	
	360		210	50	80	1,974
		(1,584)			(390)	
	20		100	220	40	
33F	20		270	90	73	
	360		70	20	80	1,363
		(840)			(523)	
	60		20	20	20	
0F	60		360	40	20	1,049
	270		20	79	80	
		(790)			(259)	
	20		360	40	340	
67V	230		140	360	43	
	360		360	20	50	2,323
		(1,470)			(853)	
	110		360	64	20	
33V	20		90	20	20	
	27		360	50	20	1,161
		(967)			(194)	
Σ		6,651			2,849	9,500

STUDY #2

TABLE 12

Source	SS	df	MS	F	F(1%)	F(5%)
Rows	101,194.11	5	20,238.82	1.39	3.34	2.37
Columns	200,766.72	1	200,766.72	13.79	7.08	4.00
Interaction	42,833.62	5	8,566.72	.59	3.34	2.37
Error	873,413.33	60	14,556.88			
TOTALS	1,218,207.78	71				

STUDY #2

TABLE 13

SCHEDULE OF REINFORCEMENT VS. NUMBER OF EXTINCTION TRIALS

Light						No Light					
100F	67F	33F	0F	67V	33V	100F	67F	33F	0F	67V	33V
20	250	20	60	20	110	40	40	220	20	40	64
30	360	20	60	230	20	30	80	90	40	360	20
360	360	360	270	360	27	100	50	20	79	20	50
190	360	100	20	360	360	70	110	40	20	340	20
360	44	270	360	140	90	60	30	73	20	43	20
40	210	70	20	360	36	330	80	80	80	50	20
$\bar{X}$=166.67	264.00	140.00	131.67	245	107.17	$\bar{X}$=105	65	87.17	43.17	142.17	32.33

STUDY #2

TABLE 14

SCHEDULE OF REINFORCEMENT VS. NUMBER OF N-RE TRANSITIONS

Light						No Light					
100F	67F	33F	0F	67V	33V	100F	67F	33F	0F	67V	33V
29	25	16	0	28	22	31	20	20	0	29	14
31	26	18	0	27	17	33	25	22	0	27	14
36	27	17	0	36	14	32	34	17	0	25	13
23	26	21	0	30	14	27	34	20	0	32	16
40	28	23	0	34	21	29	30	11	0	29	15
35	29	18	0	35	13	34	32	16	0	32	15
$\bar{X}$=32.33	26.83	18.83	0	31.67	16.83	$\bar{X}$=31.00	29.17	17.67	0	29.00	14.50

STUDY #2

TABLE 15

SCHEDULE OF REINFORCEMENT VS. NUMBER OF RE'S

Light						No Light					
100F	67F	33F	0F	67V	33V	100F	67F	33F	0F	67V	33V
21	22	8	0	18	11	25	16	10	0	20	7
35	17	9	0	22	10	22	18	11	0	23	7
33	18	9	0	27	7	29	21	9	0	15	7
32	18	11	0	22	8	24	27	10	0	20	8
26	15	12	0	18	11	34	22	6	0	21	8
32	18	9	0	23	8	38	18	8	0	17	9
$\bar{X}$=29.83	18.00	9.67	0	21.67	9.17	$\bar{X}$=28.67	20.33	9.00	0	19.33	7.67

STUDY #2

TABLE 16

SCHEDULE OF REINFORCEMENT VS. NUMBER OF R'S

Light						No Light					
100F	67F	33F	0F	67V	33V	100F	67F	33F	0F	67V	33V
28	36	27	26	35	41	32	30	33	29	32	27
42	32	31	25	43	35	25	33	42	31	45	26
42	37	29	35	48	30	33	42	31	28	26	29
37	32	39	30	43	31	31	49	36	32	36	34
29	28	40	42	32	43	41	40	26	30	36	29
40	34	30	28	43	33	47	34	32	39	31	31
$\bar{X}$=36.33	33.17	32.67	31.00	40.67	35.50	$\bar{X}$=34.83	38.00	33.33	31.50	34.33	29.33

STUDY #2

TABLE 17

SCHEDULE OF REINFORCEMENT VS. NUMBER OF CR/RE

Light						No Light					
100F	67F	33F	0F	67V	33V	100F	67F	33F	0F	67V	33V
1.33	1.64	3.38	--	1.94	3.73	1.28	1.88	3.30	--	1.60	3.86
1.20	1.88	3.44	--	1.95	3.50	1.14	1.83	3.82	--	1.96	3.71
1.27	2.06	3.22	--	1.78	4.29	1.14	2.00	3.44	--	1.73	4.14
1.16	1.78	3.55	--	1.95	3.88	1.29	1.81	3.60	--	1.80	4.25
1.12	1.87	3.33	--	1.78	3.91	1.21	1.82	4.33	--	1.71	3.63
1.25	1.89	3.33	--	1.87	4.13	1.24	1.89	4.00	--	1.77	3.44
$\bar{X}$=1.22	1.85	3.38	--	1.88	3.91	$\bar{X}$=1.22	1.87	3.75	--	1.76	3.84

TABLE 18

Study I	Study II
A(-0.3368)	F'(0.4057)
B(0.0274)	G'(-0.2205)
C(0.2701)	H'(-0.2631)
D(-0.0704)	I'(-0.3831)
E(-0.4240)	J'(0.3282)

(-0.1895, -0.2205), (-0.2432, -0.2631), (-0.3351, -0.3831), and (0.2645, 0.3282) respectively. It is worth noting that the correlation coefficient (no light) which is the second entry in an ordered pair has turned out, in each case, to be larger[149] than the correlation coefficient (light) which is the first entry of the ordered pairs. Table 18 compares the correlation coefficients of Tables A, B, C, D, and E of Study #1 with those of Tables F', G', H', I', and J' of Study #2 respectively. One can easily note that with the exception of D and I' all coefficients of Study #1 bear an inverse signed relationship with those of Study #2. Overlooking the sign there was quite a difference in the size of the coefficients between the coefficients of B and G' and those of D and I'.

Study #3

This is a study designed to determine the number of trials required to reach criterion in each of the six reinforcement conditions. Tables 23 and 24 show the number of acquisition trials under each schedule of reinforcement that took the 36 Ss to reach the first (.8) criterion and the first (.8) criterion after 60 trials respectively. A one-way analysis of variance (fixed effects) was run on the data of each of Tables 23 and 24 to determine the differential effects of reinforcement on acquisition. The results of the analysis are listed in Tables 25 and 26 respectively and indicate that there is no significant difference among the six schedules of reinforcement in their influence on acquisition. It is worth noting, however, that there is not as much variation in the sums of the column entries (and hence in the means) in Table 24 as there is in Table 23.

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[149] In absolute value.

STUDY #3

TABLE 19

S	Sch.	Sex	Bl 1	BL 2	BL 3	BL 4	BL 5	BL 6	BL 7	BL 8	BL 9	BL 10	BL 11	BL 12	BL 13	BL 14	BL 15
1	100F	M	3	3	5	9	7	8	8								
2	100F	M	6	3	6	6	7	8	8								
3	100F	M	4	5	6	4	6	8	7	8							
4	100F	F	4	6	7	7	8	10	9	10	9	9	8				
5	100F	F	4	5	6	6	5	7	7	6	6	6	7	6	8		
6	100F	F	4	6	6	4	9	7	8								
7	67F	F	6	5	5	4	5	5	4	6	5	6	7	7	8		
8	67F	F	5	5	6	8	6	8	7	8							
9	67F	F	5	2	6	3	4	2	4	5	4	3	4	3	8		
10	67F	F	4	7	7	8	7	7	9	6	9	9	9	8			
11	67F	M	5	4	6	7	8	8	9	8							
12	67F	M	5	5	4	6	5	7	7	5	6	6	7	6	6	7	6
13	33F	F	4	2	5	6	9	8	8								
14	33F	F	6	5	6	4	6	7	7	6	6	8					
15	33F	F	5	4	5	9	7	6	5	4	6	5	5	6	6	6	8
16	33F	F	6	4	6	4	5	5	6	3	7	3	8				
17	33F	F	5	5	6	6	6	5	6	6	7	7	7	8			
18	33F	F	4	7	5	6	3	5	4	6	4	5	4	7	4	7	4
19	0F	F	4	5	3	7	7	10	8								
20	0F	F	6	4	6	4	7	7	7	6	8						
21	0F	F	6	2	5	3	6	2	3	2	6	2	4	6	5	4	7
22	0F	M	4	7	6	9	9	7	8								
23	0F	F	5	9	4	8	9	8	8								
24	0F	M	5	5	5	6	5	4	5	6	7	8					
25	67V	M	5	8	5	8	9	7	8								
26	67V	M	4	5	5	5	7	6	7	5	7	8					
27	67V	M	4	8	9	7	9	8	9	7	9	9	10	9	10	9	10
28	67V	M	7	5	7	7	7	5	8								
29	67V	F	6	6	8	8	9	6	9	8							
30	67V	F	4	6	4	6	7	4	6	6	5	5	6	10	5	8	
31	33V	M	8	6	8	8	9	9	9	9	10	8					
32	33V	M	4	7	4	4	4	4	6	5	5	4	5	3	4	5	6
33	33V	M	3	3	8	8	7	6	5	6	8						
34	33V	M	4	8	9	10	5	4	9	5	8						
35	33V	F	5	5	9	7	9	7	8								
36	33V	F	5	1	4	4	5	4	3	4	7	7	7	8			

STUDY #3

TABLE 19 (continued)

	BL 16	BL 17	BL 18	BL 19	BL 20	BL 21	BL 22	BL 23	BL 24	BL 25	BL 26	BL 27	BL 28	BL 29	BL 30
1															
2															
3															
4															
5															
6															
7															
8															
9															
10															
11															
12	7	8													
13															
14															
15															
16															
17															
18	7	6	6	6	6	5	6	7	7	7	7	5	6	7	8
19															
20															
21	10	5	6	4	8										
22															
23															
24															
25															
26															
27	9	10	10	10	10	10	10	9	10	8					
28															
29															
30															
31															
32	4	5	7	5	5	6	7	8							
33															
34															
35															
36															

STUDY #3

TABLE 20

SCH. VS. NO. OF RE'S

100F	67F	33F	0F	67V	33V
32	40	11	0	27	22
34	30	16	0	33	30
36	29	23	0	118	14
69	48	15	0	26	15
67	29	22	0	32	14
35	55	43	0	44	16
$\bar{X}$ = 45.50	38.50	21.67	0	46.67	18.50

TABLE 21

SCH. VS. NO. OF R'S

100F	67F	33F	0F	67V	33V
43	73	42	44	50	84
44	53	61	55	59	117
48	53	87	96	223	54
87	90	57	50	46	62
79	55	74	51	60	50
44	103	171	56	82	59
$\bar{X}$ = 57.50	71.17	82.00	58.67	86.67	71.00

STUDY #3

TABLE 22

SCH. VS. R/RE

	100F	67F	33F	0F	67V	33V
	1.34	1.83	3.82	--	1.85	3.82
	1.29	1.77	3.81	--	1.79	3.90
	1.33	1.83	3.78	--	1.89	3.86
	1.26	1.88	3.80	--	1.77	4.13
	1.18	1.90	3.36	--	1.88	3.57
	1.26	1.87	3.98	--	1.86	3.69
$\bar{X}$ =	1.28	1.85	3.76	--	1.84	3.83

TABLE 23

NO. OF TRIALS AT FIRST (.8) CRITERION

100F	67F	33F	0F	67V	33V
60	130	60	70	20	10
60	40	100	90	100	230
60	130	150	200	20	30
50	40	110	70	70	20
130	50	120	40	30	70
70	170	300	100	140	120
$\sum$ = 430	560	840	570	380	480

STUDY #3

TABLE 24

NO. OF TRIALS AT FIRST (.8) CRITERION AFTER 60 TRIALS

100F	67F	33F	0F	67V	33V
70	130	70	70	70	100
70	80	100	90	100	230
80	130	150	200	250	90
110	120	110	70	70	90
130	80	120	70	80	70
70	170	300	100	140	120
$\sum$ = 530	710	850	600	710	700

TABLE 25

Source	SS	df	MS	F
Treatment (between groups)	22,089	5	4,417.8	1.12
Error (within groups)	118,100	30	3,936.6	
Total	140,189	35		

TABLE 26

Source	SS	df	MS	F
Treatment (between groups)	9,989	5	1,998	.621
Error (within groups)	96,467	30	3,216	
Total	106,456	35		

$F_{.05}$ (5,30) = 2.53 $F_{.01}$ (5,30) = 3.70

TABLE 27

SEX VS. NO. OF ACQUISITION TRIALS

Male	Female
70	110
70	130
80	70
80	130
170	80
70	130
100	120
70	70
100	100
250	150
70	110
100	120
230	300
90	70
90	90
	200
	70
	80
	140
	70
	120

TABLE 28

t-TEST FOR DATA IN TABLE 27

Male	Female
$\bar{X}_1 = 109.33$	$\bar{X}_2 = 117.14$
$S_1^2 = 3232.89$	$S_2^2 = 3687.07$
$N_1 = 15$	$N_2 = 21$

$t = -0.38$*

*For a similar illustration see (131), p. 320.

Table 19 lists the number of R's in each block and the sex of each subject that participated in the experiment. To determine if a sex difference existed in regard to acquisition a t-test was conducted. The data and results are listed in Tables 27 and 28 respectively. The value of t = -0.38 indicated that there was no significant difference between the two sexes.

Tables 20, 21, and 22 list respectively the number of RE's, number of R's, and number of $\frac{R's}{RE}$, each vs. the six schedules of reinforcement. Note again how the $\overline{X}$'s of $\frac{R}{RE}$ of Table 4 are almost identical with those of Table 8 (Study #1) and Table 17 (Study #2).

Study #4

Study #4 is a repetition of Study #2 with the number of acquisition trials increased to 90 trials. The first question one might ask is: Did the six schedules of reinforcement have any differential effects upon extinction? A two-way analysis of variance (fixed effects) was conducted on the data of Table 32. These data are rearranged in Table 33, and the results of the analysis are shown in Table 34. Again, as in Study #2, there was only "column" significance (F = 20.06), i.e., extinction (light on) differed significantly from extinction (light off). There was no "row" or interaction significance. The "row" non-significance can mean (a) that reinforcement in this study had a negligible effect upon extinction, and/or (b) that in this study, both fixed and variable reinforcement had a negligible effect upon extinction.

(1) The number of reinforcements, (2) the number of non-reinforced trials, (3) the average number of "R's" during the last two blocks,[150] i.e.,

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[150] Acquisition blocks.

the number of "R's" in the eighth block plus the number of "R's" in the ninth block divided by two, (4) the number of acquisition trials which took S to say 8 or more "R's" in 10 consecutive trials, (5) the number of overtraining trials, i.e., 90 trials minus the number of acquisition trials recorded in (4), (6) the number of N-RE transitions, and (7) the number of R's per RE, each (with "light on" and "light off") has been investigated with respect to effect on extinction. The respective data appear in Tables (35,36), (37,38), (39,40), (41,42), (43,44), (45,46), and (47,48). The analyses of covariance,[151] with the corresponding tests of homogeneity of regression for the data in these tables appear in Tables (a,a'), (b,b'), (c,c'), (d,d'), (e,e'), (f,f'), and (g,g') respectively.[152]

Since $F_{.05}$ (5,24) = 2.62, one can see that all the data in Tables 35 through 46 have met the test of hypothesis of common slope for all populations. Therefore, $F_{.05}$ (5,29) = 2.55 implies that none of the F-ratios (for the data in these tables) of the analyses of covariance has turned out significant.

$F_{.05}$ (4,20) = 2.87 and $F_{.05}$ (4,24) = 2.78 make the F-ratios of homogeneity of regression (F_H) for the data in Table 47 significant (F_H = 3.03), but the F-ratios of the analysis of covariance (F_C) for the same data non-significant (F_C = .495). Therefore, no reliable information can be concluded from the result of the analysis of covariance conducted on such data. However, in view of the fact that 3.03 is not too different from 2.87, one might accept the non-significance of the F_C as an established

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[151] In the "Analysis of Covariance" the covariable is usually considered not to be affected by the treatment. To satisfy this assumption, extinction was considered to be the treatment.

[152] See Appendix IV.

fact. The data in Table 48 met the homogeneity of regression hypothesis and led to a non-significant F-ratio in the analysis of covariance.

Pearson product-moment correlation coefficients for RE, R/RE, L-L, cluster of L, N-RE, non-reinforced trials, average "R" in last two acquisition blocks, each (with "light on" and "light off") are shown in Tables (K,K'), (L,L'), (M,M'), (N,N'), (O,O'), (P,P'), and (Q,Q') respectively. The respective values of the coefficients are: (0.1874, 0.2859), (-0.1652, 0.0235), (-0.2718, -0.2994), (-0.2577, -0.5441), (0.0368, 0.3205), (-0.1876, -0.2859), and (0.4377, 0.3121). With the exception of (L,L') and (Q,Q') the numerical value of the second entry in an ordered pair, i.e., the (No Lt.) coefficient (excluding the sign) again happens to be larger than the first entry in the ordered pair. Important amongst all of these coefficients is the value -0.5441 expressing the degree of negative correlation existing between number of clusters of L and number of extinction trials (No Lt.).

Tables 29 and 30 of Study #4 are identical in structure to Tables 9 and 10 of Study #2.

The number of R's, the number of RE's, and the number of R's per RE, each (with Lt. and No Lt.) under the six schedules of reinforcement are shown in Tables (49,50), (51,52), and (53,54) respectively. The data in these tables follow the same pattern (as indicated by the $\bar{X}$'s) as those shown in Tables 16, 15, and 17 of Study #2 respectively.

Table 55 is a summary of the $\bar{X}$'s of R/RE (under the schedules of reinforcement indicated) for all four studies. The numerical values under (1) 100F, (2) 67F and 67V, and (3) 33F and 33V, range from 1.22 to 1.28 in the first case, from 1.77 to 1.88 in the second, and from 3.38 to 3.91

in the third. It should be noted that these 3 categories seem distinct from each other.

Table 56 represents the number of extinction trials (Lt.) under the 100F, 67F, 33F, and 0F schedules of reinforcement. A trend analysis was conducted on the data of Table 56 and the results are shown in Table 57. The results indicate that neither the F-ratio for linear regression (F_l) nor the F-ratio for departure from linearity (F_d) is significant; a fact which demonstrates that a straight line is a good fit to the data and that the slope of this line is not significantly different from zero.

Tables 58 and 59 show the number of extinction trials (No Lt.) under the four fixed reinforcement schedules and the results of the trend analysis conducted on these data respectively. Both F_l and F_d again showed no significance. A Duncan's Range Test[153] was conducted on the data of Table 33 as a means of gaining more insight into the question of significance amongst the cells and double-checking on the results of the analysis of variance of Table 34. The cell corresponding to row 1 and column 1, i.e., to 100F and Lt., was labeled C_{11}; the cell corresponding to row 1 and column 2 was labeled C_{12}; and so on. (In other words, the first number of the subscript is the row number, the second is the column number.) The results of the test were as follows:

	Rows					
Row:	1	2	3	4	5	6
Mean:	224.2	150.8	197.5	151.7	164.2	143.3
Sum of Squares:	249,691.7	143,491.7	132,025	263,366.7	228,691.7	149,266.7

[153] See (138), pp. 173-182.

$S_e = 132.946$

df = 66

	Group				
	2	3	4	5	6
r_p:[154]	2.83	2.98	3.08	3.14	3.20
R_p:	106.125	111.750	115.500	117.750	120.000

	1	2	3	4	5	6
Means from lowest to highest:	143.3	150.8	151.7	164.2	197.5	224.2

Since 224.2 - 143.3 = 80.9 is less than every R_p value, no significant difference among the rows is apparent.

	Cells	
Cell	Mean	Sum of Squares
C_{11}	306.7	85,333.3
C_{21}	201.7	102.483.3
C_{31}	243.3	86,733.3
C_{41}	251.7	140,883.3
C_{51}	220.0	114,600
C_{61}	185.0	104,150
C_{12}	141.7	82,683.3
C_{22}	100	10,000
C_{32}	151.7	20,083.3
C_{42}	51.7	2,483.3
C_{52}	108.3	76,683.3
C_{62}	101.7	24,283.3

$S_e = 119.05$; df = 60.

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[154] Significance level = 5%. See (138), p. 175, Table 9.2.

Group	2	3	4	5	6	7	8	9	10	11	12
r_p:[155]	2.83	2.98	3.08	3.14	3.20	3.24	3.28	3.31	3.33	3.37	3.40
R_p	137.5	141.86	149.64	152.55	155.47	157.4	159.36	160.81	161.78	163.73	165.2

Means from lowest to highest:

1	2	3	4	5	6	7	8	9	10	11	12
51.7	100	101.7	108.3	141.7	151.7	185	201.7	220	243.3	251.7	306.7

Since 306.7 - 51.7 = 255.0 > 165.2, C_{11} and C_{42} are significantly different. Continuing in this manner, the following results were obtained:

1. No significant difference exists between any two cells of the first column (Lt.)
2. C_{11} differs with all cells of the second column (No Lt.) except C_{32}.
3. C_{21} does not differ with any cells of the second column.
4. C_{31} differs only with C_{42}.
5. C_{41} differs only with C_{42}.
6. C_{51} differs only with C_{42}.
7. C_{61} does not differ with any cells of the second column.

Summary

Analysis of the data revealed certain findings which are summarized in the following statements:

1. In Studies 1, 2, and 4, extinction of the response(s) learned in the two-choice probability learning situation took place when reinforcement was stopped and light was no longer turned on.

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[155] Significance level = 5%. See (138), p. 175, Table 9.2.

STUDY #4 (Acq. = 90 trials, 9 blocks; N = 72)

Table 29

S	Sch.	BL 1 1234567890	BL 2 1234567890	BL 3 1234567890	BL 4 1234567890	BL 5 1234567890	BL 6 1234567890	BL 7 1234567890
1	67F/L	x x x	x x x	xx	xx x x	xx xx	xx x	x x x
2	0F/L							
3	67V/L	xx	x x x	xxx x	x xx	xx x	x x xxx	x x x
4	33F/N	x x		x	x	x x x	x	x x
5	100F/L	xx x x	xx	x x x x x	xxx xxx	xx x xxx	x x xx x	x xx x x
6	0F/N							
7	33V/N	x	x	x x	x	x	x	x x x
8	100F/N	x xx x	x xxx x	x x	x x x	xx x x	x x x x	x xxx xxx
9	67F/N	xx	x x x x	x x	x x x	x x x x	x x x x	x xx xx
10	67V/L	xx	x x xx	x x x	x x x x	x x	x x xx x	x x xx
11	67V/N	xx	x x x	xx x	x x x	xxx x	x xxx	x x x x
12	33V/L	x x	x	x	x x	x x	x	x x
13	33F/N	x	x	x x	x	xx x	x x	x
14	0F/L							
15	100F/L	xx xx xx	xx x	x x x x	x xx x	x x x xx	x xx xx	x xxx xx
16	67V/N	xx x x	x xxx	x x	xxx x x	x xx x	x x x	xx xx x
17	33V/N	x	x	x x	x x	x	xx	x x x
18	100F/L	xx x	x xx	x x xx	xx xxx x	xxxxx xxx	x xx xxxxx	xxx xxx
19	0F/N							
20	33V/N	x x	xx	x	xx x	xx	x	xx x
21	33F/L	x	x	x	x x	x x	x	x x x
22	67F/L	xx x x	x x x	x xx x x	xx x x	x x xx	xx xx	xx xx
23	100F/N	xxx	xxxxxxx x	xxx xxxx	xxx xxxx	xxxx xxx	x xx xxxx	xxx xxx
24	33F/L	x x	x	x	x	x x	x	x
25	67V/N	x x x x	x	x x x	x x x	x xx x	x	xx xx x
26	100F/L	x x xx	x xxxx x	x x xxx	xx xxxx x	xx x xx	x xx xxx	xx xxx xxx
27	33V/N	x x	x x	x	x x	x x x	x xx	x
28	100F/N	xx x	x	x xx xxxx	xx xxx x	xxxxx xxx	x xx xx xx	xx xxx xxx
29	0F/L							
30	67V/L	xx x	x xxx x	x	x xxxx	x x x	x x x x x	xxx x
31	100F/L	x x xx	xx x x	x x x x	xx xxxx	x xx xxx	xx xxxx	xx xx xxx
32	67V/L	xx x	x x	x xx	x x x	xx x x	x xx xx	x x xx
33	67F/N	xx x x	xx	xx xx	x x	xx x	x x x	xx x x
34	0F/N							
35	33F/L	x x	x	x	x	x	x	x
36	0F/L							
37	33F/N	x	x x	x	x x	x	x x	x x

Table 29 (continued)

S	Sch.	BL 8 1234567890	BL 9 1234567890
1	67F/L	x x xx	x x xx
2	0F/L		
3	67V/L	xxx x	x x x x
4	33F/N	x x	x x
5	100F/L	x xxx	x xx xxxx
6	0F/N		
7	33V/N	x x	x x
8	100F/N	x xxx x	xxx xxx
9	67F/N	xx x x	xx xx
10	67V/L	xx x	x xx xx
11	67V/N	xxx x	x xx
12	33V/L	x	x x
13	33F/N	xx x	xx x
14	0F/L		
15	100F/L	x x xx x	x x xx xx
16	67V/N	x xxxx	xx xx
17	33V/N	x xx	x xx
18	100F/L	xxxxxxx x	x xxx xxxx
19	0F/N		
20	33V/N	xx	x xx
21	33F/L	x x	x xx
22	67F/L	xx xx x	x x x xx
23	100F/N	x xxx x	x xxx
24	33F/L	x x	x x
25	67V/N	x xx x	x x x
26	100F/L	xxx xxx x	x x x xxxx
27	33V/N	xx x	xx x
28	100F/N	xx x x	x xxx xxxx
29	0F/L		
30	67V/L	x x x x	x x x x
31	100F/L	x xx xx x	x x x xxx
32	67V/L	x x x x	xx xx
33	67F/N	xx xx x	x xx
34	0F/N		
35	33F/L	x x	x x
36	0F/L		
37	33F/N	x x	x x

Table 29 (continued)

S	Sch.	BL 1 1234567890	BL 2 1234567890	BL 3 1234567890	BL 4 1234567890	BL 5 1234567890	BL 6 1234567890	BL 7 1234567890
38	33V/L	x	x x	x	xx	x	x x x	x x
39	100F/N	x xx xxx	xxxxx x x	x x x x x	xxx xxx x	xx xx xx	x xx xxxxx	xx xxx xxx
40	67F/N	xx	xx x	x x x xx	xx x x	x x x	x x x x	x xx xx
41	67F/N	x x x	x xx x	x x x x	x x x xx	x x x x x	x x x	xx xx xx
42	67F/L	xx xx xx	xx xx	xx xx x	x x x xx	xx xx x x	x x x x	x xx x
43	33V/L	x x	x x	x	x x	x	x x	x
44	100F/L	xx	xx x	x xxxx	xxxx x	x x x	x x x	xx xxx x
45	67V/N	x x x	x	x xx	x x x	xxx x x	x xxx x	x x xxx
46	33F/N	x x	x x	x x	x	x x	x x	x x
47	33F/L	x	x	x	x x	x x	x x	x
48	67V/N	x x	x xx	x x x	x x	x xx x	x x	x xx x
49	33V/N	x	x	x x	x	xx	x x	x x
50	0F/L							
51	67F/N	xx x	x x	x xx	xx	xx x	x xx	x x x
52	33F/L	x x	x x	x	x x	x x	x x	x x x
53	33V/L	x x	xx	x	x x	x	x x x	xx
54	67F/L	x x x x	xx x	x xx	x x	x x xx	xx	xx x
55	67V/L	xx x x	x xxx x	x xx	xx x x x	x x x x	x xxx	x x x x
56	33F/N	x	x x	x	x x x	x x	x x	x x x
57	33F/L	x x	x	x x	x	x x	x x	x x x
58	0F/L							
59	100F/N	xxx	x x	x xx xxxx	xx xxx x	xxx xxx	x xx xxx	xx xxx xxx
60	67F/L	xx x x x	x x	x x x x	x x	x xx	x x xx	xx xx
61	33V/L	x	x	x x	x x	x x	x	x
62	33V/L	x	x x	x x	x x x	x x	x x	x x
63	33F/N	x x	x	x x	x x	x x	x x	x x
64	67V/L	xx x	x x x x	x x	x xx x	x x x	xx x x	x x xx
65	100F/N	x x x xx	xx xxx x	xxx xxx	xxx xxx x	xxxxx xx	x xx xxxxx	x xxx xxx
66	67V/N	x x x	x	x x x	x x x	x x xx	x x x	xx x x
67	0F/N							
68	33V/N	x	x	x x	x	xx x	x	x
69	67F/L	x x x	x x x	xx x	x x x	xx x x	x x	x x x
70	0F/N							
71	67F/N	xx xx	xx xx x	x xx xx	x x xx	x x x x	x x x x	xx xx
72	0F/N							

Table 29 (continued)

S	Sch.	BL 8 1234567890	BL 9 1234567890
38	33V/L	x	x x
39	100F/N	xxxxxxx x	x xxx xxxx
40	67F/N	x	x xx xx
41	67F/N	xx x	x x x xx
42	67F/L	x xx xx	x x x x
43	33V/L	x x x	x
44	100F/L	xxxxx x	x x x x
45	67V/N	x x x	x x x x
46	33F/N	x x	x
47	33F/L	x	x x
48	67V/N	x xxx x	x x x
49	33V/N	xx	x x
50	0F/L		
51	67F/N	xx xx	xx xx
52	33F/L	x	x x x
53	33V/L	x x xx	x xx
54	67F/L	x xx x	x x x
55	67V/L	xx x x	x
56	33F/N	x x	x
57	33F/L	x x	x x
58	0F/L		
59	100F/N	x xxxx x	x x xxxx
60	67F/L	x	x x x
61	33V/L	x x	x x
62	33V/L	x x	x
63	33F/N	x x	x x
64	67V/L	xx x x	x x x x
65	100F/N	xx xxxx	x xxx xxxx
66	67V/N	x x x	x x x
67	0F/N		
68	33V/N	x	x x
69	67F/L	x xx	xx xx x
70	0F/N		
71	67F/N	x x xx	x x xx
72	0F/N		

STUDY #4 (Acq. = 90 trials, 9 blocks; N = 72)

Table 30

S	Sch.	Sex	Number of R's BL1	BL2	BL3	BL4	BL5	BL6	BL7	BL8	BL9	No. of Ext. Trials	No. of R's	No. of RE's	No. of R's per RE	No. of L-L	Cluster of L (3 or more)	N-RE Transitions
1	67F/L	M	4	5	5	7	6	7	6	7	8	360	55	30	1.83	8	3	45
2	0F/L	F	6	5	8	9	10	9	8	8	8	360	71	0	--	3	0	0
3	67V/L	F	4	6	6	7	6	9	7	8	7	320	60	31	1.94	4	2	45
4	33F/N	F	5	0	3	6	8	7	7	7	7	200	50	14	3.57	9	6	28
5	100F/L	F	4	4	7	6	8	6	6	5	8	360	54	45	1.20	9	4	45
6	0F/N	F	7	6	5	3	5	4	7	8	8	20	53	0	--	8	2	0
7	33V/N	F	5	3	6	4	5	4	8	8	9	110	53	14	3.79	10	4	27
8	100F/N	M	5	7	3	3	7	5	7	6	8	180	51	40	1.28	8	3	52
9	67F/N	M	3	5	5	6	6	7	8	8	7	30	55	32	1.72	11	2	50
10	67V/L	M	4	7	7	5	6	8	9	7	8	360	60	32	1.88	6	2	47
11	67V/N	F	4	6	7	6	6	8	8	7	7	70	58	30	1.93	5	2	37
12	33V/L	F	6	5	5	6	6	5	8	5	7	360	53	14	3.79	8	1	27
13	33F/N	F	6	4	8	7	8	7	9	10	8	250	67	17	3.94	1	1	26
14	0F/L	F	4	6	5	8	7	7	8	10	9	360	64	0	--	3	0	0
15	100F/L	F	6	4	5	6	7	6	7	6	8	360	55	44	1.25	7	2	52
16	67V/N	F	7	7	6	8	7	8	9	8	8	70	68	36	1.89	4	1	42
17	33V/N	F	5	5	6	4	6	10	10	10	10	20	66	18	3.67	4	5	28
18	100F/L	F	3	4	6	6	10	9	8	10	10	360	66	54	1.22	6	4	39
19	0F/N	F	4	5	5	5	5	5	8	6	4	80	47	0	--	10	4	0
20	33V/N	F	6	7	5	8	8	7	8	10	8	20	67	19	3.53	7	3	25
21	33F/L	F	3	4	6	7	9	8	10	8	7	360	62	17	3.65	2	3	30
22	67F/L	F	7	6	7	6	8	7	9	9	9	260	68	38	1.79	6	1	52
23	100F/N	F	4	10	9	8	9	9	7	7	6	30	69	54	1.28	3	3	30
24	33F/L	F	7	4	7	5	4	5	5	5	8	180	50	13	3.85	6	2	25
25	67V/N	F	6	4	5	8	5	4	8	6	6	50	52	28	1.86	8	2	46
26	100F/L	M	4	7	5	9	7	8	8	9	9	360	66	55	1.20	6	1	50
27	33V/N	F	5	7	6	8	9	10	9	9	10	180	73	20	3.65	4	2	33
28	100F/N	M	3	2	9	7	10	9	9	7	10	40	66	52	1.27	5	3	40
29	0F/L	F	7	8	8	9	6	7	10	7	8	360	70	0	--	2	0	0
30	67V/L	F	5	7	5	9	6	9	8	8	8	360	65	34	1.91	5	0	48
31	100F/L	F	5	5	6	6	8	7	8	8	7	360	60	49	1.22	8	0	52
32	67V/L	F	4	4	5	6	7	7	8	6	8	200	55	32	1.72	11	5	48
33	67F/N	F	6	5	6	5	6	7	8	8	6	160	57	30	1.90	6	3	38
34	0F/N	F	6	5	4	6	3	7	7	5	8	70	51	0	--	7	3	0

Table 30 (continued)

S	Sch.	Sex	Number of R's BL1	BL2	BL3	BL4	BL5	BL6	BL7	BL8	BL9	No. of Ext. Trials	No. of R's	No. of RE's	No. of R's per RE	No. of L-L	Cluster of L (3 or more)	N-RE Transi-tions
35	33F/L	M	4	4	6	4	6	3	5	8	5	80	40	12	3.33	7	5	24
36	0F/L	F	6	6	7	6	7	7	7	8	5	360	59	0	--	9	1	0
37	33F/N	F	4	7	6	6	6	8	7	8	6	70	58	15	3.87	4	2	29
38	33V/L	F	4	8	6	8	7	8	9	6	6	130	62	16	3.88	5	2	29
39	100F/N	F	7	9	7	9	7	9	10	10	10	360	78	63	1.24	3	0	47
40	67F/N	F	3	5	8	9	6	8	8	3	9	90	59	32	1.84	6	5	42
41	67F/N	F	5	7	8	9	9	7	10	7	8	110	70	38	1.84	4	0	59
42	67F/L	F	10	9	8	10	10	8	8	9	8	360	80	43	1.86	2	0	53
43	33V/L	F	5	6	6	7	6	5	5	8	6	30	54	15	3.60	8	3	29
44	100F/L	F	3	5	6	7	4	5	7	8	6	40	51	38	1.34	5	6	44
45	67V/N	F	6	4	5	7	7	8	10	7	8	360	62	32	1.94	4	1	49
46	33F/N	F	5	6	7	7	7	8	8	8	4	130	60	16	3.75	6	4	31
47	33F/L	F	3	5	3	7	8	7	7	3	9	360	52	13	4.00	6	5	25
48	67V/N	F	4	5	4	5	5	5	7	7	8	60	50	29	1.72	12	5	45
49	33V/N	M	4	5	7	5	7	7	7	7	8	170	57	15	3.80	6	3	26
50	0F/L	F	1	5	6	9	8	7	3	8	6	40	53	0	--	8	6	0
51	67F/N	F	5	4	6	5	4	7	6	7	8	80	52	27	1.93	7	6	32
52	33F/L	F	6	4	7	8	8	7	10	7	8	360	65	18	3.61	5	2	34
53	33V/L	F	7	6	5	8	7	8	9	9	9	360	68	20	3.40	5	1	30
54	67F/L	M	6	6	5	6	5	6	5	8	5	40	52	28	1.86	7	4	41
55	67V/L	F	7	8	6	10	7	7	9	6	5	30	65	34	1.91	5	1	49
56	33F/N	F	3	8	5	9	9	8	10	8	7	130	67	17	3.94	2	2	34
57	33F/L	F	4	5	6	6	7	7	8	8	6	120	57	17	3.35	10	5	34
58	0F/L	M	4	5	5	7	6	8	7	7	8	30	57	0	--	8	2	0
59	100F/N	M	4	4	9	8	8	8	10	8	8	50	67	50	1.34	1	2	41
60	67F/L	F	7	3	7	5	6	8	7	3	7	90	53	28	1.89	7	7	45
61	33V/L	F	5	5	6	5	7	7	5	6	8	60	54	13	4.15	7	4	25
62	33V/L	M	5	6	8	9	8	8	7	6	9	170	66	17	3.88	5	3	33
63	33F/N	F	4	5	6	7	8	8	8	8	7	130	61	17	3.59	8	1	33
64	67V/L	F	6	6	6	7	5	6	8	8	7	50	59	32	1.84	8	2	51
65	100F/N	F	6	8	7	9	9	10	9	7	10	190	75	60	1.25	3	0	43
66	67V/N	F	5	5	4	6	8	6	8	5	5	40	52	27	1.93	6	6	47
67	0F/N	M	4	7	7	5	7	7	8	5	8	40	58	0	--	6	2	0
68	33V/N	F	5	4	5	3	8	5	6	9	8	110	53	15	3.53	10	7	22
69	67F/L	F	5	5	7	6	6	4	7	6	9	100	55	29	1.90	6	6	42
70	0F/N	F	4	6	4	6	5	7	8	5	7	40	52	0	--	8	4	0
71	67F/N	F	4	9	7	9	8	6	9	8	8	130	68	38	1.79	6	1	53
72	0F/N	M	3	6	6	7	6	7	8	8	6	60	57	0	--	7	2	0

STUDY #4

TABLE 31

Sch.	BL 1	BL 2	BL 3	BL 4	BL 5	BL 6	BL 7	BL 8	BL 9
100F	4.49	5.74	6.58	6.99	7.83	7.58	7.99	7.58	8.33
67F	5.41	5.75	6.58	6.91	6.66	6.83	7.58	6.91	7.66
33F	4.50	4.66	5.83	6.33	7.33	6.91	7.66	7.33	6.83
0F	4.66	5.83	5.83	6.66	6.25	6.83	7.41	7.08	7.08
67V	5.16	5.75	5.33	7.00	6.25	7.08	8.25	6.91	7.08
33V	5.16	5.58	5.91	6.25	7.00	7.00	7.58	7.75	8.15

Note: The numbers represent average values of blocks.

STUDY #4

TABLE 32

100F/L	100F/N	67F/L	67F/N	33F/L	33F/N	0F/L	0F/N	67V/L	67V/N	33V/L	33V/N
360	180	360	30	360	200	360	20	320	70	360	110
360	30	260	160	180	250	360	80	360	70	130	20
360	40	360	90	80	70	360	70	360	50	30	20
360	360	40	110	360	130	360	40	200	360	360	180
360	50	90	80	360	130	40	40	30	60	60	170
40	190	100	130	120	130	30	60	50	40	170	110
$\sum$ = 1840	850	1210	600	1460	910	1510	310	1320	650	1110	610

Note: The numbers represent extinction trials.

STUDY #4

TABLE 33

	Light			No Light			Σ
100F	360	C_{11}	360	180	C_{12}	360	
	360		360	30		50	
	360		40	40		190	
	1840			850			2690
67F	360	C_{21}	40	30	C_{22}	110	
	260		90	160		80	
	360		100	90		130	
	1210			600			1810
33F	360	C_{31}	360	200	C_{32}	130	
	180		360	250		130	
	80		120	70		130	
	1460			910			2370
0F	360	C_{41}	360	20	C_{42}	40	
	360		40	80		40	
	360		30	70		60	
	1510			310			1820
67V	320	C_{51}	200	70	C_{52}	360	
	360		30	70		60	
	360		50	50		40	
	1320			650			1970
33V	360	C_{61}	360	110	C_{62}	180	
	130		60	20		170	
	30		170	20		110	
	1110			610			1720
Σ	8450			3930			12380

STUDY #4

TABLE 34

Source	SS	df	MS	F	F@1%	F@5%
Column	283,755.55	1	283,755.55	20.02	7.08	4.00
Row	61,394.44	5	12,278.88	.86	3.34	2.37
Inter-action	32,377.79	5	6,475.55	.45	3.34	2.37
Error	850,400	60	14,173.33			
Total	1,227,927.78	71				

Remark:

$$F_c = \frac{MS_c}{MS_e}$$

$$F_r = \frac{MS_r}{MS_e}$$

$$F_i = \frac{MS_i}{MS_e}$$

STUDY #4

TABLE 35

RE VS. EXT. TRIALS...LT.

100F		67F		33F		0F		67V		33V	
Y	X	Y	X	Y	X	Y	X	Y	X	Y	X
45	360	30	360	17	360	0	360	31	320	14	360
44	360	38	260	13	180	0	360	32	360	16	130
54	360	43	360	12	80	0	360	34	360	15	30
55	360	28	40	13	360	0	360	32	200	20	360
49	360	28	90	18	360	0	40	34	30	13	60
38	40	29	100	17	120	0	30	32	50	17	170

TABLE 36

RE VS. EXT. TRIALS...NO LT.

100F		67F		33F		0F		67V		33V	
Y	X	Y	X	Y	X	Y	X	Y	X	Y	X
40	180	32	30	14	200	0	20	30	70	14	110
54	30	30	160	17	250	0	80	36	70	18	20
52	40	32	90	15	70	0	70	28	50	19	20
63	360	38	110	16	130	0	40	32	360	20	180
50	50	27	80	17	130	0	40	29	60	15	170
60	190	38	130	17	130	0	60	27	40	15	110

STUDY #4

TABLE 37

NON-REINFORCED TRIALS VS. EXTINCTION TRIALS...LT

100F		67F		33F		0F		67V		33V	
Y	X	Y	X	Y	X	Y	X	Y	X	Y	X
45	360	60	360	73	360	90	360	59	320	76	360
46	360	52	260	77	180	90	360	58	360	74	130
36	360	47	360	78	80	90	360	56	360	75	30
35	360	62	40	77	360	90	360	58	200	70	360
41	360	62	90	72	360	90	40	56	30	77	60
52	40	61	100	73	120	90	30	58	50	73	170

TABLE 38

NON-REINFORCED TRIALS VS. EXTINCTION TRIALS...NO LT

100F		67F		33F		0F		67V		33V	
Y	X	Y	X	Y	X	Y	X	Y	X	Y	X
50	180	58	30	76	200	90	20	60	70	76	110
36	30	60	160	73	250	90	80	54	70	72	20
38	40	58	90	75	70	90	70	62	50	71	20
27	360	52	110	74	130	90	40	58	360	70	180
40	50	63	80	73	130	90	40	61	60	75	170
30	190	52	130	73	130	90	60	63	40	75	110

STUDY #4

TABLE 39

AVERAGE "R" OF LAST TWO ACQ. BLOCKS VS. EXT. TRIALS...LT

100F		67F		33F		0F		67V		33V	
Y	X	Y	X	Y	X	Y	X	Y	X	Y	X
6.5	360	7.5	360	7.5	360	8.0	360	7.5	320	6.0	360
7.0	360	9.0	260	6.5	180	9.5	360	7.5	360	6.0	130
10.0	360	8.5	360	6.5	80	7.5	360	8.0	360	7.0	30
9.0	360	6.5	40	6.0	360	6.5	360	7.0	200	9.0	360
7.5	360	5.0	90	7.5	360	7.0	40	5.5	30	7.0	60
7.0	40	7.5	100	7.0	120	7.5	30	7.5	50	7.5	170

TABLE 40

AVERAGE "R" OF LAST TWO ACQ. BLOCKS VS. EXT. TRIALS...NO LT

100F		67F		33F		0F		67V		33V	
Y	X	Y	X	Y	X	Y	X	Y	X	Y	X
7.0	180	7.5	30	7.0	200	8.0	20	7.0	70	8.5	110
6.5	30	7.0	160	9.0	250	5.0	80	8.0	70	10	20
8.5	40	6.0	90	7.0	70	6.5	70	6.0	50	9.0	20
10.0	360	7.5	110	6.0	130	6.5	40	7.5	360	9.5	180
8.0	50	7.5	80	7.5	130	6.0	40	7.5	60	7.5	170
8.5	190	8.0	130	7.5	130	7.0	60	5.0	40	8.5	110

STUDY #4

TABLE 41

NO. OF ACQ. TRIALS AT FIRST .8 OR MORE VS. EXT. TRIALS...LT

100F		67F		33F		0F		67V		33V	
Y	X	Y	X	Y	X	Y	X	Y	X	Y	X
50	360	90	360	50	360	30	360	60	320	70	360
90	360	50	260	90	180	40	360	60	360	20	130
50	360	10	360	80	80	20	360	40	360	80	30
40	360	80	40	50	360	80	360	70	200	40	360
50	360	60	90	40	360	40	40	20	30	90	60
80	40	90	100	70	120	60	30	70	50	30	170

TABLE 42

NO. OF ACQ. TRIALS AT FIRST .8 OR MORE VS. EXT. TRIALS...NO LT

100F		67F		33F		0F		67V		33V	
Y	X	Y	X	Y	X	Y	X	Y	X	Y	X
90	180	70	30	50	200	80	20	60	70	70	110
20	30	70	160	30	250	70	80	40	70	60	20
30	40	30	90	60	70	90	70	40	50	40	20
20	360	30	110	60	130	70	40	60	360	40	180
30	50	90	80	50	130	70	40	90	60	90	170
20	190	20	130	20	130	70	60	50	40	50	110

STUDY #4

TABLE 43

OVERTRAINING TRIALS VS. EXT. TRIALS...LT

100F/L		67F/L		33F/L		0F/L		67V/L		33V/L	
Y	X	Y	X	Y	X	Y	X	Y	X	Y	X
40	360	0	360	40	360	60	360	30	320	20	360
0	360	40	260	0	180	50	360	30	360	70	130
40	360	80	360	10	80	70	360	50	360	10	30
50	360	10	40	40	360	10	360	20	200	50	360
40	360	30	90	50	360	50	40	70	30	0	60
10	40	0	100	20	120	30	30	20	50	60	170

TABLE 44

OVERTRAINING TRIALS VS. EXT. TRIALS...NO LT

100F/N		67F/N		33F/N		0F/N		67V/N		33V/N	
Y	X	Y	X	Y	X	Y	X	Y	X	Y	X
0	180	20	30	40	200	10	20	30	70	20	110
70	30	20	160	60	250	20	80	50	70	30	20
60	40	60	90	30	70	0	70	50	50	50	20
70	360	60	110	30	130	20	40	30	360	50	180
60	50	0	80	40	130	20	40	0	60	0	170
70	190	70	130	70	130	20	60	40	40	40	110

STUDY #4

TABLE 45

N-RE VS. EXT. TRIALS...LT

100F		67F		33F		0F		67V		33V	
Y	X	Y	X	Y	X	Y	X	Y	X	Y	X
45	360	45	360	30	360	0	360	45	320	27	360
52	360	52	260	25	180	0	360	47	360	29	130
39	360	53	360	24	80	0	360	48	360	29	30
50	360	41	40	25	360	0	360	48	200	30	360
52	360	45	90	34	360	0	40	49	30	25	60
44	40	42	100	34	120	0	30	51	50	33	170

TABLE 46

N-RE VS. EXT. TRIALS...NO LT

100F		67F		33F		0F		67V		33V	
Y	X	Y	X	Y	X	Y	X	Y	X	Y	X
52	180	50	30	28	200	0	20	37	70	27	110
30	30	38	160	26	250	0	80	42	70	28	20
40	40	42	90	29	70	0	70	46	50	25	20
47	360	59	110	31	130	0	40	49	360	33	180
41	50	32	80	34	130	0	40	45	60	26	170
43	190	53	130	33	130	0	60	47	40	22	110

STUDY #4

TABLE 47

R/RE VS. EXT. TRIALS...LT

100F		67F		33F		67V		33V	
Y	X	Y	X	Y	X	Y	X	Y	X
1.20	360	1.83	360	3.88	360	1.94	320	3.79	360
1.25	360	1.79	260	3.85	180	1.88	360	3.88	130
1.22	360	1.86	360	3.33	80	1.91	360	3.60	30
1.20	360	1.86	40	4.00	360	1.72	200	3.40	360
1.22	360	1.89	90	3.61	360	1.91	30	4.15	60
1.34	40	1.90	100	3.35	120	1.84	50	3.88	170

TABLE 48

R/RE VS. EXT. TRIALS...NO LT

100F		67F		33F		67V		33V	
Y	X	Y	X	Y	X	Y	X	Y	X
1.28	180	1.72	30	3.57	200	1.93	70	3.79	110
1.28	30	1.90	160	3.94	250	1.89	70	3.67	20
1.27	40	1.84	90	3.87	70	1.86	50	3.53	20
1.24	360	1.84	110	3.75	130	1.94	360	3.64	180
1.34	50	1.93	80	3.94	130	1.72	60	3.80	170
1.25	190	1.79	130	3.59	130	1.93	40	3.53	110

STUDY #4

TABLE 49

SCH. VS. NO. OF R'S...LT

100F	67F	33F	0F	67V	33V
54	55	62	71	60	53
55	68	50	64	60	62
66	80	40	70	65	54
66	52	52	59	55	68
60	53	65	53	65	54
51	55	57	57	59	66
$\bar{X}$ = 58.67	60.50	54.33	62.33	60.67	59.50

TABLE 50

SCH. VS. NO. OF R'S...NO LT

100F	67F	33F	0F	67V	33V
51	55	50	53	58	53
69	57	67	47	68	66
66	59	58	51	52	67
78	70	60	58	62	73
67	52	67	52	50	57
75	68	61	57	52	53
$\bar{X}$ = 67.67	60.17	60.50	53.00	57.00	61.50

STUDY #4

TABLE 51

SCH. VS. NO. OF RE'S...LT

100F	67F	33F	0F	67V	33V
45	30	16	0	31	14
44	38	13	0	32	16
54	43	12	0	34	15
55	28	13	0	32	20
49	28	18	0	34	13
38	29	17	0	32	17
$\overline{X}$ = 47.50	32.67	14.83	0	32.50	15.83

TABLE 52

SCH. VS. NO. OF RE'S...NO LT

100F	67F	33F	0F	67V	33V
40	32	14	0	30	14
54	30	17	0	36	18
52	32	15	0	28	19
63	38	16	0	32	20
50	27	17	0	29	15
60	38	17	0	27	15
$\overline{X}$ = 53.17	32.83	16.00	0	30.33	16.83

STUDY #4

TABLE 53

SCH. VS. CR/RE...LT

	100F	67F	33F	0F	67V	33V
	1.20	1.83	3.88	--	1.94	3.79
	1.25	1.79	3.85	--	1.88	3.88
	1.22	1.86	3.33	--	1.91	3.60
	1.20	1.86	4.00	--	1.72	3.40
	1.22	1.89	3.61	--	1.91	4.15
	1.34	1.90	3.35	--	1.84	3.88
$\bar{X}$ =	1.24	1.86	3.67	--	1.87	3.78

TABLE 54

SCH. VS. CR/RE...NO LT

	100F	67F	33F	0F	67V	33V
	1.28	1.72	3.57	--	1.93	3.79
	1.28	1.90	3.94	--	1.89	3.67
	1.27	1.84	3.87	--	1.86	3.53
	1.24	1.84	3.75	--	1.94	3.65
	1.34	1.93	3.94	--	1.72	3.80
	1.25	1.79	3.59	--	1.93	3.53
$\bar{X}$ =	1.28	1.84	3.78	--	1.88	3.66

SUMMARY

STUDY #1-4

TABLE 55

SCH. VS. $\bar{X}$ OF CR/RE

	100F	67F	33F	67V	33V
#1 (NO LT)	1.28	1.81	3.50	1.84	3.60
#2 (NO LT)	1.22	1.87	3.75	1.77	3.84
#3 (NO LT)	1.28	1.85	3.76	1.84	3.83
#4 (NO LT)	1.28	1.84	3.78	1.88	3.66
#2 (LT)	1.22	1.85	3.38	1.88	3.91
#4 (LT)	1.24	1.86	3.67	1.87	3.78

TABLE 56

NO. OF EXTINCTION TRIALS (LT) UNDER 100F, 67F, 33F, AND 0F SCHEDULES OF REINFORCEMENT

100F	67F	33F	0F
360	360	360	360
360	260	180	360
360	360	80	360
360	40	360	360
360	90	360	40
40	100	120	30

TABLE 57

LINEAR TREND ANALYSIS FOR THE DATA OF TABLE 56

Source of Variation	Sum of Squares	Degrees of Freedom	Variance Estimate
Linear regression	4,563.33	1	$S_b^2 = 4563.33$
Deviation	28,986.68	2	$S_d^2 = 14,493.34$
Within	415,433.32	20	$S_w^2 = 20,771.67$
TOTAL	448,983.33	23	

$$F_l = \frac{4,563.33}{20,771.67} = 0.22, \quad F_d = \frac{14,493.34}{20,771.67} = 0.70.$$

$F_{.05}(1,20) = 4.35$

$F_{.05}(2,20) = 3.49$

TABLE 58

NO. OF EXTINCTION TRIALS (NO LT) UNDER 100F, 67F, 33F, and 0F SCHEDULES OF REINFORCEMENT

100F	67F	33F	0F
180	30	200	20
30	160	250	80
40	90	70	70
360	110	130	40
50	80	130	40
190	130	130	60

TABLE 59

LINEAR TREND ANALYSIS FOR THE DATA OF TABLE 58

Source of Variation	Sum of Squares	Degrees of Freedom	Variance Estimate
Linear regression	14,300.83	1	14,300.83
Deviation	23,111.68	2	11,555.84
Within	115,249.99	20	5,762.50
TOTAL	152,662.50		

$F_1 = \frac{14,300.83}{5,762.50} = 2.48$, $F_d = \frac{11,555.84}{5,762.50} = 2.01$ $F_{.05}(1,20) = 4.35$

$F_{.05}(2,20) = 3.49$

2. In Studies 1, 2, and 4, extinction of the response(s) learned in the two-choice probability learning situation did not occur in patterns directly related to schedules of reinforcement. There were no significant differences among the six schedules of reinforcement between fixed and variable reinforcement schedules.
3. In both Studies 2 and 4, a significant difference existed between extinction conducted with "light on" and extinction conducted with "light off."
4. In both Studies 2 and 4, there were no interactions between the six schedules of reinforcement whether the extinction was conducted with "light on" or "light off."
5. For each of number of RE, number of $\frac{R}{RE}$, number of L-L, number of clusters of L, and number of N-RE transitions vs. number of extinction trials, the Pearson product-moment correlation coefficients for the "No Lt." groups turned out larger (in absolute value) than those for the "Lt." groups.
6. In their effect upon acquisition, the six schedules of reinforcement showed no significant difference.
7. The number of RE, number of non-reinforced trials, average of R's during the last two acquisition blocks, number of acquisition trials which took Ss to say 8 or more R's in 10 consecutive trials, number of overtraining trials, number of N-RE transitions, and number of $\frac{R}{RE}$, each with Lt. and No Lt. had no significant effect upon the number of extinction trials.

8. A straight line was a good fit for the data describing number of extinction trials under the 100F, 67F, 33F, and 0F. The slope of this line, however, was not significantly different from zero.
9. During acquisition, there were no differences attributable to sex membership.
10. The means of number of RE, number of N-RE, and number of $\frac{R}{RE}$ for the 67F and 33F groups were almost identical with those for the 67V and 33V groups respectively. The means of the number of $\frac{R}{RE}$ for the (a) 100F, (b) 67F or 67V, and (c) 33F or 33V groups were numerically distinct with (a) and (c) bearing the smallest and largest values respectively.
11. Referring to Study #4, Table 5, no significant difference existed between any two cells of either "Lt." (first) column or "No Lt." (second) column. C_{11} differed from all cells of second column; C_{21} and C_{61} differed from no cell of column 2; and C_{31}, C_{41}, and C_{51} differed only from C_{42} of column 2.

Discussion

In the present study, extinction following continuous reinforcement was found to be as rapid as extinction following partial reinforcement. This result is not predictable from five partial-reinforcement hypotheses: discrimination, stimulus-generalization, expectancy, secondary-reinforcement, and response-unit. The first three would predict greater resistance to extinction following partial reinforcement than

following continuous reinforcement, and the last two would predict greater resistance to extinction after continuous reinforcement than after partial reinforcement.

Another major finding of this study was the significant difference between extinction conducted "light on" and extinction conducted "light off." The change from stimuli of repeated flashes of light to absence of these stimuli may have permitted Ss to discriminate the beginning of the extinction series and, thus, the rate of extinction was enhanced for the "light off" group. The "Discrimination hypothesis" maintains that extinction takes place when it becomes in some manner apparent to the subject that no more reinforcements are likely to occur. During acquisition the subject learned that light flashes preceded reinforcement but reinforcement did not succeed every flash of light. Even under the 100%-reinforcement schedule, and in the extreme case of a subject saying "right" all the time, the subject could only be reinforced a maximum of 80% of the time. Therefore, during extinction "light on," the subject may have still expected reinforcement to occur as it did during acquisition. This situation may not have existed when extinction was "light off." In view of this, therefore, this finding would best be predicted from the discrimination, the secondary reinforcement, the expectancy, as well as the stimulus-generalization hypotheses. Such a finding, however, would not be predictable from the response-unit theory.

It has been hypothesized[156] that the greater the percentage of reinforcement, the more different will be the acquisition series from the extinction series, and the easier it will be to discriminate between

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[156] See (95) and (65).

the two. One then would expect a difference in the resistance to extinction between the 100F, for example, and the 0F whether extinction was conducted "light on" or "light off." A very similar study to this research conducted by Grant, Hake and Hornseth (36) showed that the rates of extinction varied inversely with the rates at which positive reinforcements were given during acquisition. Analysis of the present research showed that there were no significant differences in resistance to extinction among the six schedules of reinforcement. This may indicate the presence of factors in addition to reinforcement that may have also influenced resistance to extinction.

Extinction in the present study did not occur in patterns directly related to schedules of reinforcement; an explanation of this result may be sought in the acquisition phase. It should be noted that as discriminability of reinforcement patterns during acquisition goes up, resistance to extinction goes down.[157] Over blocks of acquisition trials the schedules of reinforcement had little effect on the slopes of acquisition curves. This might indicate that the different schedules of reinforcement were not well discriminated, which in turn might explain the similarity among rates at which extinction occurs for the different schedules of reinforcement. Some factors supporting this line of reasoning are:

1. Sixty or ninety trials might not have been enough to make the difference among the schedules of reinforcement discernible across Ss. In other words, using the two-stage learning model of Sutherland et al., Ss might not have had

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[157] See (46). This is also called the generalization decrement hypothesis.

the opportunity to learn which features of the stimulus to attend to nor might they have been able to make the appropriate responses to the discriminative stimulus.

2. If the number of acquisition trials were increased to 1000, for example,[158] this could cause extreme discomfort to the subject, the result of which might lead him to ignore the stimuli or to close his eyes to them.[159]

3. Edwards (28) reports that for early trials Ss showed a tendency to predict one of two events less often as its run increased. He attributed this finding to what he termed the gambler's fallacy.[160]

4. The inter-trial interval (10 seconds) was perhaps enough for the subject to observe that the right light occurred more often, but not long enough to give him a chance to keep track of previous outcomes and previous responses. Again, the gradual strengthening of the learned response could have been biased by the force of saying the word "right" more often than the word "left." In Oklahoma, the word "right" is often used to express agreement on an issue; hence, there may be a stronger tendency (higher habit-strength) to say "right" than left.

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[158] Uhl (113) concludes that something near 1000 trials is necessary to accurately assess behavior in probabilistic outcome situations. (See also (137), p. 443).

[159] See (111), p. 438.

[160] The gambler's fallacy can best be described as follows: If a flipped coin, for example, comes up heads nine or ten times in a row, then S is likely to decide that tails is due and therefore predict or bet on it on the next toss (see (28), p. 385).

There was a negative correlation[161] between number of clusters of "left" responses during acquisition and number of extinction trials in Studies 1, 2, and 4[162] with respective coefficients of -.0704, -.3831, and -.5441. The discrepancy between the first two values could be attributed to the fact that only sixty acquisition trials were used in these studies as opposed to ninety in Study 4. The coefficient -.5441, however, could support the idea of greater habit strength (ninety versus sixty trials) influencing extinction.[163]

The results of this research revealed good internal consistency. The ratio R/RE for the same schedule of reinforcement varied little from one study to another. This shows that similarity existed among the subjects within a reinforcement schedule. Ss were apparently consistent in understanding and reacting to the experimental situation. In Table 5 both the 67F and 33F groups had approximately the same $\bar{X}$ values of number of reinforcements as the 67V and 33V groups respectively, which supports the results of the analysis of variance: no difference between variable and fixed reinforcement schedules was significant.

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[161]Pearson product-moment correlation. The decision to use the Pearson product-moment correlation was made after checking that the distribution of the data fitted more a straight than a curvilinear line. This was later supported by the non-significance of (the homogeneity of regression) F-ratios.

[162]In comparison with Study 1 only the "no light" parts of Studies 2 and 4 were considered.

[163]Since saying 3 "lefts" in a row was a part of the extinction criterion, a negative correlation between number of clusters of L during acquisition and number of extinction trials indicates that if the subject was in the habit of saying 3 or more "lefts" in a row during acquisition, he tended to have fewer extinction trials, i.e., the same pattern of saying "left" during acquisition generalized to extinction trials.

Consistency is also observed in the results of the trend analysis. A straight line was a good fit for the data describing number of extinction trials under the 100F, 67F, 33F, and 0F but its slope was not significantly different from zero. This corresponds to Figure 1 and the results of the analysis of variance.

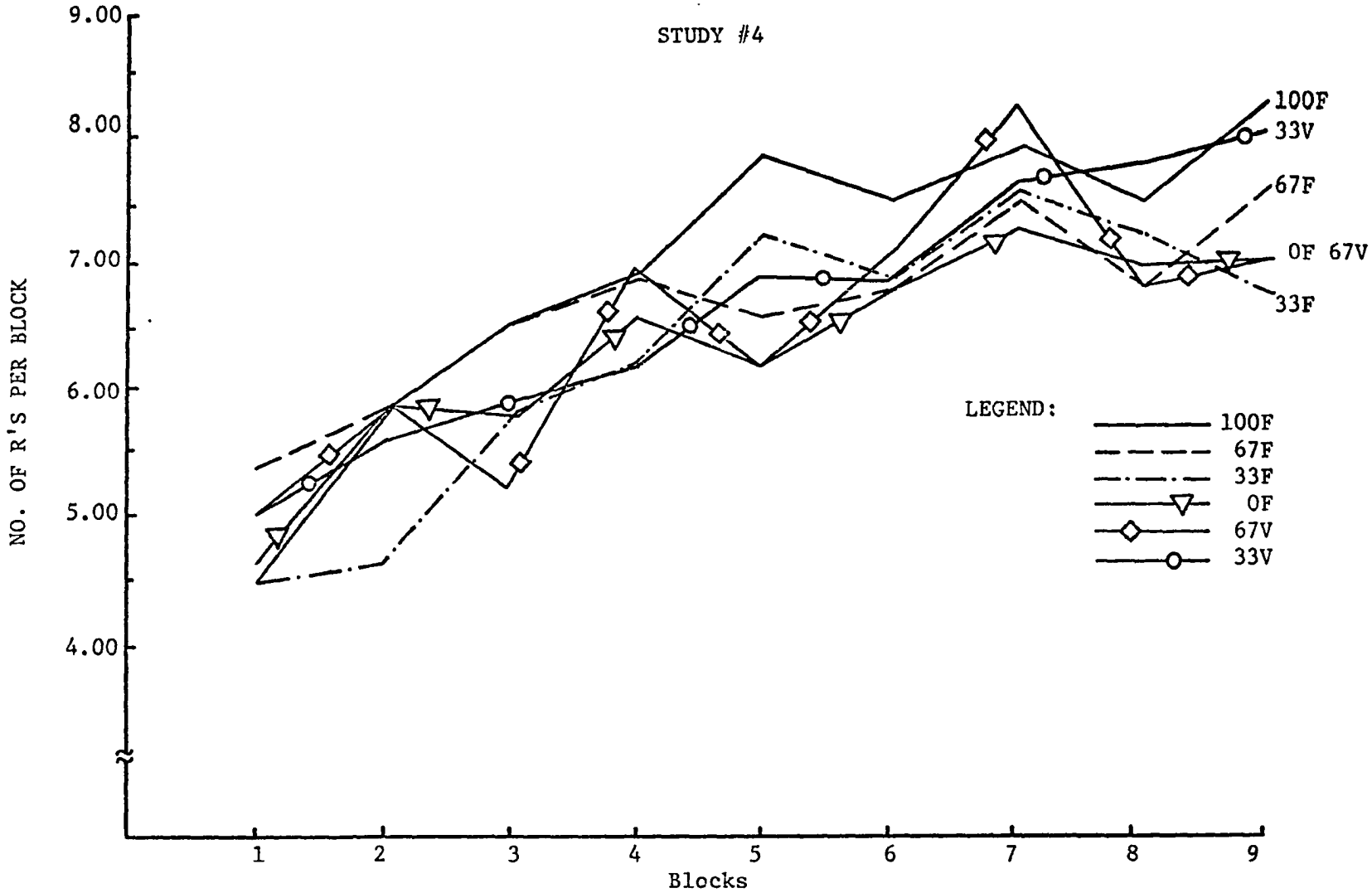

FIG. 1. NUMBER OF R's PER BLOCK VS. NUMBER OF BLOCKS

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Chapter V presents a summary of the study. The conclusions that were reached after an analysis of the data will be given and recommendations for further research will be made.

Summary

Purpose of the Study

Many studies have been conducted to explain the relationship between reinforcement and acquisition and between reinforcement and resistance to extinction. Some of the studies have given sustenance to existing theories; others have either defied the existing theories, the consequence of which has led to the formation of new ones, or else have denied them all forms of support. Amidst this controversy, therefore, the present study proposed to test the effects of differential schedules of reinforcement upon acquisition and extinction in a two-choice probability learning situation. It examined the effects of different reinforcement schedules upon acquisition and extinction and also their effects on extinction in the presence and absence of certain cues during extinction. The deductions of five theories--the stimulus-generalization theory, the expectancy theory, the discrimination theory,

the secondary reinforcement theory, and the response-unit theory were tested so that more light could be shed on the interpretation of the findings.

Specific Aims of the Study

The reinforcement schedules: 100F, 67F, 33F, 0F, 67V, and 33V upon acquisition and resistance to extinction were compared; and the effects of these schedules upon resistance to extinction when extinction was conducted "light on" and "light off" was examined. Specifically, the following hypotheses were tested:

H_o-1 The six schedules of reinforcement--100F, 67F, 33F, 0F, 67V, and 33V have the same effect upon acquisition.

H_o-2 The six schedules of reinforcement--100F, 67F, 33F, 0F, 67V, and 33V have the same effect on resistance to extinction.

H_o-3 There is no difference in the resistance to extinction (a) when extinction is conducted, "light on" and (b) when extinction is conducted, "light off."

Subjects for the Study

The subjects for the study were selected from a population of undergraduate students of both sexes between the ages of eighteen and twenty-two enrolled at the University of Oklahoma. The subjects were volunteers and were randomly assigned to each experimental group. No subject received more than one experimental treatment.

Statistical Treatment of the Data

One- and two-way analysis of variance were used to determine

whether the difference among the means of the treatment groups was significant. Post-hoc comparisons using Duncan's Range Test were made to determine if any significance existed among the cells, and as a double-check on the results of, the two-way analysis of variance. Pearson product-moment correlation coefficients were obtained for number of RE, number of $\frac{R}{RE}$, number of L-L, clusters of L, number of N-RE transitions, number of non-reinforced trials, average 'R' of last two acquisition blocks, each vs. number of extinction trials. To determine if each of number of RE, number of $\frac{R}{RE}$, number of N-RE transitions, number of non-reinforced trials, average of 'R' of last two acquisition blocks, number of acquisition trials at first (.8) criterion or more, number of over-training trials, had any effect upon the number of extinction trials, the analysis of covariance was used. Difference between the two sexes was checked using the t-test. And finally, to see if extinction in PL is a linear function of schedule of FR, a trend analysis was conducted on 100F, 67F, 33F, and 0F.

Summary of the Findings

Analysis of the data revealed the following findings:

1. In Studies 1, 2, and 4, extinction of the response(s) learned in the two-choice probability learning situation took place when reinforcement was stopped and light was no longer turned on.
2. In Studies 1, 2, and 4, extinction of the response(s) learned in the two-choice probability learning situation did not occur in patterns directly related to schedules

of reinforcement. There were no significant differences among the six schedules of reinforcement between fixed and variable reinforcement schedules.

3. In both Studies 2 and 4, a significant difference existed between extinction conducted with "light on" and extinction conducted with "light off."
4. In both Studies 2 and 4, there were no interactions between the six schedules of reinforcement whether the extinction was conducted with "light on" or "light off."
5. For each of number of RE, number of $\frac{R}{RE}$, number of L-L, number of clusters of L, and number of N-RE transitions vs. number of extinction trials, the Pearson product-moment correlation coefficients for the "No Lt." groups turned out larger (in absolute value) than those for the "Lt." groups.
6. In their effect upon acquisition, the six schedules of reinforcement showed no significant difference.
7. The number of RE, number of non-reinforced trials, average of R's during the last two acquisition blocks, number of acquisition trials which took Ss to say 8 or more R's in 10 consecutive trials, number of overtraining trials, number of N-RE transitions, and number of $\frac{R}{RE}$, each with Lt. and No Lt. had no significant effect upon the number of extinction trials.
8. A straight line was a good fit for the data describing number of extinction trials under the 100F, 67F, 33F, and 0F. The slope of this line, however, was not significantly different from zero.

9. During acquisition, there were no differences attributable to sex membership.

10. The means of number of RE, number of N-RE, and number of $\frac{R}{RE}$ for the 67F and 33F groups were almost identical with those for the 67V and 33V groups respectively. The means of the number of $\frac{R}{RE}$ for the (a) 100F, (b) 67F or 67V, and (c) 33F or 33V groups were numerically distinct with (a) and (c) bearing the smallest and largest values respectively.

11. Referring to Study #4, Table 5, no significant difference existed between any two cells of either "Lt." (first) column or "No Lt." (second) column. C_{11} differed from all cells of second column; C_{21} and C_{61} differed from no cell of column 2; and C_{31}, C_{41}, and C_{51} differed only from C_{42} of column 2.

Conclusions

Within the limitations of this research the following conclusions appear to be valid:

1. Extinction does not occur in patterns directly related to schedules of reinforcement.

2. Resistance to extinction is increased when cues present during training are also present during extinction. Of the five theories (see p. 4), the "discrimination hypothesis" gives the best interpretation of this result.

3. Rate of acquisition is not affected by reinforcement in a manner directly related to the schedule.

4. Extinction in probability learning is a linear function of fixed reinforcement.
5. Extinction is not a function of the number of RE's, the number of R's, the number of N-RE transitions, the number of L-L's, the number of clusters of L, the number of $\frac{R's}{RE}$, the average number of R's during the last two blocks of acquisition, the number of acquisition trials which took S to reach criterion, and the number of overtraining trials.
6. The two sexes show no significant difference in regard to acquisition.
7. No significant difference exists between fixed and variable reinforcement in their effect upon acquisition and/or extinction.

Recommendations

This study has probably raised more questions than it was able to answer. Some suggestions might, therefore, be relevant.

A similar study to that of #4 should be conducted with the following changes:

1. Different criteria for both acquisition and extinction could be defined.
2. The number of acquisition trials could be increased. In one experiment all Ss should receive the same number of trials, in another each S will receive as many trials (above a certain minimum) until he meets the criterion of acquisition. In each case, S should be asked to describe

what he observed during training. Those qualified will then be retained, and those disqualified will be replaced.

3. A monetary reward could be given to each S in proportion to the number of times he matches guesses with E.
4. The inter-trial interval could be increased.
5. "Red" and "Blue" or some other words should replace the words "Right" and "Left."
6. The 2 min. rest period (see p. 98) should be eliminated.

BIBLIOGRAPHY

Journal Articles

1. Bacon, W. E. "Partial Reinforcement Extinction Effect Following Different Amounts of Training." Journal of Comparative and Physiological Psychology, Vol. 55, 998-1003, 1962.

2. Birch, D. "Extended Training Extinction Effect Under Massed and Spaced Extinction Trials." Journal of Experimental Psychology, Vol. 70, 315-322, 1965.

3. Birch, D., Ison, J. R., and Sperling, S. E. "Reversal Learning Under Single Stimulus Presentation." Journal of Experimental Psychology, Vol. 60, 36-40, 1960.

4. Birnbaum, I. M. "Discrimination - Reversal, Extinction, and Acquisition After Different Amounts of Training." American Journal of Psychology, Vol. 80, 363-369, 1967.

5. Bitterman, M. E., Feddersen, W. E., and Tyler, D. W. "Secondary Reinforcement and the Discrimination Hypothesis." American Journal of Psychology, Vol. 66, 456-464, 1953.

6. Black, R. W., and Spence, K. W. "Effects of Intertrial Reinforcement on Resistance to Extinction Following Extended Training." Journal of Experimental Psychology, Vol. 70, 559-563, 1965.

7. Boren, J. J. "Resistance to Extinction as a Function of the Fixed Ratio." Journal of Experimental Psychology, Vol. 61, 304-308, 1961.

8. Bugelski, R. "Extinction With and Without Sub-Goal Reinforcement." Journal of Comparative Psychology, Vol. 26, 121-133, 1938.

9. Bush, R. R., and Mosteller, F. "A Mathematical Model for Simple Learning." The Psychological Review, Vol. 58, 313-323, 1951.

10. Bush, R. R., and Mosteller, F. "A Model for Stimulus Generalization and Discrimination." The Psychological Review, Vol. 58, 413-423, 1951.

11. Capaldi, E. J. "The Effect of Different Amounts of Training on the Resistance to Extinction of Different Patterns of Partially Reinforced Responses." Journal of Comparative and Physiological Psychology, Vol. 51, 367-371, 1958.

12. Capaldi, E. J. "Overlearning Reversal Effect in a Spatial Discrimination Task." Perceptual and Motor Skills, Vol. 16, 335-336, 1963.

13. Capaldi, E. J. "Partial Reinforcement: A Hypothesis of Sequential Effects." The Psychological Review, Vol. 73, 459-477, 1966.

14. Capaldi, E. J., and Hart, D. "Influence of a Small Number of Partial Reinforcement Training Trials on Resistance to Extinction." Journal of Experimental Psychology, Vol. 64, 166-171, 1962.

15. Capaldi, E. J., Hart, D., and Stanley, L. R. "Effect of Inter-trial Reinforcement on the Aftereffect of Nonreinforcement and Resistance to Extinction." Journal of Experimental Psychology, Vol. 65, 70-74, 1963.

16. Capaldi, E. J., and Minkoff, R. "Influence of Order of Occurrence of Non-Reward and Large and Small Reward on Acquisition and Extinction." Journal of Experimental Psychology, Vol. 81, 156-160, 1969.

17. Capaldi, E. J. and Senko, M. G. "Acquisition and Transfer in Partial Reinforcement." Journal of Experimental Psychology, Vol. 63, 155-159, 1962.

18. Capaldi, E. J., and Spivey, J. E. "Schedule of Partial Delay of Reinforcement and Resistance to Extinction." Journal of Comparative and Physiological Psychology, Vol. 60, 274-276, 1965.

19. Capaldi, E. J., and Stevenson, H. W. "Response Reversal Following Different Amounts of Training." Journal of Comparative and Physiological Psychology, Vol. 50, 195-198, 1957.

20. Clayton, K. N. "Overlearning and Reversal of a Spatial Discrimination by Rats." Perceptual and Motor Skills, Vol. 17, 83-85, 1963.

21. Cotler, S. B., and Nygaard, J. E. "Resistance to Extinction Following Sequences of Partial and Continuous Reinforcement in a Human Choice Task." Journal of Experimental Psychology, Vol. 81, 270-274, 1969.

22. Coughlin, R. C. Jr. "Frustration Effect and Resistance to Extinction as a Function of Percentage of Reinforcement." Journal of Experimental Psychology, Vol. 84, 113-119, 1970.

23. Crum, J., Brown, W. L., and Bitterman, M. E. "The Effect of Partial and Delayed Reinforcement on Resistance to Extinction." American Journal of Psychology, Vol. 64, 228-237, 1951.

24. D'Amato, M. R., and Jagoda, H. "Overlearning and Position Reversal." Journal of Experimental Psychology, Vol. 64, 117-122, 1962.

25. D'Amato, M. R., Schiff, D., and Jagoda, H. "Resistance to Extinction After Varying Amounts of Discriminative or Nondiscriminative Instrumental Training." Journal of Experimental Psychology, Vol. 64, 526-532, 1962.

26. Dufort, R. H., and Kimble, G. A. "Changes in Response Strength with Changes in the Amount of Reinforcement." Journal of Experimental Psychology, Vol. 51, 185-191, 1956.

27. Dyal, J. A., and Holland, T. A. "Resistance to Extinction as a Function of Number of Reinforcements." American Journal of Psychology, Vol. 76, 332-333, 1963.

28. Edwards, W. "Probability Learning in 1000 Trials." Journal of Experimental Psychology, Vol. 62, 385-394, 1961.

29. Erlebacher, A. "Reversal Learning in Rats as a Function of Percentage of Reinforcement and Degree of Learning." Journal of Experimental Psychology, Vol. 66, 84-90, 1963.

30. Estes, W. K. "Toward a Statistical Theory of Learning." Psychological Review, Vol. 57, 94-107, 1950.

31. Estes, W. K., and Straughan, J. H. "Analysis of a Verbal Conditioning Situation in Terms of Statistical Learning Theory." Journal of Experimental Psychology, Vol. 47, 225-234, 1954.

32. Fehrer, E. "Effects of Amount of Reinforcement and of Pre- and Postreinforcement Delays on Learning and Extinction." Journal of Experimental Psychology, Vol. 52, 167-176, 1956.

33. Gagnè, R. M. "The Effect of Spacing of Trials on the Acquisition and Extinction of a Conditioned Operant Response." Journal of Experimental Psychology, Vol. 29, 201-216, 1941.

34. Gardner, R. A. "Probability-Learning With Two and Three Choices." American Journal of Psychology, Vol. 70, 174-185, 1957.

35. Gonzalez, R. C., and Bitterman, M. E. "Resistance to Extinction in the Rat as a Function of Percentage and Distribution of Reinforcement." Journal of Comparative and Physiological Psychology, Vol. 58, 258-263, 1964.

36. Grant, D. A., Hake, H. W., and Hornseth, J. P. "Acquisition and Extinction of a Verbal Conditioned Response With Differing Percentages of Reinforcement." Journal of Experimental Psychology, Vol. 42, 1-5, 1951.

37. Grant, D. A., Hornseth, J. P., and Hake, H. W. "The Influence of the Inter-Trial Interval on the Humphrey's 'Random Reinforcement' Effect During the Extinction of a Verbal Response." Journal of Experimental Psychology, Vol. 40, 609-612, 1950.

38. Grant, D. A., Riopelle, A. J., and Hake, H. W. "Resistance to Extinction and the Pattern of Reinforcement. I. Alternation of Reinforcement and the Conditioned Eyelid Response." Journal of Experimental Psychology, Vol. 40, 53-60, 1950.

39. Grant, D. A., and Schipper, L. M. "The Acquisition and Extinction of Conditioned Eyelid Responses as a Function of the Percentage of Fixed-Ratio Random Reinforcement." Journal of Experimental Psychology, Vol. 43, 313-320, 1952.

40. Grant, D. A., Schipper, L. M., and Ross, B. M. "Effect of Intertrial Interval During Acquisition and Extinction of the Conditioned Eyelid Response Following Partial Reinforcement." Journal of Experimental Psychology, Vol. 44, 203-210, 1952.

41. Grossen, N. E. "Resistance to Extinction as a Joint Function of Partial Reward Pattern and Length of Training." Journal of Experimental Psychology, Vol. 79, 385-386, 1969.

42. Grosslight, J. H., Hall, J. F., and Murnin, J. "Patterning Effect in Partial Reinforcement." Journal of Experimental Psychology, Vol. 46, 103-106, 1953.

43. Harris, P., and Nygaard, J. E. "Resistance to Extinction and Number of Reinforcements." Psychological Reports, Vol. 8, 233-234, 1961.

44. Hartman, T. F., and Grant, D. A. "Effect of Intermittent Reinforcement on Acquisition, Extinction, and Spontaneous Recovery of the Conditioned Eyelid Response." Journal of Experimental Psychology, Vol. 60, 89-96, 1960.

45. Hergenhahn, B. R. "The Influence of Training Level and Probability Magnitude on the Extinction of Probability Matching Responses." Dissertation Abstracts, Vol. XXVII, Number 7, 1967.

46. Hergenhahn, B. R., and Potts, G. R. "Extinction Following Various Types of Partial Reinforcement in a Probability Matching Situation." Perceptual and Motor Skills, Vol. 24, 317-318, 1967.

47. Hill, W. F., and Spear, N. E. "Extinction in a Runway as a Function of Acquisition Level and Reinforcement Percentage." Journal of Experimental Psychology, Vol. 65, 495-500, 1963.

48. Hill, W. F., Spear, N. E., and Clayton, K. N. "T-Maze Reversal Learning After Several Different Overtraining Procedures." Journal of Experimental Psychology, Vol. 64, 533-540, 1962.

49. Hothersall, David. "Resistance to Extinction When Continuous Reinforcement is Followed by Partial Reinforcement." Journal of Experimental Psychology, Vol. 72, 109-112, 1966.

50. Hovland, C. I. "The Generalization of Conditioned Responses. IV. The Effects of Varying Amounts of Reinforcement Upon the Degree of Generalization of Conditioned Responses." Journal of Experimental Psychology, Vol. 21, 261-276, 1937.

51. Hulicka, I. M., Capehart, J., and Viney, W. "The Effect of Stimulus Variation on Response Probability During Extinction." Journal of Comparative and Physiological Psychology, Vol. 53, 79-82, 1960.

52. Hulse, S. H. "Partial Reinforcement, Continuous Reinforcement, and Reinforcement Shift Effects." Journal of Experimental Psychology, Vol. 64, 451-459, 1962.

53. Hulse, S. H., and Firestone, R. J. "Mean Amount of Reinforcement and Instrumental Response Strength." Journal of Experimental Psychology, Vol. 67, 417-422, 1964.

54. Humphreys, L. G. "Acquisition and Extinction of Verbal Expectations in a Situation Analogous to Conditioning." Journal of Experimental Psychology, Vol. 25, 294-301, 1939.

55. Humphreys, L. G. "The Effect of Random Alternation of Reinforcement on the Acquisition and Extinction of Conditioned Eyelid Reactions." Journal of Experimental Psychology, Vol. 25, 141-158, 1939.

56. Humphreys, L. G. "Extinction of Conditioned Psychogalvanic Response Following Two Conditions of Reinforcement." Journal of Experimental Psychology, Vol. 27, 71-75, 1940.

57. Humphreys, L. G. "Generalization as a Function of Method of Reinforcement." Journal of Experimental Psychology, Vol. 25, 361-372, 1939.

58. Humphreys, L. G. "The Strength of a Thorndikian Response as a Function of the Number of Practice Trials." Journal of Comparative Psychology, Vol. 35, 101-110, 1943.

59. Humphreys, L. G., Miller, J., and Ellson, D. G. "The Effect of the Inter-Trial Interval on the Acquisition, Extinction, and Recovery of Verbal Expectations." Journal of Experimental Psychology, Vol. 27, 195-202, 1940.

60. Ison, J. R. "Experimental Extinction as a Function of Number of Reinforcements." Journal of Experimental Psychology, Vol. 64, 314-317, 1962.

61. Jenkins, H. M. "Resistance to Extinction When Partial Reinforcement is Followed by Regular Reinforcement." Journal of Experimental Psychology, Vol. 64, 441-450, 1962.

62. Jenkins, W. O., and Rigby, M. K. "Partial (Periodic) Versus Continuous Reinforcement in Resistance to Extinction." Journal of Comparative and Physiological Psychology, Vol. 43, 30-40, 1950.

63. Jenkins, W. O., and Stanley, J. C. Jr. "Partial Reinforcement: A Review and Critique." Psychological Bulletin, Vol. 47, 193-234, 1950.

64. Jensen, G. D., and Hill, W. F. "Resistance to Extinction When a Single Nonreinforced Sequence is Followed by Immediate Reinforcement or Delayed Reinforcement." Journal of Experimental Psychology, Vol. 75, 396-399, 1967.

65. Juola, J. F., and Hergenhahn, B. R. "Probability Matching and the Overlearning Reversal Effect." Psychon. Sciences, Vol. 8, 309-310, 1967.

66. Kass, N. "Resistance to Extinction as a Function of Age and Schedules of Reinforcement." Journal of Experimental Psychology, Vol. 64, 249-252, 1962.

67. Kass, N., and Wilson, H. "Resistance to Extinction as a Function of Percentage of Reinforcement, Number of Training Trials, and Conditioned Reinforcement." Journal of Experimental Psychology, Vol. 71, 355-357, 1966.

68. Katz, S., Woods, G. T., and Carrithers, J. H. "Reinforcement After Effects and Intertrial Interval." Journal of Experimental Psychology, Vol. 72, 624-626, 1966.

69. Kendler, H. H., Pliskoff, S. S., D'Amato, M. R., and Katz, S. "Nonreinforcements Versus Reinforcements as Variables in the Partial Reinforcement Effect." Journal of Experimental Psychology, Vol. 53, 269-276, 1957.

70. King, R. A., Wood, P., and Butcher, J. "Decreased Resistance to Extinction as a Function of Reinforcement." American Psychologist, Vol. 16, 468, 1961.

71. Koteskey, R. L., and Stettner, L. J. "Role of Nonreinforcement-Reinforcement Sequences in the Partial-Reinforcement Effect." Journal of Experimental Psychology, Vol. 76, 198-205, 1968.

72. Levine, M. "Cue Neutralization: The Effects of Random Reinforcements upon Discrimination Learning." Journal of Experimental Psychology, Vol. 63, 438-443, 1962.

73. Lewis, D. J. "Acquisition, Extinction, and Spontaneous Recovery as a Function of Percentage of Reinforcement and Intertrial Intervals." Journal of Experimental Psychology, Vol. 51, 45-53, 1956.

74. Lewis, D. J. "Partial Reinforcement: A Selective Review of the Literature Since 1950." The Psychological Bulletin, Vol. 57, 1-28, 1960.

75. Lewis, D. J., and Duncan, C. P. "Effect of Different Percentages of Money Reward on Extinction of a Lever-Pulling Response." Journal of Experimental Psychology, Vol. 52, 23-27, 1956.

76. Lewis, D. J., and Duncan, C. P. "Expectation and Resistance to Extinction of a Lever-Pulling Response as a Function of Percentage of Reinforcement and Number of Acquisition Trials." Journal of Experimental Psychology, Vol. 55, 121-128, 1958.

77. Lewis, D. J., and Duncan, C. P. "Expectation and Resistance to Extinction Under Partial Reinforcement and Risk-Taking." American Journal of Psychology, Vol. 75, 77-84, 1962.

78. Logan, F. A., Beier, E. M., and Kincaid, W. D. "Extinction Following Partial and Varied Reinforcement." Journal of Experimental Psychology, Vol. 52, 65-70, 1956.

79. Longenecker, E. D., Krauskopf, John, and Bitterman, M. E. "Extinction Following Alternating and Random Partial Reinforcement." American Journal of Psychology, Vol. 65, 580-587, 1952.

80. McAllister, W. R. "Eyelid Conditioning as a Function of the CS-US Interval." Journal of Experimental Psychology, Vol. 45, 417-422, 1953.

81. McCain, G., Lee, P., and Powell, N. "Extinction as a Function of Partial Reinforcement and Overtraining." Journal of Comparative and Physiological Psychology, Vol. 55, 1004-1006, 1962.

82. McCray, C. L., and Harper, R. S. "Some Relationships of Schedules of Reinforcement to Variability of Response." Journal of Comparative and Physiological Psychology, Vol. 55, 19-21, 1962.

83. Mowrer, O. H., and Jones, H. "Habit Strength as a Function of the Pattern of Reinforcement." Journal of Experimental Psychology, Vol. 35, 293-311, 1945.

84. Murillo, N. R., and Capaldi, E. J. "The Role of Overlearning Trials in Determining Resistance to Extinction." Journal of Experimental Psychology, Vol. 61, 345-349, 1961.

85. Myers, N. A. "Extinction Following Partial and Continuous Primary and Secondary Reinforcement." Journal of Experimental Psychology, Vol. 60, 172-179, 1960.

86. North, A. J., and Stimmel, D. T. "Extinction of an Instrumental Response Following a Larger Number of Reinforcements." Psychological Reports, Vol. 6, 227-234, 1960.

87. Passey, G. E., and Wood, D. L. "Effect of Pattern of Reinforcement on the Conditioned Eyelid Response." Journal of Experimental Psychology, Vol. 66, 241-244, 1963.

88. Pennes, E. S., and Ison, J. R. "Effects of Partial Reinforcement on Discrimination Learning and Subsequent Reversal or Extinction." Journal of Experimental Psychology, Vol. 74, 219-224, 1967.

89. Petrinovich, L. F., and Hardyck, C. D. "Error Rates for Multiple Comparison Methods: Some Evidence Concerning the Frequency of Erroneous Conclusions." Psychological Bulletin, Vol. 71, 43-54, 1969.

90. Porter, J. M. Jr. "Experimental Extinction as a Function of the Interval Between Successive Non-Reinforced Elicitations." Journal of General Psychology, Vol. 20, 109-134, 1939.

91. Pubols, B. H. Jr. "Constant Versus Variable Delay of Reinforcement." Journal of Comparative and Physiological Psychology, Vol. 55, 52-56, 1962.

92. Pubols, B. H. Jr. "The Facilitation of Visual and Spatial Discrimination Reversal by Overlearning." Journal of Comparative and Physiological Psychology, Vol. 49, 243-248, 1956.

93. Reid, L. S. "The Development of Noncontinuity Behavior Through Continuity Learning." Journal of Experimental Psychology, Vol. 46, 107-112, 1953.

94. Restle, F. "A Theory of Discrimination Learning." Psychological Review, Vol. 62, 11-19, 1955.

95. Restle, F. "Theory of Selective Learning With Probable Reinforcements." Psychological Review, Vol. 64, 182-191, 1957.

96. Reynolds, W. F. "Acquisition and Extinction of the Conditioned Eyelid Response Following Partial and Continuous Reinforcement." Journal of Experimental Psychology, Vol. 55, 335-341, 1958.

97. Scott, E. D., and Wike, E. L. "The Effect of Partially Delayed Reinforcement and Trial-Distribution on the Extinction of an Instrumental Response." American Journal of Psychology, Vol. 69, 264-268, 1956.

98. Senko, M. G., Champ, R. A., and Capaldi, E. J. "Supplementary Report: Resistance to Extinction of a Verbal Response as a Function of the Number of Acquisition Trials." Journal of Experimental Psychology, Vol. 61, 350-351, 1961.

99. Sgro, J. A., Dyal, J. A., and Anastasio, E. J. "Effects of Constant Delay of Reinforcement on Acquisition Asymptote and Resistance to Extinction." Journal of Experimental Psychology, Vol. 73, 634-636, 1967.

100. Sheffield, V. F. "Extinction as a Function of Partial Reinforcement and Distribution of Practice." Journal of Experimental Psychology, Vol. 39, 511-526, 1949.

101. Sheffield, V. F. "Resistance to Extinction as a Function of the Distribution of Extinction Trials." Journal of Experimental Psychology, Vol. 40, 305-313, 1950.

102. Shelly, M. W. II. "Effects of Increments of Reinforcement In Human Probability Learning." Journal of Experimental Psychology, Vol. 59, 345-350, 1960.

103. Siegel, S., and Wagner, A. R. "Extended Acquisition Training and Resistance to Extinction." Journal of Experimental Psychology, Vol. 66, 308-310, 1963.

104. Skinner, B. F. "Resistance to Extinction in the Process of Conditioning." Journal of General Psychology, Vol. 9, 420-429, 1933.

105. Spence, K. W., Rutledge, E. F., and Talbott, J. H. "Effect of Number of Acquisition Trials and the Presence or Absence of the UCS on Extinction of the Eyelid CR." Journal of Experimental Psychology, Vol. 66, 286-291, 1963.

106. Spivey, J. E. "Resistance to Extinction as a Function of Number of N-R Transitions and Percentage of Reinforcement." Journal of Experimental Psychology, Vol. 75, 43-48, 1967.

107. Stanley, W. C. "Extinction as a Function of the Spacing of Extinction Trials. Journal of Experimental Psychology, Vol. 43, 249-260, 1952.

108. Surridge, C. T., and Amsel, A. "Acquisition and Extinction Under Single Alternation and Random Partial-Reinforcement Conditions with a 24-hour Intertrial Interval." Journal of Experimental Psychology, Vol. 72, 361-368, 1966.

109. Sutherland, N. S., Mackintosh, N. J., and Wolfe, J. B. "Extinction as a Function of the Order of Partial and Consistent Reinforcement." Journal of Experimental Psychology, Vol. 69, 56-59, 1965.

110. Teichner, W. H. "Experimental Extinction as a Function of the Intertrial Intervals During Conditioning and Extinction." Journal of Experimental Psychology, Vol. 44, 170-178, 1952.

111. Theios, J., and McGinnis, R. W. "Partial Reinforcement Before and After Continuous Reinforcement." Journal of Experimental Psychology, Vol. 73, 479-481, 1967.

112. Tyler, D. W., Wortz, E. C., and Bitterman, M. E. "The Effect of Random and Alternating Partial Reinforcement on Resistance to Extinction in the Rat." American Journal of Psychology, Vol. 66, 57-65, 1953.

113. Uhl, C. N. "Two-Choice Probability Learning in the Rat as a Function of Incentive, Probability of Reinforcement, and Training Procedure." Journal of Experimental Psychology, Vol. 66, 443-449, 1963.

114. Uhl, C. N., and Young, A. G. "Resistance to Extinction as a Function of Incentive, Percentage of Reinforcement, and Number of Non-Reinforced Trials." Journal of Experimental Psychology, Vol. 73, 556-564, 1967.

115. Underwood, B. J. "Ten Years of Massed Practice on Distributed Practice." Psychological Review, Vol. 68, 229-247, 1961.

116. Wagner, A. R. "Effects of Amount and Percentage of Reinforcement and Number of Acquisition Trials on Conditioning and Extinction." Journal of Experimental Psychology, Vol. 62, 234-242, 1961.

117. White, R. K. "The Completion Hypothesis and Reinforcement." Psychological Review, Vol. 43, 396-404, 1936.

118. Wike, E. L. "Extinction of a Partially and Continuously Reinforced Response With and Without a Rewarded Alternative." Journal of Experimental Psychology, Vol. 46, 255-260, 1953.

119. Wike, E. L., Kintsch, W., and Gutekunst, R. "Patterning Effects in Partially Delayed Reinforcement." Journal of Comparative and Physiological Psychology, Vol. 52, 411-414, 1959.

120. Wike, E. L., Platt, J. R., Wicker, A., and Tesar, V. "Effects of Random Versus Alternating Delay of Reinforcement in Training upon Extinction Performance." Psychological Reports, Vol. 14, 826, 1964.

121. Williams, S. B. "Resistance to Extinction as a Function of the Number of Reinforcements." Journal of Experimental Psychology, Vol. 23, 506-522, 1938.

122. Wilson, W., Weiss, E. J., and Amsel, A. "Two Tests of the Sheffield Hypothesis Concerning Resistance to Extinction, Partial Reinforcement, and Distribution of Practice." Journal of Experimental Psychology, Vol. 50, 51-60, 1955.

123. Yamaguchi, H. G. "The Effect of Continuous, Partial and Varied Magnitude Reinforcement on Acquisition and Extinction." Journal of Experimental Psychology, Vol. 61, 319-321, 1961.

124. Zeaman, D. "Response Latency as a Function of the Amount of Reinforcement." Journal of Experimental Psychology, Vol. 39, 466-483, 1949.

Books

125. Amsel, A. "Partial Reinforcement Effects on Vigor and Persistence: Advances in Frustration Theory Derived From a Variety of Within-Subject Experiments." In K. W. Spence and J. T. Spence (Editors), The Psychology of Learning and Motivation: Advances in Research and Theory, Academic Press, New York, 1967.

126. Bartle, R. G. The Elements of Real Analysis. John Wiley and Sons, Inc., New York, 1964.

127. Bush, R. R., and Mosteller, F. Stochastic Models For Learning. John Wiley and Sons, Inc., New York, 1955.

128. Estes, W. K. "Probability Learning." In A. W. Melton (Editor), Categories of Human Learning, Academic Press, New York, 1964.

129. Ferguson, G. A. Statistical Analysis in Psychology and Education. McGraw-Hill Book Company, New York, New York, 1959.

130. Ferster, C. B., and Skinner, B. F. Schedules of Reinforcement. Appleton-Century-Crofts, Inc., New York, 1957.

131. Hays, W. L. Statistics. Holt, Rinehart, and Winston, Inc., New York, 1963.

132. Hilgard, E. R., and Bower, G. H. Theories of Learning. Appleton-Century-Crofts, Inc., New York, 1966.

133. Hilgard, E. R., and Marquis, D. G. Conditioning and Learning. (Revised by G. A. Kimble), Appleton-Century-Crofts, Inc., New York, 1961.

134. Hill, W. F. Learning: A Survey of Psychological Interpretations. Chandler Publishing Company, San Francisco, California, 1963.

135. Kirk, R. E. Experimental Design: Procedures for the Behavioral Sciences. Brooks/Cole Publishing Company, Belmont, California, 1968.

136. Lawrence, D. H., and Festinger, L. Deterrents and Reinforcement - The Psychology of Insufficient Reward. Stanford University Press, Stanford, 1962.

137. Logan, F. A. Incentive, How the Conditions of Reinforcement Affect the Performance of Rats. Yale University Press, New Haven, 1960.

138. McGuigan, F. J. Experimental Psychology - A Methodological Approach. Prentice-Hall, Inc., Englewood Cliffs, N. J. 1960.

139. Morgan, C. T., and King, R. A. Introduction to Psychology. McGraw-Hill Book Company, New York, N. Y., 1966.

140. Olmsted, J. M. H. Advanced Calculus. Appleton-Century-Crofts, Inc., New York, 1961.

141. Pavlov, I. P. Conditioned Reflexes. (Translated by G. V. Anrep), Oxford University Press, 1927.

142. Restle, F. Psychology of Judgement and Choice - A Theoretical Essay. John Wiley and Sons, Inc., New York, 1961.

143. Thomas, G. B. Jr. Calculus and Analytic Geometry. Addison-Wesley Publishing Company, Inc., Reading, Massachusetts, 1962.

APPENDIX I

GLOSSARY

Acquisition: The gradual strengthening of a learning response (139, p. 762).

Adapted: (See footnote 114.)

Asymptote: As the point P(x,y) on a given curve moves farther and farther away from the vicinity of the origin, if the distance between P and some fixed line tends to zero, then the line is called the asymptote of the curve (143, p. 439).

Average stimulating effect of an unconditioned stimulus: (See footnote 74.)

Conditioned response (CR): (See footnote 89.)

Conditioned stimulus (CS): (See footnote 88.)

Conditioning: The process of training which results in the formation of conditioned responses (133, p. 478).

Consummatory responses: (See footnote 97.)

Continuous reinforcement: (See full reinforcement).

Cue: (See footnote 13.)

Dependent variable: If Y is a function of X, then given the value of X, and the functional relationship, the value of Y is completely determined. Y and X are called the dependent and independent variables respectively (131, p. 39).

Discrimination operator: (See footnote 116.)

Discrimination theory: (See p. 5.)

Discrimination theory using the concept of set: Following continuous reinforcement during acquisition, the rapidity with which extinction occurs suggests that with the cessation of the UCS a strong inhibitory set is immediately adapted by S. In the case of extinction following partial reinforcement, since S has already experienced failures of occurrence of the UCS on some portion of the trials, this inhibitory set does not develop, at least not immediately. Performance, therefore, in the early stages of extinction following partial reinforcement would not be affected by an inhibitory set and hence, would not show the precipitous drop that occurs following full reinforcement (105, p. 290).

Dissonance theory: Dissonance is conceived as tension resulting when the organism is confronted with two items of information about his behavior which are inconsistent with one another. For example, dissonance might arise when (a) a hungry rat has just expended much effort to get into a goal-box, and (b) there is no food reward there. It is assumed that in a case like this the subject either modifies his behavior, i.e., stops responding, or develops extra attractions in the goal-box. Since conditions under partial reinforcement are arranged in such a way as to preclude the first alternative the subject cannot quit entirely. It is these extra attractions at the goal, therefore, elaborated under conditions of impoverished reward, that will keep the

subject responding for a longer period of time during extinction (132, p. 491).

Expectancy theory: (See p. 6.)

Extinction (Pavlov): The specific procedure of presenting the conditioned stimulus unaccompanied by the usual reinforcement; also the decrement in a conditioned response which results from that procedure (133, p. 479).

Fixed-interval reinforcement: (See schedule of reinforcement).

Fixed-ratio reinforcement: (See schedule of reinforcement).

Fractional anticipatory goal response (Hull): Hull described the CR as a fractional component of the UCR. He referred to the complete unconditioned response as a goal response (R_g) and to the component as a fractional anticipatory goal response (r_g). The fractional component can occur in the absence of the UCS and at points remote from it in time or space (133, p. 53).

Frustration-drive theory: (See footnote 82.)

Frustrative non-reward hypothesis: (See p. 56.)

Full reinforcement (continuous reinforcement): Reinforcement of all correct responses (139, p. 766).

Function: A function f from a set A to a set B is a rule of correspondence that assigns to each x in a certain subset D of A, a uniquely determined element f(x) of B (126, p. 12).

Generalization: The phenomenon of an organism's responding to all situations similar to one in which it has been conditioned (139, p. 770).

Generalization decrement: All extinction procedures involve changes in

the experimental situation in that the proprioceptive consequence of reinforcement, and eventually responding, are eliminated. If the conditioned response (CR) is at all under the control of these stimuli, it should lose strength as a result of such changes, and extinction should be hastened to a degree which depends upon the magnitude of these differences in stimulation between conditioning and extinction. The generalization decrement hypothesis stresses this interpretation (133, p. 293).

Gradient of reinforcement: The concept that the closer a response is in time and space to a reinforcement, the more the response is strengthened (139, p. 771).

Hull-Sheffield hypothesis: Also known as the stimulus-generalization theory (see p. 4.)

Hull's theory of reactive inhibition: (See p. 47.)

Inhibition: A decreasing tendency to respond with repetition of a response (139, p. 772).

Interference-by-new-learning extinction theory: (See footnote 79.)

Intermittent reinforcement: (See partial reinforcement).

I_R (Reactive inhibition): (See footnote 41.)

J.N.D. (Just Noticeable Difference): (See footnote 33.)

Latency: A response measure (See p. 12.)

Latin square: (See footnote 112.)

Learning: A relatively permanent change in response potentiality which occurs as a result of reinforced practice (133, p. 481).

Linear function (also linear transformation): A function f with domain A and range in B is said to be linear if, for all vectors x, y in A and real numbers c, $f(x + y) = f(x) + f(y)$, $f(cx) = cf(x)$

(126, p. 154).

Matrix: Is a rectangular array of numbers, which acquires meaning as soon as its rules of operation are specified (127, pp. 21-22).

Modified after-effects hypothesis: (See p. 83.)

Modified version of the Hull-Sheffield hypothesis: (See theory 1, p. 4.)

Monotone decreasing function: A function f(x) is monotone decreasing on a set A if and only if whenever a and b are elements of A and $a<b$, then $f(a) \geq f(b)$, (140, p. 49).

Monotone increasing function: A function f(x) is monotone increasing on a set A if and only if whenever a and b are elements of A and $a<b$, then $f(a) \leq f(b)$, (140, p. 49).

Mutually exclusive: Two sets A and B, neither is equal to $\emptyset$, are said to be mutually exclusive if $A \cap B = \emptyset$ (131, p. 50).

Mutually exhaustive: Two sets A and B are said to be mutually exhaustive if $A \cup B$ is equal to the universal set (131, p. 50).

Negative acceleration: (See footnote 34.)

Negative induction (Pavlov): The intensification of inhibition under the influence of preceding excitation (133, p. 481).

Negative reinforcement: (See punishment).

Negative transfer: The harmful effect on learning in one situation because of previous learning in another situation. It is due to incompatible responses being required in the two situations (139, p. 776).

Operator: An operator O is a transformation on all values of x such that when applied to x defines a new quantity O(x) (127, p. 18).

Overlearning reversal effect (ORE): In discrimination learning, prolonged

training decreases resistance to extinction and facilitates the learning of the reversal of the original discrimination (65, p. 309).

Partial reinforcement: A training procedure in which the reinforcement occurs on only a fraction of the trials (133, p. 480).

Pavlov's theory of internal inhibition: (See p. 14.)

Positive event: (See footnote 30.)

Positive induction (Pavlov): (See footnote 133.)

Positive reinforcement: (See reward).

Positive transfer: More rapid learning in one situation because of previous learning in another situation. It is due to a similarity of the stimuli and/or responses required in the two situations (139, p. 779).

Power series (around X = 0): A series of the form $\sum_{n=0}^{\infty} A_n X^n = A_o + a_1 X + a_2 X^2 + a_3 X^3 + \ldots$ (126, p. 409).

Primary reinforcement: In conditioning, the presentation of the unconditioned stimulus immediately following the conditioned stimulus; in instrumental learning, the presentation of an incentive immediately following the instrumental response (139, p. 779).

Probability of an event: The ratio of the number of favorable cases to the total number of equally likely cases (129, p. 80).

Probability invariance rule: States that probability cannot be created or destroyed; the total probability is always the same on every trial (127, p. 15).

Probability of occurrence: A response measure (see p. 11).

Punishment: The application of an unpleasant stimulus for the purpose of eliminating undesirable behavior (139, p. 780).

Rate of responding: A response measure (see p. 12).

Reinforcement (Pavlov): The experimental arrangement of presenting the CS accompanied by the UCS, or, more generally, the arrangement of following the CS and response by reward or punishment, or some substitute for these (133, p. 483).

"Reinforcement-discrimination" hypothesis of Grant and Schipper: (See p. 54.)

Resistance to extinction: A response measure (see p. 12).

Response magnitude: A response measure (see p. 12).

Response speed: A response measure (see p. 12).

Response-unit theory: (See p. 7.)

Reward: (1) Loosely equivalent to reinforcement. (2) In social psychology, pleasures or satisfactions occurring as a result of behaviors chosen (139, p. 781).

Schedule of reinforcement: Some specified sequence of partial reinforcement where (a) reinforcement may be administered on a time-or response-determined basis, and (b) the temporal or response contingency may be regular or irregular. Time-based schedules are interval schedules; response-based schedules are ratio schedules. Regular schedules are referred to as fixed; irregular schedules are variable. The four basic schedules studied by Skinner and his associates[164] are: (1) Fixed Interval, (2) Variable Interval, (3) Fixed Ratio, and (4) Variable Ratio.

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[164]See (130).

Fixed Interval: Reinforcement follows the first response which occurs after some specified period of time measured from the last reinforcement.

Variable Interval: Reinforcement occurs after a period of time which varies from reinforcement to reinforcement.

Fixed Ratio: Reinforcement occurs after every n^{th} response.

Variable Ratio: Reinforcement occurs after a number of responses which changes from one reinforcement to another (133, pp. 162-163).

Secondary reinforcement: The reinforcing effect of a stimulus that has been paired with a primary reinforcement (139, p. 782).

Secondary reinforcement theory: (See p. 6.)

Sequence: A sequence in A is a function whose domain is the set of natural numbers and whose range is contained in A (126, p. 98).

S^{H}_{R} (Habit strength): (See footnote 40.)

S^{I}_{R} (Conditioned inhibition): (See footnote 41.)

Spontaneous recovery: An increase in the strength of an extinguished conditioned response after the passage of an interval of time (139, p. 784).

Statistical significance: Applies to the rejection of a statistical hypothesis (131, p. 247).

Stimulus-generalization: Refers to the fact that the response spreads from the conditioned stimulus to adjacent stimuli (133, pp. 87-88).

Stimulus-generalization theory: (See p. 4.)

Stimulus-response learning theories: (See footnote 12.)

Strength of response: Any descriptive characteristic of single responses or of groups of responses which may be expressed quantitatively (133, p. 484).

Subgoal reinforcement: (See footnote 43.)

Theory of serial patterning: (See footnote 95.)

Two-factor hypothesis of Grant and Schipper: (See p. 84.)

Two-stage model of learning hypothesis of Sutherland et al: (See p. 87.)

Unconditioned stimulus (UCS): (See footnote 87.)

Universal set: A set that contains all the elements under discussion (131, p. 15).

Variable-interval reinforcement: (See schedule of reinforcement).

Variable-ratio reinforcement: (See schedule of reinforcement).

Vector: A matrix with one row or one column (127, p. 25).

Well-behaved function: A function f which meets the criteria of Taylor's theorem, that is, f and its (n - 1) derivatives are defined and continuous on its closed domain and its nth derivative exists on its open domain (126, p. 211).

Symbols and Abbreviations

$\rightarrow$	approaches
$\simeq$	is approximately equal to
$=$	is equal to
$\equiv$	is equivalent to
$>$	is greater than
$<$	is less than
$\leq$	is less than or equal to

∞	infinity
$\cap$	intersection
$\emptyset$	null (empty) set
/	per
%	percent
$\sum$	summation (single)
$\sum\sum$	summation (double)
U	union
acq.	acquisition
bl.	block
C_{rc}	cell in r^{th} row and c^{th} column
CR	conditioned response or continuous reinforcement
CR/RE	R/RE ≡ no. of R's per reinforcement
df	degrees of freedom
E, $\underline{E}$	experimenter
eq.	equation
est.	estimated
ext.	extinction
F	fixed reinforcement, F-ratio, or female
F/L	fixed reinforcement with Lt.
F/N	fixed reinforcement with No Lt.
FR	fixed reinforcement
ft.	foot
gms.	grams
Gp#	group number
i.e.	that is

LT, Lt. light on

M grand mean, or male

MS mean square

Msec. millisecond

$\overline{X}$ mean

No. number

ORE overlearning reversal effect

NO LT (No Lt.) light off

p. page

PL probability-learning

pp. pages

PRE partial reinforcement effect

PSI pounds/square inch

RE reinforcement

S, Ss (S, Ss) subject, subjects

S# subject number

Sch. schedule

Secs. seconds

SS sum of squares

V/L variable reinforcement with LT.

V/N variable reinforcement with No LT.

vs. versus, against

n-W n Watts

APPENDIX II

PROCEDURAL & METHODOLOGICAL CONSIDERATIONS

The pattern which the experimenter followed in actuating the bulbs; (probability of occurrence of "right" (R) is set at .8).

ACQ _____ EXT _____

S# _____ Gp# _____ Schedule _____

Trial	Lt	G	RE	Trial	Lt	G	RE
1	R			31	R		
2	R			32	R		
3	L			33	R		
4	R			34	L		
5	R			35	R		
6	R			36	R		
7	L			37	R		
8	R			38	R		
9	R			39	L		
10	R			40	R		
11	R			41	L		
12	R			42	R		
13	R			43	R		
14	R			44	R		
15	R			45	R		
16	R			46	R		
17	R			47	L		
18	L			48	R		
19	R			49	R		
20	L			50	R		
21	R			51	R		
22	L			52	L		
23	R			53	R		
24	R			54	R		
25	R			55	L		
26	L			56	R		
27	R			57	R		
28	R			58	R		
29	R			59	R		
30	R			60	R		

Legend:
- ACQ Acquisition
- EXT Extinction
- S# Subject number
- Gp# Group number
- Schedule Schedule of reinforcement
- Lt Light
- G Group
- RE Reinforcement

Note: There are eight "rights" and 2 "lefts" in every block of 10 trials. The "lefts" occupy different positions in different blocks. When more than 60 trials were needed either for acquisition or extinction, duplicates of this sheet were used.

Assignment of Subjects to Groups and Choice of Sample Size

Method of Assigning N Subjects to K Groups

The random assignment of N subjects to K groups (K<N) was accomplished (using a table of random numbers) as follows: The last two digits of the first row and first column taken as a number ≤ N were first selected and assigned to Group 1. A second number ≤ N made up of the last two digits of the second row and first column was assigned to Group 2; a third number ≤ N made up of the last two digits of the third row and first column was assigned to Group 3; and so on. . . until K numbers were chosen. The $(K + 1)^{th}$ number to be chosen was then assigned to Group 1 and the process was continued until the N numbers were all selected. If a number formed was > N or was a repeated number already chosen, it was passed over and the next appropriate number was taken. If column 1 was not adequate, columns 2, 3, 4, etc. . . . in order were than used until completion of the process.

"It is entirely possible," says Hays, "for a given factor to show up as statistically significant in a study, even though only a very small percentage of variance is attributable to that factor. This is most likely to happen if the sample n is very large, of course."[165] Since, in the analysis of variance, the level of significance of an over-all F test sets an upper bound on the Type I error in the decision rule, a choice of a suitably large n under each treatment could make the power of the test with respect to a specified hypothesis, as large as desired. How large should n be to make it suitable depends, among many things, upon

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[165] See (131), p. 423.

the availability of subjects. The choice of six subjects per group in this research was first made as a convenient good guess. It was not until Study #1 was completed, that this choice was justified statistically. The formula used in the statistical justification for using six subjects per cell in the analysis of variance of Study #4 appears on page 198.

Determination of Sample Size

Let M_j and M denote the mean of the jth group and grand mean of the J groups respectively. Let N be the total number of subjects in the J groups.

est. $\alpha_j = M_j - M$[166] and est. $\sigma_e^2 = \sum_j^J \sum_i^I (Y_{ij} - M_j)^2/N-J.$[167]

Therefore, from Study #4, Table 5,

$$M_1 = \frac{1840 + 1210 + 1460 + 1510 + 1320 + 1110}{36} = 234.72.$$

$$M_2 = \frac{850 + 600 + 910 + 310 + 650 + 610}{36} = 109.16$$

$$M = \frac{234.72 + 109.16}{2} = 171.93.$$

est. $\alpha_1 = M_1 - M = 62.79$

est. $\alpha_2 = M_2 - M = -62.77$

est. $\sigma_e^2 = \{(360 - 234.72)^2 + (360 - 234.72)^2 + ... +$
$(60 - 234.72)^2 + (170 - 234.72)^2 + (180 - 109.16)^2 +$
$(30 - 109.16)^2 + ... + (170 - 109.16)^2 +$
$(110 - 109.16)^2\}/(72 - 2) = \frac{944,171.92}{70} = 13,488.17$

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[166] See (131), p. 381.

[167] See (131), p. 367.

est. $\sigma_e = \sqrt{13,488.17} = 116.13$

est. α_1 - est. $\alpha_2 = 62.79 + 62.77 = 125.56$

$125.56 = C \times 116.13$ where C is a constant.

$C = 1.08$

$\Phi = \sqrt{\frac{HC^2}{2J}}$[168], where H = number of subjects in a cell (n) x number of rows.

At $\alpha = .01$, $1 - \beta = .90$, $\nu_1 = 1$, $\nu_2 = 60$, $\Phi = 2.8$[169]

Therefore, $(2.8)^2 = \frac{(1.08)^2 H}{2 \times 2}$; $H = \frac{7.84 \times 4}{1.17} = 26.8$; and $n = \frac{26.8}{6} \simeq 4$.

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[168] See (135), p. 109.

[169] See (135), p. 540.

APPENDIX III

MATHEMATICAL ANALYSIS OF THE PROBABILITY LEARNING SITUATION

Let $S = S_1 \cup S_2$ ($S_1 \cap S_2 = \emptyset$) be the universal set of stimulus elements, each of which is connected to (tends to evoke) exactly one response at a given time. S_1 is the set of all elements connected to response A_1, and S_2 is the set of all elements connected to response A_2. At a particular moment, then, n_1 elements from S_1 evoke response A_1 and n_2 elements from S_2 evoke response A_2. At this same instant, therefore, the proportion of elements connected to response A_1 would be equal to $\frac{n_1}{n_1+n_2}$. Since n_1 and n_2 are changing over trials, let P_n designate the proportion of A_1-connected elements at the moment a response is evoked on the nth trial, or equivalently, the probability that the response on the nth trial is A_1. One is interested in an operator T which when applied to P_n will yield a new probability value $T(P_n)$. This operator can be, for example, P_{n+1} (the probability of the occurrence of A_1 on the $(n+1)^{th}$ trial). In other words, granted P_n is given, what is P_{n+1}?

Suppose that $T(P_n)$ can be expressed in terms of P_n and is a well-behaved function of it.[170] It can, then, be expanded as a power series of P_n: $T(P_n) = C_o + C_1P_n + C_2P_n^2 + C_3P_n^3 + \ldots\ldots$ where C_o, C_1, C_2, C_3,

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[170] Here the probability $T(P_n)$ is assumed to depend only on the probability P_n and not upon previous probabilities. Later in the sequel other factors such as reward and punishment, etc. . . . would be taken into account.

. . . are constants independent of P_n. For the sake of simplifying the mathematical development, only the first two terms are retained, making $T(P_n) = C_o + C_1P_n$--a linear function of P_n (1). Once the constants C_o and C_1 are specified, the operator T becomes completely defined. Therefore, for reasons[171] to be indicated later, let $C_o = a$, and $C_1 = 1-a-b$. Equation (1) becomes

$$T(P_n) = P_{n+1} = a + (1-a-b)P_n$$
$$= P_n + a(1-P_n) - bP_n. \quad (2)$$

To maintain the probability values between 0 and 1 inclusive, a and b must also take the values between 0 and 1 inclusive. Furthermore, if the events $E_i (i = 1,2)$ are to be considered as the only source of reinforcement[172] variation (including zero variation), then one can associate with a ($a \neq 0$) the factor which always increases the probability P_{n+1} and with b ($b \neq 0$) the factor which always decreases P_{n+1}; a=0 and b=0 indicate that no reinforcement (positive or negative) would take place. In this case, therefore, it is appropriate to write a_i and b_i in lieu of a and b respectively. Equation (2) takes the final forms

$$T_i(P_n) = P_{n+1} = a_i + (1-a_i-b_i)P_n$$
$$= a_i + [1-(a_i+b_i)]P_n$$
$$= P_n + a_i (1-P_n) - b_iP_n. \quad (3)$$

Letting $n = 1,2,3,4,\ldots\ldots$, N and $a_i + b_i = x$, the second form of equation (3) would give:

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[171] See p. 203.

[172] Reinforcement is taken here in the general sense--when positive, it includes reward, etc. . . . and when negative, it includes punishment and other related factors (see footnote 170).

$$P_2 = a_i + (1-x)P_1,$$

$$P_3 = a_i + (1-x)P_2 = a_i + (1-x)[a_i + (1-x)P_1]$$

$$= a_i + a_i(1-x) + (1-x)^2P_1,$$

$$P_4 = a_i + (1-x)P_3 = a_i + (1-x)\{a_i + a_i\,(1-x) + (1-x)^2P_1\}$$

$$= a_i + a_i\,(1-x) + a_i\,(1-x)^2 + (1-x)^3P_1,$$

$$P_5 = a_i + (1-x)P_4 = a_i + (1-x)\{a_i+a_i(1-x) + a_i(1-x)^2 + (1-x)^3P_1\}$$

$$= a_i+a_i(1-x) + a_i(1-x)^2 + a_i(1-x)^3 + (1-x)^4P_1,$$

$$P_6 = a_i + a_i(1-x) + a_i(1-x)^2 + a_i(1-x)^3 + a_i(1-x)^4 + (1-x)^5P_1,$$

. . . . . , and

$$P_{N+1} = a_i+a_i(1-x) + a_i(1-x)^2 + a_i(1-x)^3 + ... + a_i(1-x)^{N-1} + (1-x)^NP_1$$

$$= a_i\{1+(1-x) + (1-x)^2 + (1-x)^3 + ... + (1-x)^{N-1}\} + (1-x)^NP_1. \quad (4)$$

However, $1 + (1-x) + (1-x)^2 + (1-x)^3 + ... + (1-x)^{N-1} = \frac{1}{x} - \frac{(1-x)^N}{x}$, for all x (except x = 0). Therefore, eq. (4) reduces to:

$$P_{N+1} = a_i\left[\frac{1}{x} - \frac{(1-x)^N}{x}\right] + (1-x)^NP_1$$

$$= \frac{a_i}{x} - \frac{a_i(1-x)^N}{x} + (1-x)^NP_1$$

$$= \frac{a_i}{x} - [1-x]^N \cdot \left[\frac{a_i}{x} - P_1\right]. \quad (5)$$

Replacing x by $a_i + b_i$ in eq. (5) would result in:

$$P_{N+1} = \frac{a_i}{a_i+b_i} - [1 - (a_i+b_i)]^N \cdot \left[\frac{a_i}{a_i+b_i} - P_1\right]. \quad (6)$$

Since $a_i + b_i$ cannot be zero (otherwise eq. (6) is meaningless), and if one can assume that $a_i + b_i$ cannot be unity,[173] then as $N \to \infty$, $[1 - (a_i+b_i)]^N \to 0$ Therefore, P_{N+1} (eq. (6)) would eventually approach a limiting value of

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[173] In practical situations it is unlikely that a_i and b_i would both be zero or both unity.

$\frac{a_i}{a_i+b_i}$. Eq. (6) describes the phase of learning (acquisition).

A look at eq. (6) reveals the following:

1. $a_i = b_i$ ($a_i \neq 0$, $a_i \neq 1$)[174] implies $P_{N+1} = \frac{1}{2}$. In other words, if the measures of positive and negative reinforcement are equal and do not take extreme values, then the ultimate probability of occurrence of the A_1-response is $\frac{1}{2}$;
2. $a_i = 1$ and $b_i = 0$ implies $P_{N+1} = 1$; and
3. $a_i = 0$ and $b_i = 1$ implies $P_{N+1} = 0$.

When $a_i = 0$ (i.e., when there is no positive reinforcement), eq. (3) becomes:

$$P_{n+1} = P_n - b_i P_n = (1-b_i)P_n. \quad (7)$$

Upon letting n = 1,2,3,4,....,N, eq. (7) takes the values:

$$P_2 = (1-b_i)P_1,$$

$$P_3 = (1-b_i)P_2 = (1-b_i)(1-b_i)P_1 = (1-b_i)^2 P_1,$$

$$P_4 = (1-b_i)^3 P_1,$$

. . . . . ., and

$$P_{N+1} = (1-b_i)^N P_1. \quad (8)$$

Provided that $b_i \neq 0$,[175] as $N \to \infty$, P_{N+1} (eq. (8)) $\to 0$. Eq. (8) describes the phase of extinction.

The fact that a matrix can operate on a whole set of variables at the same time, makes it a convenient mathematical operator. Moreover, a

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[174] No meaningful interpretation can be obtained from eq. (3) if $a_i=b_i=\lambda(\lambda\neq 0,\lambda\neq 1)$. However, $a_i=b_i=0$ and $a_i=b_i=1$ (while cannot be assumed in eq. (6)) reduce eq. (3) to ${}^1P_{n+1}=P_n$ and ${}^1P_{n+1} = 1-P_n$ respectively.

[175] If $b_i=0$ (already a_i assumed equal to zero), then P_{N+1} (eq. (4)) $= P_1$ and P_{N+1} (eq. (8)) $= P_1$. These two results indicate that when both measures of reinforcement are non-existent, there is no acquisition and hence no extinction.

matrix is a linear operator used to represent all linear transformations on a set of variables.

Let p_n and q_n designate the probability that the responses on the nth trial are A_1 and A_2 respectively ($p_n + q_n = 1$). Define a probability vector $P = \begin{bmatrix} p_n \\ q_n \end{bmatrix}$. A suitable event operator could then be $T = \begin{bmatrix} u_{11} & u_{12} \\ u_{21} & u_{22} \end{bmatrix}$. Applying T to P, one obtains the vector:

$$T(P) = \begin{bmatrix} u_{11} & u_{12} \\ u_{21} & u_{22} \end{bmatrix} \cdot \begin{bmatrix} p_n \\ q_n \end{bmatrix} = \begin{bmatrix} u_{11}\, p_n + u_{12}\, q_n \\ u_{21}\, p_n + u_{22}\, q_n \end{bmatrix}. \quad (9)$$

Eq. (9) can be interpreted to mean that the probabilities of occurrence of A_1 and A_2 are now $u_{11}p_n + u_{12}q_n$ and $u_{21}p_n + u_{22}q_n$ respectively. Since S_1 and S_2[176] are mutually exclusive and exhaustive, $(u_{11}p_n + u_{12}q_n) + (u_{21}p_n + u_{22}q_n) = 1$[177], or $(u_{11} + u_{21})p_n + (u_{12} + u_{22})q_n = 1$. (10)

Eq.(10) must hold for all values of p_n and q_n, and so, for $p_n = 1$ and $q_n = 0$, $u_{11} + u_{21} = 1$, whereas for $p_n = 0$ and $q_n = 1$, $u_{12} + u_{22} = 1$. These two restrictions assert that the column sums of matrix T must each be unity. Therefore, if $u_{12} = a$ and $u_{21} = b$, then T can equivalently be expressed in the form $\begin{bmatrix} 1-b & a \\ b & 1-a \end{bmatrix}$. Hence T(P) becomes $\begin{bmatrix} (1-b)\, p_n + aq_n \\ bp_n + (1-a)q_n \end{bmatrix}$. (11)

Since T is an event operator, and there are only two events (E_1 and E_2), eq.(11) must be written:

$$T_i(P) = \begin{bmatrix} (1-b_i)p_n + a_i q_n \\ b_i p_n + (1-a_i)q_n \end{bmatrix}, \quad (i = 1,2). \quad (12)$$

One concludes from eq.(12) that $T_i(p_n) = (1-b_i)p_n + a_i q_n = (1-b_i)p_n + a_i(1-p_n) = p_n - b_i p_n + a_i - a_i p_n = a_i + (1-a_i-b_i)p_n$[178] defines a linear function of p_n.

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[176] See p. 199.

[177] By the probability invariance rule. (See Glossary, p. 188.)

[178] See eq. (3), p. 200.

APPENDIX IV

CORRELATIONAL ANALYSES AND ANALYSES OF COVARIANCE

STUDY 1

RE VS. EXTINCTION TRIALS

TABLE A

RAW DATA

28.0000	20.0000
0.0000	100.0000
30.0000	40.0000
34.0000	40.0000
0.0000	360.0000
23.0000	20.0000
11.0000	30.0000
11.0000	90.0000
13.0000	160.0000
19.0000	30.0000
11.0000	20.0000
18.0000	100.0000
20.0000	20.0000
9.0000	20.0000
9.0000	20.0000
7.0000	30.0000
7.0000	40.0000
20.0000	20.0000
21.0000	100.0000
15.0000	20.0000
0.0000	20.0000
16.0000	40.0000
22.0000	30.0000
41.0000	40.0000
16.0000	60.0000
0.0000	50.0000
10.0000	20.0000
0.0000	360.0000
10.0000	20.0000
0.0000	20.0000
8.0000	20.0000
11.0000	20.0000
31.0000	30.0000
22.0000	40.0000
16.0000	40.0000
35.0000	30.0000

Number of observations = 36.

Means are: 15.1111; 58.8888.

Standard deviations are: 10.7962; 80.4195.

Standard Errors are: 1.7993; 13.4032. Correlation Coefficient: -0.3368.

STUDY 1

CR/RE VS. EXTINCTION TRIALS

TABLE B

RAW DATA

1.6400	20.0000
1.3300	40.0000
1.2400	40.0000
1.5700	20.0000
3.6400	30.0000
3.5000	20.0000
3.6400	90.0000
3.2300	160.0000
1.9500	20.0000
1.7400	30.0000
3.3600	20.0000
1.6700	100.0000
1.9500	20.0000
3.5600	20.0000
3.5700	30.0000
1.9000	100.0000
1.8700	20.0000
1.8100	40.0000
1.7700	30.0000
1.2700	40.0000
4.0000	40.0000
2.1300	60.0000
3.5000	20.0000
3.6000	20.0000
3.4500	20.0000
1.2900	30.0000
1.3600	40.0000
1.8800	40.0000
1.2000	30.0000

Number of observations = 29.

Means are: 2.3662; 41.0344.

Standard deviations are: 0.9759; 32.4416.

Standard errors are: 0.1812; 6.0242

Correlation Coefficient: 0.0274

STUDY 1

NO. OF L-L VS. EXTINCTION TRIALS

TABLE C

RAW DATA

5.0000	20.0000
8.0000	100.0000
3.0000	40.0000
3.0000	40.0000
9.0000	360.0000
7.0000	20.0000
4.0000	30.0000
5.0000	20.0000
7.0000	20.0000
3.0000	90.0000
7.0000	160.0000
3.0000	20.0000
7.0000	30.0000
6.0000	20.0000
8.0000	100.0000
2.0000	20.0000
6.0000	20.0000
5.0000	20.0000
7.0000	30.0000
4.0000	100.0000
6.0000	20.0000
7.0000	20.0000
7.0000	40.0000
5.0000	30.0000
2.0000	40.0000
4.0000	40.0000
3.0000	60.0000
8.0000	50.0000
5.0000	20.0000
5.0000	360.0000
5.0000	20.0000
6.0000	20.0000
4.0000	30.0000
4.0000	40.0000
6.0000	40.0000
5.0000	30.0000

Number of observations = 36.

Means are: 5.3055; 58.8888.

Standard deviations are: 1.8176; 80.4195.

Standard errors are: 0.3029; 13.4032. Correlation Coefficient: 0.2701.

STUDY 1

CLUSTER OF L VS. EXTINCTION TRIALS

TABLE D

RAW DATA

1.0000	20.0000
2.0000	100.0000
1.0000	40.0000
2.0000	40.0000
3.0000	360.0000
1.0000	20.0000
1.0000	30.0000
7.0000	20.0000
4.0000	20.0000
1.0000	90.0000
1.0000	160.0000
0.0000	20.0000
4.0000	30.0000
2.0000	20.0000
3.0000	100.0000
2.0000	20.0000
2.0000	20.0000
4.0000	20.0000
4.0000	30.0000
3.0000	100.0000
6.0000	20.0000
7.0000	20.0000
4.0000	40.0000
2.0000	30.0000
1.0000	40.0000
2.0000	40.0000
3.0000	60.0000
2.0000	50.0000
5.0000	20.0000
3.0000	360.0000
2.0000	20.0000
3.0000	20.0000
4.0000	30.0000
4.0000	40.0000
4.0000	40.0000
1.0000	30.0000

Number of observations = 36.

Means are: 2.8055; 58.8888.

Standard deviations are: 1.7041; 80.4195.

Standard errors are: 0.2840; 13.4032. Correlation Coefficient: -0.0704

STUDY 1

N-RE VS. EXTINCTION TRIALS

TABLE E

RAW DATA

40.0000	20.0000
0.0000	100.0000
32.0000	40.0000
28.0000	40.0000
0.0000	360.0000
30.0000	20.0000
22.0000	30.0000
0.0000	20.0000
16.0000	20.0000
22.0000	90.0000
24.0000	160.0000
24.0000	20.0000
29.0000	30.0000
21.0000	20.0000
27.0000	100.0000
31.0000	20.0000
18.0000	20.0000
17.0000	20.0000
12.0000	30.0000
28.0000	20.0000
0.0000	20.0000
28.0000	40.0000
26.0000	30.0000
24.0000	40.0000
13.0000	40.0000
29.0000	60.0000
0.0000	50.0000
17.0000	20.0000
23.0000	100.0000
0.0000	360.0000
15.0000	20.0000
18.0000	20.0000
23.0000	30.0000
24.0000	40.0000
17.0000	40.0000
31.0000	30.0000

Number of observations = 36.

Means are: 19.6944; 58.8888.

Standard deviations are: 10.6926; 80.4195.

Standard errors are: 1.7821; 13.4032. Correlation Coefficient: -0.4240.

STUDY 2

RE VS. EXTINCTION TRIALS...LT

TABLE F

RAW DATA

22.0000	250.0000
0.0000	60.0000
18.0000	20.0000
21.0000	20.0000
22.0000	230.0000
11.0000	110.0000
0.0000	60.0000
35.0000	30.0000
33.0000	360.0000
8.0000	20.0000
17.0000	360.0000
9.0000	20.0000
32.0000	190.0000
0.0000	270.0000
27.0000	360.0000
26.0000	360.0000
22.0000	360.0000
9.0000	360.0000
0.0000	20.0000
10.0000	20.0000
18.0000	360.0000
7.0000	27.0000
32.0000	40.0000
11.0000	100.0000
0.0000	360.0000
12.0000	270.0000
8.0000	360.0000
18.0000	360.0000
18.0000	140.0000
9.0000	70.0000
0.0000	20.0000
15.0000	44.0000
11.0000	90.0000
8.0000	360.0000
23.0000	360.0000
18.0000	210.0000

Number of observations = 36.

Means are: 14.7222; 184.7500.

Standard deviations are: 10.1576; 145.1789.

Standard errors are: 1.6929; 24.1964. Correlation Coefficient: 0.2311.

STUDY 2

RE VS. EXTINCTION TRIALS...NO LT

TABLE F'

RAW DATA

10.0000	220.0000
0.0000	20.0000
7.0000	64.0000
25.0000	40.0000
16.0000	40.0000
20.0000	40.0000
11.0000	90.0000
23.0000	360.0000
7.0000	20.0000
0.0000	40.0000
7.0000	50.0000
22.0000	30.0000
15.0000	20.0000
8.0000	20.0000
29.0000	100.0000
18.0000	80.0000
0.0000	79.0000
9.0000	20.0000
24.0000	70.0000
21.0000	50.0000
27.0000	110.0000
20.0000	340.0000
10.0000	40.0000
21.0000	43.0000
8.0000	20.0000
22.0000	30.0000
6.0000	73.0000
34.0000	60.0000
8.0000	80.0000
38.0000	330.0000
17.0000	50.0000
0.0000	20.0000
9.0000	20.0000
0.0000	20.0000
18.0000	80.0000
0.0000	80.0000

Number of observations = 36.

Means are: 14.1666; 79.1389.

Standard deviations are: 10.1432; 89.4024.

Standard errors are: 1.6905; 14.9004. Correlation Coefficient: 0.4057.

STUDY 2

R/RE VS. EXTINCTION TRIALS...LT

TABLE G

RAW DATA

1.6400	250.0000
1.9400	20.0000
1.3300	20.0000
1.9500	230.0000
3.7300	110.0000
1.2000	30.0000
1.2700	360.0000
3.3800	20.0000
1.8800	360.0000
3.4400	20.0000
1.1600	190.0000
1.7800	360.0000
1.1200	360.0000
1.9500	360.0000
3.2200	360.0000
3.5000	20.0000
2.0600	360.0000
4.2900	27.0000
1.2500	40.0000
3.5500	100.0000
3.3300	270.0000
3.8800	360.0000
1.7800	360.0000
1.7800	140.0000
3.3300	70.0000
1.8700	44.0000
3.9100	90.0000
4.1300	360.0000
1.8700	360.0000
1.8900	210.0000

Number of observations = 30.

Means are: 2.4469; 195.3666.

Standard deviations are: 1.0443; 145.1420.

Standard errors are: 0.1906; 26.4991.

Correlation Coefficient: -0.1895.

STUDY 2

R/RE VS. EXTINCTION TRIALS...NO LT

TABLE G'

RAW DATA

3.3000	220.0000
3.8600	64.0000
1.2800	40.0000
1.8800	40.0000
1.6000	40.0000
3.8200	90.0000
1.9600	360.0000
3.7100	20.0000
4.1400	50.0000
1.1400	30.0000
1.7300	20.0000
4.2500	20.0000
1.1400	100.0000
1.8300	80.0000
3.4400	20.0000
1.2900	70.0000
2.0000	50.0000
1.8100	110.0000
1.8000	340.0000
3.6000	40.0000
1.7100	43.0000
1.7700	30.0000
4.3300	73.0000
1.2100	60.0000
3.6300	20.0000
4.0000	80.0000
1.8200	50.0000
3.4400	20.0000
1.8800	80.0000
1.2400	330.0000

Number of observations = 30.

Means are: 2.4869; 86.3333.

Standard deviations are: 1.1287; 95.8033.

Standard errors are: 0.2060; 17.4912.

Correlation Coefficient: -0.2205.

STUDY 2

L-L VS. EXTINCTION TRIALS...LT

TABLE H

RAW DATA

7.0000	60.0000
5.0000	20.0000
5.0000	20.0000
8.0000	250.0000
3.0000	230.0000
4.0000	110.0000
8.0000	60.0000
5.0000	30.0000
3.0000	360.0000
7.0000	20.0000
5.0000	360.0000
7.0000	20.0000
7.0000	190.0000
4.0000	270.0000
4.0000	360.0000
9.0000	360.0000
2.0000	360.0000
9.0000	360.0000
7.0000	20.0000
6.0000	20.0000
2.0000	360.0000
3.0000	27.0000
4.0000	40.0000
7.0000	100.0000
2.0000	360.0000
5.0000	270.0000
5.0000	360.0000
7.0000	140.0000
8.0000	70.0000
5.0000	20.0000
6.0000	44.0000
1.0000	90.0000
3.0000	360.0000
3.0000	360.0000
5.0000	210.0000
7.0000	360.0000

Number of observations = 36.

Means are: 5.2222; 184.7500.

Standard deviations are: 2.1261; 145.1789.

Standard errors are: 0.3543; 24.1964. Correlation Coefficient: -0.2432

STUDY 2

L-L VS. EXTINCTION TRIALS...NO LT

TABLE H'

RAW DATA

8.0000	220.0000
6.0000	20.0000
7.0000	64.0000
5.0000	40.0000
7.0000	40.0000
8.0000	40.0000
2.0000	90.0000
2.0000	360.0000
6.0000	20.0000
6.0000	40.0000
4.0000	50.0000
9.0000	30.0000
8.0000	20.0000
2.0000	20.0000
8.0000	100.0000
5.0000	80.0000
8.0000	79.0000
7.0000	20.0000
5.0000	70.0000
1.0000	50.0000
3.0000	110.0000
7.0000	340.0000
5.0000	40.0000
8.0000	43.0000
6.0000	20.0000
4.0000	30.0000
4.0000	73.0000
5.0000	60.0000
4.0000	80.0000
2.0000	330.0000
6.0000	50.0000
6.0000	20.0000
8.0000	20.0000
7.0000	20.0000
5.0000	80.0000
5.0000	80.0000

Number of observations = 36.

Means are: 5.5277; 79.1389.

Standard deviations are: 2.1042; 89.4024.

Standard errors are: 0.3507; 14.9004. Correlation Coefficient: -0.2631

STUDY 2

CLUSTER OF L VS. EXTINCTION TRIALS...LT

TABLE I

RAW DATA

3.0000	250.0000
6.0000	60.0000
3.0000	20.0000
6.0000	20.0000
1.0000	230.0000
2.0000	110.0000
3.0000	60.0000
1.0000	30.0000
1.0000	360.0000
3.0000	20.0000
3.0000	360.0000
5.0000	20.0000
5.0000	190.0000
3.0000	270.0000
0.0000	360.0000
3.0000	360.0000
1.0000	360.0000
2.0000	360.0000
5.0000	20.0000
4.0000	20.0000
2.0000	360.0000
1.0000	27.0000
2.0000	40.0000
3.0000	100.0000
0.0000	360.0000
3.0000	360.0000
4.0000	360.0000
3.0000	140.0000
4.0000	20.0000
3.0000	44.0000
0.0000	90.0000
4.0000	360.0000
4.0000	210.0000
2.0000	270.0000
2.0000	70.0000
2.0000	360.0000

Number of observations = 36.

Means are: 2.7500; 184.7500.

Standard deviations are: 1.5743; 145.1789.

Standard errors are: 0.2623; 24.1964. Correlation Coefficient: -0.3351.

STUDY 2

CLUSTER OF L VS. EXTINCTION TRIALS...NO LT

TABLE I'

RAW DATA

2.0000	220.0000
5.0000	20.0000
2.0000	64.0000
0.0000	40.0000
7.0000	40.0000
4.0000	40.0000
1.0000	90.0000
2.0000	360.0000
6.0000	20.0000
5.0000	40.0000
3.0000	50.0000
6.0000	30.0000
4.0000	20.0000
2.0000	20.0000
2.0000	100.0000
4.0000	80.0000
5.0000	79.0000
3.0000	20.0000
6.0000	70.0000
2.0000	50.0000
2.0000	110.0000
2.0000	340.0000
4.0000	40.0000
2.0000	43.0000
4.0000	20.0000
3.0000	30.0000
5.0000	73.0000
3.0000	60.0000
6.0000	80.0000
0.0000	330.0000
3.0000	50.0000
4.0000	20.0000
3.0000	20.0000
2.0000	20.0000
0.0000	80.0000
2.0000	80.0000

Number of observations = 36.

Means are: 3.2222; 79.1389.

Standard deviations are: 1.8065; 89.4024.

Standard errors are: 0.3010; 14.9004. Correlation Coefficient: -0.3831.

STUDY 2

N-RE VS. EXTINCTION TRIALS...LT

TABLE J

RAW DATA

25.0000	250.0000
0.0000	60.0000
28.0000	20.0000
29.0000	20.0000
27.0000	230.0000
22.0000	110.0000
0.0000	60.0000
31.0000	30.0000
36.0000	360.0000
16.0000	20.0000
26.0000	360.0000
18.0000	20.0000
23.0000	190.0000
0.0000	270.0000
36.0000	3600.0004
40.0000	360.0000
30.0000	360.0000
17.0000	360.0000
0.0000	20.0000
17.0000	20.0000
27.0000	360.0000
14.0000	27.0000
35.0000	40.0000
21.0000	100.0000
0.0000	360.0000
23.0000	270.0000
14.0000	360.0000
26.0000	360.0000
34.0000	140.0000
18.0000	70.0000
0.0000	20.0000
28.0000	44.0000
21.0000	90.0000
13.0000	360.0000
35.0000	360.0000
29.0000	210.0000

Number of observations = 36.

Means are: 21.0833; 274.7500.

Standard deviations are: 11.7214; 587.4713.

Standard errors are: 1.9535; 97.9118. Correlation Coefficient: 0.2645.

STUDY 2

N-RE VS. EXTINCTION TRIALS...NO LT

TABLE J'

RAW DATA

20.0000	220.0000
0.0000	20.0000
14.0000	64.0000
31.0000	40.0000
20.0000	40.0000
29.0000	40.0000
22.0000	90.0000
27.0000	360.0000
14.0000	20.0000
0.0000	40.0000
13.0000	50.0000
33.0000	30.0000
25.0000	20.0000
16.0000	20.0000
32.0000	100.0000
25.0000	80.6000
0.0000	79.0000
17.0000	20.0000
27.0000	70.0000
34.0000	50.0000
34.0000	110.0000
32.0000	340.0000
20.0000	40.0000
29.0000	43.0000
15.0000	20.0000
30.0000	30.0000
11.0000	73.0000
29.0000	60.0000
16.0000	80.0000
34.0000	330.0000
32.0000	50.0000
0.0000	20.0000
15.0000	20.0000
0.0000	20.0000
32.0000	80.0000
0.0000	80.0000

Number of observations = 36.

Means are: 20.2222; 79.1555.

Standard deviations are: 11.5142; 89.4026.

Standard errors are: 1.9190; 14.9004. Correlation Coefficient: 0.3282.

STUDY 4

RE VS. EXT. TRIALS...LT

TABLE K

RAW DATA

30.0000	360.0000
0.0000	360.0000
31.0000	320.0000
45.0000	360.0000
32.0000	360.0000
14.0000	360.0000
0.0000	360.0000
44.0000	360.0000
54.0000	360.0000
17.0000	360.0000
38.0000	260.0000
13.0000	180.0000
55.0000	360.0000
0.0000	360.0000
34.0000	360.0000
49.0000	360.0000
32.0000	200.0000
12.0000	80.0000
0.0000	360.0000
16.0000	130.0000
43.0000	360.0000
15.0000	30.0000
38.0000	40.0000
13.0000	360.0000
0.0000	40.0000
18.0000	360.0000
20.0000	360.0000
28.0000	40.0000
34.0000	30.0000
17.0000	120.0000
0.0000	30.0000
28.0000	90.0000
13.0000	60.0000
17.0000	170.0000
32.0000	50.0000
29.0000	100.0000

Number of observations = 36.

Means are: 23.92; 234.72.

Standard deviations are: 15.82; 138.46.

Correlation Coefficient: 0.1874.

STUDY 4

RE VS. EXT. TRIALS...NO LT

TABLE K'

RAW DATA

14.0000	200.0000
0.0000	20.0000
14.0000	110.0000
40.0000	180.0000
32.0000	30.0000
30.0000	70.0000
17.0000	250.0000
36.0000	70.0000
18.0000	20.0000
0.0000	80.0000
19.0000	20.0000
54.0000	30.0000
28.0000	50.0000
20.0000	180.0000
52.0000	40.0000
30.0000	160.0000
0.0000	70.0000
15.0000	70.0000
63.0000	360.0000
32.0000	90.0000
38.0000	110.0000
32.0000	360.0000
16.0000	130.0000
29.0000	60.0000
15.0000	170.0000
27.0000	80.0000
17.0000	130.0000
50.0000	50.0000
17.0000	130.0000
60.0000	190.0000
27.0000	40.0000
0.0000	40.0000
15.0000	110.0000
0.0000	40.0000
38.0000	130.0000
0.0000	60.0000

Number of observations = 36.

Means are 24.86; 109.17.

Standard deviations are: 17.04; 84.01.

Correlation Coefficient: 0.2859.

STUDY 4

R/RE VS. EXTINCTION TRIALS...LT

TABLE L

RAW DATA

1.8300	360.0000
1.2000	360.0000
1.8800	360.0000
3.7900	360.0000
1.9400	320.0000
1.2500	360.0000
1.2200	360.0000
3.6500	360.0000
1.7900	260.0000
3.8500	180.0000
1.2000	360.0000
1.9100	360.0000
1.2200	360.0000
1.7200	200.0000
3.3300	80.0000
3.8800	130.0000
1.8600	360.0000
3.6000	30.0000
1.3400	40.0000
4.0000	360.0000
3.6100	360.0000
3.4000	360.0000
1.8600	40.0000
1.8900	90.0000
4.1500	60.0000
3.8800	170.0000
1.8400	50.0000
1.9000	100.0000
3.3500	120.0000
1.9100	30.0000

Number of observations = 30.

Means are: 2.4749; 231.3333.

Standard deviations are: 1.0625; 137.3575.

Standard errors are: 0.1939; 25.0779.

Correlation Coefficient: -0.1652.

STUDY 4

R/RE VS. EXTINCTION TRIALS...NO LT

TABLE L'

RAW DATA

3.5700	200.0000
3.7900	110.0000
1.2800	180.0000
1.7200	30.0000
1.9300	70.0000
3.9400	250.0000
1.8900	70.0000
3.6700	20.0000
3.5300	20.0000
1.2800	30.0000
1.8600	50.0000
3.6500	180.0000
1.2700	40.0000
1.9000	160.0000
3.8700	70.0000
1.2400	360.0000
1.8400	90.0000
1.8400	110.0000
1.9400	360.0000
3.7500	130.0000
1.7200	60.0000
3.8000	170.0000
3.0600	80.0000
3.9400	130.0000
1.3400	50.0000
3.5900	130.0000
1.2500	190.0000
3.5300	110.0000
1.7900	130.0000
1.9300	40.0000

Number of observations = 30.

Means are: 2.5236; 120.6666.

Standard deviations are: 1.0515; 88.6267.

Standard errors are: 0.1919; 16.1809.

Correlation Coefficient: 0.0235.

STUDY 4

NO. OF L-L VS. EXTINCTION TRIALS...LT

TABLE M

RAW DATA

8.0000	360.0000
4.0000	320.0000
8.0000	360.0000
9.0000	360.0000
6.0000	360.0000
8.0000	360.0000
3.0000	360.0000
7.0000	360.0000
6.0000	360.0000
2.0000	360.0000
6.0000	260.0000
6.0000	180.0000
6.0000	360.0000
2.0000	360.0000
5.0000	360.0000
8.0000	360.0000
7.0000	80.0000
5.0000	130.0000
2.0000	360.0000
8.0000	30.0000
5.0000	40.0000
6.0000	360.0000
8.0000	40.0000
5.0000	360.0000
5.0000	30.0000
10.0000	120.0000
8.0000	30.0000
7.0000	90.0000
7.0000	60.0000
5.0000	170.0000
8.0000	50.0000
6.0000	100.0000
7.0000	40.0000
11.0000	200.0000
9.0000	360.0000
5.0000	360.0000

Number of observations = 36.

Means are: 6.3333; 234.7222.

Standard deviations are: 2.1380; 140.4173.

Standard errors are: 0.3563; 23.4028. Correlation Coefficient: -0.2718.

STUDY 4

NO. OF L-L VS. EXTINCTION TRIALS..NO LT

TABLE M'

RAW DATA

9.0000	200.0000
8.0000	20.0000
10.0000	110.0000
8.0000	180.0000
11.0000	30.0000
5.0000	70.0000
1.0000	250.0000
4.0000	70.0000
4.0000	20.0000
10.0000	80.0000
7.0000	20.0000
4.0000	180.0000
5.0000	40.0000
6.0000	160.0000
7.0000	70.0000
4.0000	70.0000
3.0000	360.0000
6.0000	90.0000
4.0000	110.0000
4.0000	360.0000
6.0000	130.0000
12.0000	60.0000
6.0000	170.0000
7.0000	80.0000
1.0000	50.0000
8.0000	130.0000
3.0000	190.0000
6.0000	40.0000
6.0000	40.0000
10.0000	110.0000
8.0000	40.0000
6.0000	130.0000
7.0000	60.0000
2.0000	130.0000
3.0000	30.0000
8.0000	50.0000

Number of observations = 36.

Means are: 6.0833; 109.1666.

Standard deviations are: 2.7294; 85.2013.

Standard errors are: 0.4549; 14.2002. Correlation Coefficient: -0.2994.

STUDY 4

CLUSTER OF L VS. EXT. TRIALS...LT

TABLE N

RAW DATA

3.0000	360.0000
0.0000	360.0000
2.0000	320.0000
4.0000	360.0000
2.0000	360.0000
1.0000	360.0000
0.0000	360.0000
2.0000	360.0000
4.0000	360.0000
3.0000	360.0000
1.0000	260.0000
2.0000	180.0000
1.0000	360.0000
0.0000	360.0000
0.0000	360.0000
0.0000	360.0000
5.0000	200.0000
5.0000	80.0000
1.0000	360.0000
2.0000	130.0000
0.0000	360.0000
3.0000	30.0000
6.0000	40.0000
5.0000	360.0000
6.0000	40.0000
2.0000	360.0000
1.0000	360.0000
4.0000	40.0000
1.0000	30.0000
5.0000	120.0000
2.0000	30.0000
7.0000	90.0000
4.0000	60.0000
3.0000	170.0000
2.0000	50.0000
6.0000	100.0000

Number of observations = 36.

Means are: 2.64; 234.72.

Standard deviations are: 4.24; 138.46.

Correlation Coefficient: -0.2577.

STUDY 4

CLUSTER OF L VS. EXT. TRIALS...NO LT

TABLE N'

RAW DATA

6.0000	200.0000
2.0000	20.0000
4.0000	110.0000
3.0000	180.0000
2.0000	30.0000
2.0000	70.0000
1.0000	250.0000
1.0000	70.0000
5.0000	20.0000
4.0000	80.0000
3.0000	20.0000
3.0000	30.0000
2.0000	50.0000
2.0000	180.0000
3.0000	40.0000
3.0000	160.0000
3.0000	70.0000
2.0000	70.0000
0.0000	360.0000
5.0000	90.0000
0.0000	110.0000
1.0000	360.0000
4.0000	130.0000
5.0000	60.0000
3.0000	170.0000
6.0000	80.0000
2.0000	130.0000
2.0000	50.0000
1.0000	130.0000
0.0000	190.0000
6.0000	40.0000
2.0000	40.0000
7.0000	110.0000
4.0000	40.0000
1.0000	130.0000
2.0000	60.0000

Number of observations = 36.

Means are: 2.83; 109.17.

Standard deviations are: 1.79; 51.11.

Correlation Coefficient: -0.5441.

STUDY 4

N-RE VS. EXTINCTION TRIALS...LT

TABLE 0

RAW DATA

45.0000	360.0000
0.0000	360.0000
45.0000	320.0000
45.0000	360.0000
47.0000	360.0000
27.0000	360.0000
0.0000	360.0000
52.0000	360.0000
39.0000	360.0000
30.0000	360.0000
52.0000	260.0000
25.0000	180.0000
50.0000	360.0000
48.0000	360.0000
52.0000	360.0000
48.0000	200.0000
24.0000	80.0000
0.0000	360.0000
29.0000	130.0000
53.0000	360.0000
29.0000	30.0000
44.0000	40.0000
25.0000	360.0000
0.0000	40.0000
34.0000	360.0000
30.0000	360.0000
41.0000	40.0000
49.0000	30.0000
34.0000	120.0000
0.0000	30.0000
45.0000	92.0000
25.0000	60.0000
33.0000	170.0000
51.0000	50.0000
42.0000	100.0000
0.0000	360.0000

Number of observations = 36.

Means are: 33.1388; 234.8055.

Standard deviations are: 17.5420; 140.3298.

Standard errors are: 2.9236; 23.3883. Correlation Coefficient: 0.0368.

STUDY 4

N-RE VS. EXTINCTION TRIALS...NO LT

TABLE O'

RAW DATA

28.0000	200.0000
0.0000	20.0000
27.0000	110.0000
52.0000	180.0000
50.0000	30.0000
37.0000	70.0000
26.0000	250.0000
42.0000	70.0000
25.0000	20.0000
30.0000	30.0000
46.0000	50.0000
33.0000	180.0000
40.0000	40.0000
38.0000	160.0000
0.0000	70.0000
29.0000	70.0000
47.0000	360.0000
42.0000	90.0000
59.0000	110.0000
49.0000	360.0000
31.0000	130.0000
45.0000	60.0000
26.0000	170.0000
32.0000	80.0000
34.0000	130.0000
41.0000	50.0000
33.0000	130.0000
43.0000	190.0000
47.0000	40.0000
0.0000	40.0000
22.0000	110.0000
53.0000	130.0000
0.0000	60.0000
0.0000	40.0000
28.0000	20.0000
0.0000	80.0000

Number of observations = 36.

Means are: 31.5277; 109.1666.

Standard deviations are: 16.8683; 85.2013.

Standard errors are: 2.8113; 14.2002. Correlation Coefficient: 0.3205.

STUDY 4

NON-REINFORCED TRIALS VS. EXTINCTION TRIALS (LT.)

TABLE P

RAW DATA

45.0000	360.0000
46.0000	360.0000
36.0000	360.0000
35.0000	360.0000
41.0000	360.0000
52.0000	40.0000
60.0000	360.0000
52.0000	260.0000
47.0000	360.0000
62.0000	40.0000
62.0000	90.0000
61.0000	100.0000
73.0000	360.0000
77.0000	180.0000
78.0000	80.0000
77.0000	360.0000
72.0000	360.0000
73.0000	120.0000
90.0000	360.0000
90.0000	360.0000
90.0000	360.0000
90.0000	360.0000
90.0000	40.0000
90.0000	30.0000
59.0000	320.0000
58.0000	360.0000
56.0000	360.0000
58.0000	200.0000
56.0000	30.0000
58.0000	50.0000
76.0000	360.0000
74.0000	130.0000
75.0000	30.0000
70.0000	360.0000
77.0000	60.0000
73.0000	170.0000

Number of observations = 36.

Means are: 66.0833; 234.7222.

Standard deviations are: 16.0541; 140.4173.

Standard errors are: 2.6756; 23.4028. Correlation Coefficient: -0.1876.

STUDY 4

NON-REINFORCED TRIALS VS. EXTINCTION TRIALS (NO LT.)

TABLE P'

RAW DATA

50.0000	180.0000
36.0000	30.0000
38.0000	40.0000
27.0000	360.0000
40.0000	50.0000
30.0000	190.0000
58.0000	30.0000
60.0000	160.0000
58.0000	90.0000
52.0000	110.0000
63.0000	80.0000
52.0000	130.0000
76.0000	200.0000
73.0000	250.0000
75.0000	70.0000
74.0000	130.0000
73.0000	130.0000
73.0000	130.0000
90.0000	20.0000
90.0000	80.0000
90.0000	70.0000
90.0000	40.0000
90.0000	40.0000
90.0000	60.0000
60.0000	70.0000
54.0000	70.0000
62.0000	50.0000
58.0000	360.0000
61.0000	60.0000
63.0000	40.0000
76.0000	110.0000
72.0000	20.0000
71.0000	20.0000
70.0000	180.0000
75.0000	170.0000
75.0000	110.0000

Number of observations = 36.

Means are: 65.1389; 109.1666.

Standard deviations are: 17.2811; 85.2013.

Standard errors are: 2.8801; 14.2002. Correlation Coefficient: -0.2859.

STUDY 4

AVERAGE 'R' OF LAST TWO ACQ. BLOCKS VS. EXT. TRIALS...(LT.)

TABLE Q

RAW DATA

6.5000	360.0000
7.0000	360.0000
10.0000	360.0000
9.0000	360.0000
7.5000	360.0000
7.0000	40.0000
7.5000	360.0000
9.0000	260.0000
8.5000	360.0000
6.5000	40.0000
5.0000	90.0000
7.5000	100.0000
7.5000	360.0000
6.5000	180.0000
6.5000	80.0000
6.0000	360.0000
7.5000	360.0000
7.0000	120.0000
8.0000	360.0000
9.5000	360.0000
7.5000	360.0000
6.5000	360.0000
7.0000	40.0000
7.5000	30.0000
7.5000	320.0000
7.5000	360.0000
8.0000	360.0000
7.0000	200.0000
5.5000	30.0000
7.5000	50.0000
6.0000	360.0000
6.0000	130.0000
7.0000	30.0000
9.0000	360.0000
7.0000	60.0000
7.5000	170.0000

Number of observations = 36.

Means are: 7.3194; 234.7222.

Standard deviations are: 1.0833; 140.4173.

Standard errors are: 0.1805; 23.4028. Correlation Coefficient: 0.4377.

STUDY 4

AVERAGE 'R' OF LAST TWO ACQ. BLOCKS VS. EXT. TRIALS...(NO LT.)

TABLE Q'

RAW DATA

7.0000	180.0000
6.5000	30.0000
8.5000	40.0000
10.0000	360.0000
8.0000	50.0000
8.5000	190.0000
7.5000	30.0000
7.0000	160.0000
6.0000	90.0000
7.5000	110.0000
7.5000	80.0000
8.0000	130.0000
7.0000	200.0000
9.0000	250.0000
7.0000	70.0000
6.0000	130.0000
7.5000	130.0000
7.5000	130.0000
8.0000	20.0000
5.0000	80.0000
6.5000	70.0000
6.5000	40.0000
6.0000	40.0000
7.0000	60.0000
7.0000	70.0000
8.0000	70.0000
6.0000	50.0000
7.5000	360.0000
7.5000	60.0000
5.0000	40.0000
8.5000	110.0000
10.0000	20.0000
9.0000	20.0000
9.5000	180.0000
7.5000	170.0000
8.5000	110.0000

Number of observations = 36.

Means are: 7.4722; 109.1666.

Standard deviations are: 1.2185; 85.2013.

Standard errors are: 0.2030; 14.2002. Correlation Coefficient: 0.3121.

STUDY 4

RE VS. EXT. TRIALS...LT

TABLE a

ANALYSIS OF COVARIANCE

	SOURCE OF VARIATION		
	BETWEEN	WITHIN	TOTAL
SUM OF SQUARES Y	8539.58	481.17	9020.75
SUM OF SQUARES X	55913.47	634183.87	690097.25
SUM OF PRODUCTS	7205.82	7598.34	14804.16
DEGREES OF FREEDOM	5.00	30.00	35.00
ADJUSTED SUM OF SQUARES X	151605.90	514195.81	665801.75
DEGREES OF FREEDOM FOR ADJUSTED SUM OF SQUARES	5.00	29.00	34.00
VARIANCE ESTIMATES	30321.17	17730.89	

F = 1.710

TABLE a

MEAN OF Y = 47.5000 MEAN OF X = 306.6666

MEAN OF Y = 32.6666 MEAN OF X = 201.6666

MEAN OF Y = 15.0000 MEAN OF X = 243.3333

MEAN OF Y = 0.0000 MEAN OF X = 251.6666

MEAN OF Y = 32.5000 MEAN OF X = 220.0000

MEAN OF Y = 15.83333 MEAN OF X = 185.0000

ADJUSTED MEANS = -65.7455; 63.4925; 384.1393; 629.3426; 84.4577; 312.6466

TABLE a

HOMOGENEITY OF REGRESSION COEFFICIENTS

GROUP	SUM OF SQUARES		SUM OF PRODUCTS	ADJ. SUM OF SQUARES
	Y	X		FOR X
1	209.50	85333.34	3040.00	41220.67
2	199.33	102483.34	3173.33	51964.72
3	34.00	86733.34	720.00	71486.28
4	0.00	140883.34	0.00	140883.34
5	7.50	114600.01	-200.00	109266.67
6	30.83	104150.01	865.00	79883.25
TOTAL	481.16	634183.37	7598.33	494704.81

A = 494704.81; B = 514194.37; F = 0.18.

STUDY 4

RE VS. EXT. TRIALS...NO LT

TABLE a'

ANALYSIS OF COVARIANCE

	SOURCE OF VARIATION		
	BETWEEN	WITHIN	TOTAL
SUM OF SQUARES Y	9934.46	517.84	10452.30
SUM OF SQUARES X	37858.19	216216.84	254075.03
SUM OF PRODUCTS	11732.47	3003.35	14735.83
DEGREES OF FREEDOM	5.00	30.00	35.00
ADJUSTED SUM OF SQUARES X	34502.07	198798.12	233300.18
DEGREES OF FREEDOM FOR ADJUSTED SUM OF SQUARES	5.00	29.00	34.00
VARIANCE ESTIMATES	6900.41	6855.10	

F = 1.006

TABLE a'

MEAN OF Y = 53.1666 MEAN OF X = 141.6666

MEAN OF Y = 32.8333 MEAN OF X = 100.0000

MEAN OF Y = 16.0000 MEAN OF X = 151.6666

MEAN OF Y = 0.0000 MEAN OF X = 51.6666

MEAN OF Y = 30.3333 MEAN OF X = 108.3333

MEAN OF Y = 16.8333 MEAN OF X = 101.6666

ADJUSTED MEANS = -22.4981; 53.7632; 203.0588; 195.8546; 76.5958; 148.2257.

TABLE a'

HOMOGENEITY OF REGRESSION COEFFICIENTS

GROUP	SUM OF SQUARES		SUM OF PRODUCTS	ADJ. SUM OF SQUARES
	Y	X		FOR X
1	328.83	82683.34	2288.33	66758.95
2	96.83	10000.00	220.00	9500.17
3	8.00	20083.33	40.00	19883.33
4	0.00	2483.33	0.00	2483.33
5	53.33	76683.34	643.33	68923.12
6	30.83	24283.33	-188.33	23132.97
TOTAL	517.83	216216.65	3003.33	190681.87

A = 190681.87; B = 198797.90; F = 0.20.

STUDY 4

NON-REINFORCED TRIALS VS. EXT. TRIALS...(LT.)

TABLE b

ANALYSIS OF COVARIANCE

	SOURCE OF VARIATION		
	BETWEEN	WITHIN	TOTAL
SUM OF SQUARES Y	8539.56	481.18	9020.75
SUM OF SQUARES X	*********	548850.62	665030.62
SUM OF PRODUCTS	*********	-4558.25	-19310.83
DEGREES OF FREEDOM	5.00	30.00	35.00
ADJUSTED SUM OF SQUARES X	118020.95	505670.62	623691.62
DEGREES OF FREEDOM FOR ADJUSTED SUM OF SQUARES	5.00	29.00	34.00
VARIANCE ESTIMATES	23604.19	17436.91	
F = 1.353			

TABLE b

MEAN OF Y = 42.5000	MEAN OF X = 360.0000
MEAN OF Y = 57.3333	MEAN OF X = 201.6666
MEAN OF Y = 75.0000	MEAN OF X = 243.3333
MEAN OF Y = 90.0000	MEAN OF X = 251.6666
MEAN OF Y = 57.5000	MEAN OF X = 220.0000
MEAN OF Y = 74.1666	MEAN OF X = 185.0000

ADJUSTED MEANS = 136.5970; 118.7786; 327.8002; 478.2273; 138.6908; 261.5727.

TABLE b

HOMOGENEITY OF REGRESSION COEFFICIENTS

GROUP	SUM OF SQUARES		SUM OF PRODUCTS	ADJ. SUM OF SQUARES
	Y	X		FOR X
1	209.50	0.00	0.00	0.00
2	199.33	102483.34	-3173.33	51964.72
3	34.00	86733.34	-720.00	71486.28
4	0.00	140883.34	0.00	140883.34
5	7.50	114600.01	200.00	109266.67
6	30.83	104150.01	-865.00	79883.28
TOTAL	481.16	548850.00	-4558.33	453484.18

A = 453484.18; B = 505666.56; F = 0.55.

STUDY 4

NON-REINFORCED TRIALS VS. EXT. TRIALS...(NO LT.)

TABLE b'

ANALYSIS OF COVARIANCE

	SOURCE OF VARIATION		
	BETWEEN	WITHIN	TOTAL
SUM OF SQUARES Y	9934.43	517.87	10452.30
SUM OF SQUARES X	37858.19	216216.84	254075.03
SUM OF PRODUCTS	********	-3003.28	-14735.83
DEGREES OF FREEDOM	5.00	30.00	35.00
ADJUSTED SUM OF SQUARES X	34500.10	198800.09	233300.18
DEGREES OF FREEDOM FOR ADJUSTED SUM OF SQUARES	5.00	29.00	34.00
VARIANCE ESTIMATES	6900.01	6855.17	

F = 1.006

TABLE b'

MEAN OF Y = 36.8333 MEAN OF X = 141.6666

MEAN OF Y = 57.1666 MEAN OF X = 100.0000

MEAN OF Y = 74.0000 MEAN OF X = 151.6666

MEAN OF Y = 90.0000 MEAN OF X = 51.6666

MEAN OF Y = 39.6666 MEAN OF X = 108.3333

MEAN OF Y = 73.6666 MEAN OF X = 101.6666

ADJUSTED MEANS = -22.4840; 53.7671; 203.0543; 195.8422; 76.5986; 148.2216.

TABLE b'

HOMOGENEITY OF REGRESSION COEFFICIENTS

GROUP	SUM OF SQUARES		SUM OF PRODUCTS	ADJ. SUM OF SQUARES
	Y	X		FOR X
1	328.83	82683.34	-2288.33	66758.95
2	96.83	10000.00	-220.00	9500.17
3	8.00	20083.33	-40.00	19883.33
4	0.00	2483.33	0.00	2483.33
5	53.33	76683.34	-643.33	68923.12
6	30.83	24283.33	188.33	23132.97
TOTAL	517.83	216216.65	-3003.33	190681.87

A = 190681.87; B = 198797.90; F = 0.20.

STUDY 4

AVERAGE 'R' OF LAST TWO ACQ. BLOCKS VS. EXT. TRIALS...(LT.)

TABLE c

ANALYSIS OF COVARIANCE

	SOURCE OF VARIATION		
	BETWEEN	WITHIN	TOTAL
SUM OF SQUARES Y	4.20	36.87	41.07
SUM OF SQUARES X	55913.47	634183.87	690097.25
SUM OF PRODUCTS	313.18	2017.50	2330.69
DEGREES OF FREEDOM	5.00	30.00	35.00
ADJUSTED SUM OF SQUARES X	34049.25	523803.18	557852.50
DEGREES OF FREEDOM FOR ADJUSTED SUM OF SQUARES	5.00	29.00	34.00
VARIANCE ESTIMATES	6809.85	18062.17	

F = 0.377

TABLE c

MEAN OF Y = 7.8333	MEAN OF X = 306.6666
MEAN OF Y = 7.3333	MEAN OF X = 201.6666
MEAN OF Y = 6.8333	MEAN OF X = 243.3333
MEAN OF Y = 7.6666	MEAN OF X = 251.6666
MEAN OF Y = 7.1666	MEAN OF X = 220.0000
MEAN OF Y = 7.0833	MEAN OF X = 185.0000

ADJUSTED MEANS = 278.5510; 200.9067; 269.9291; 232.6696; 228.3586; 197.9179.

TABLE c

HOMOGENEITY OF REGRESSION COEFFICIENTS

GROUP	SUM OF SQUARES		SUM OF PRODUCTS	ADJ. SUM OF SQUARES
	Y	X		FOR X
1	9.33	85333.34	266.66	77714.28
2	10.33	102483.34	686.66	56853.22
3	1.83	86733.34	113.33	79727.28
4	5.33	140883.34	268.33	127382.79
5	3.83	114600.01	460.00	59400.00
6	6.20	104150.01	222.50	96175.84
TOTAL	36.87	634183.37	2017.50	497253.37

A = 497253.37; B = 523802.12; F = 0.25.

STUDY 4

AVERAGE 'R' OF LAST TWO ACQ. BLOCKS VS. EXT. TRIALS...(NO LT.)

TABLE c'

ANALYSIS OF COVARIANCE

	SOURCE OF VARIATION		
	BETWEEN	WITHIN	TOTAL
SUM OF SQUARES Y	21.88	30.08	51.97
SUM OF SQUARES X	37858.19	216216.84	254075.03
SUM OF PRODUCTS	373.32	760.83	1134.16
DEGREES OF FREEDOM	5.00	30.00	35.00
ADJUSTED SUM OF SQUARES X	32349.97	196974.62	229324.59
DEGREES OF FREEDOM FOR ADJUSTED SUM OF SQUARES	5.00	29.00	34.00
VARIANCE ESTIMATES	6469.99	6792.22	

F = 0.952

TABLE c'

MEAN OF Y = 8.0833 MEAN OF X = 141.6666

MEAN OF Y = 7.2500 MEAN OF X = 100.0000

MEAN OF Y = 7.3333 MEAN OF X = 151.6666

MEAN OF Y = 6.5000 MEAN OF X = 51.6666

MEAN OF Y = 6.8333 MEAN OF X = 108.3333

MEAN OF Y = 8.8333 MEAN OF X = 101.6666

ADJUSTED MEANS = 126.2112; 105.6201; 155.1792; 76.2548; 124.4912; 67.2431.

TABLE c'

HOMOGENEITY OF REGRESSION COEFFICIENTS

GROUP	SUM OF SQUARES		SUM OF PRODUCTS	ADJ. SUM OF SQUARES
	Y	X		FOR X
1	7.70	82683.34	539.16	44970.82
2	2.37	10000.00	0.00	10000.00
3	4.83	20083.33	196.66	12081.03
4	5.00	2483.33	-80.00	1203.33
5	6.33	76683.34	258.33	66146.06
6	3.83	24283.33	-153.33	18150.00
TOTAL	30.08	216216.65	760.83	152551.25

A = 152551.25; B = 196974.53; F = 1.39

STUDY 4

NO. OF ACQ. TRIALS AT FIRST .8 (OR MORE) VS. EXT. TRIALS...LT

TABLE d

ANALYSIS OF COVARIANCE

	SOURCE OF VARIATION		
	BETWEEN	WITHIN	TOTAL
SUM OF SQUARES Y	1499.98	17100.01	18600.00
SUM OF SQUARES X	55913.47	634183.87	690097.25
SUM OF PRODUCTS	66.60	-33899.94	-33833.33
DEGREES OF FREEDOM	5.00	30.00	35.00
ADJUSTED SUM OF SQUARES X	61575.63	566978.87	628554.50
DEGREES OF FREEDOM FOR ADJUSTED SUM OF SQUARES	5.00	29.00	34.00
VARIANCE ESTIMATES	12315.12	19550.99	

F = 0.629

TABLE d

MEAN OF Y = 60.0000 MEAN OF X = 306.6666

MEAN OF Y = 63.3333 MEAN OF X = 201.6666

MEAN OF Y = 63.3333 MEAN OF X = 243.3333

MEAN OF Y = 45.0000 MEAN OF X = 251.6666

MEAN OF Y = 53.3333 MEAN OF X = 220.0000

MEAN OF Y = 55.0000 MEAN OF X = 185.0000

ADJUSTED MEANS = 313.2748; 214.8829; 256.5496; 228.5380; 213.3918; 181.6959.

TABLE d

HOMOGENEITY OF REGRESSION COEFFICIENTS

GROUP	SUM OF SQUARES		SUM OF PRODUCTS	ADJ. SUM OF SQUARES
	Y	X		FOR X
1	2000.00	85333.34	-6400.00	64853.33
2	4733.33	102483.34	-10033.33	81215.50
3	1933.33	86733.34	-11066.66	23386.20
4	2350.00	140883.34	-3350.00	136107.78
5	1933.33	114600.01	2900.00	110250.00
6	4150.00	104150.01	-5950.00	95619.28
TOTAL	17100.00	634183.37	-33900.00	511432.00

A = 511432.00; B = 566978.12; F = 0.52.

STUDY 4

NO. OF ACQ. TRIALS AT FIRST .8 (OR MORE) VS. EXT. TRIALS...NO LT

TABLE d'

ANALYSIS OF COVARIANCE

	SOURCE OF VARIATION		
	BETWEEN	WITHIN	TOTAL
SUM OF SQUARES Y	5480.52	13150.03	18630.55
SUM OF SQUARES X	37858.19	216216.84	254075.03
SUM OF PRODUCTS	-13325.04	-166.62	-13491.66
DEGREES OF FREEDOM	5.00	30.00	35.00
ADJUSTED SUM OF SQUARES X	28090.06	216214.71	244304.78
DEGREES OF FREEDOM FOR ADJUSTED SUM OF SQUARES	5.00	29.00	34.00
VARIANCE ESTIMATES	5618.01	7455.67	
F = 0.753			

TABLE d'

MEAN OF Y = 35.0000	MEAN OF X = 141.6666
MEAN OF Y = 51.6666	MEAN OF X = 100.0000
MEAN OF Y = 45.0000	MEAN OF X = 151.6666
MEAN OF Y = 75.0000	MEAN OF X = 51.6666
MEAN OF Y = 56.6666	MEAN OF X = 108.3333
MEAN OF Y = 58.3333	MEAN OF X = 101.6666

ADJUSTED MEANS = 141.4308; 99.9753; 151.5575; 51.9376; 108.3720; 101.726.

TABLE d'

HOMOGENEITY OF REGRESSION COEFFICIENTS

GROUP	SUM OF SQUARES		SUM OF PRODUCTS	ADJ. SUM OF SQUARES
	Y	X		FOR X
1	3750.00	82683.34	750.00	82533.34
2	4083.33	10000.00	-1900.00	9115.91
3	1350.00	20083.33	-2350.00	15992.59
4	350.00	2483.33	50.00	2476.19
5	1733.33	76683.34	1166.66	75898.07
6	1883.33	24283.33	2116.66	21904.42
TOTAL	13149.99	216216.65	-166.66	207920.50

A = 207920.50; B = 216214.53; F = 0.19.

STUDY 4

OVERTRAINING TRIALS VS. EXT. TRIALS...LT

TABLE e

ANALYSIS OF COVARIANCE

	SOURCE OF VARIATION		
	BETWEEN	WITHIN	TOTAL
SUM OF SQUARES Y	1499.99	17100.01	18600.00
SUM OF SQUARES X	55913.47	634183.87	690097.25
SUM OF PRODUCTS	-66.72	33900.07	33833.33
DEGREES OF FREEDOM	5.00	30.00	35.00
ADJUSTED SUM OF SQUARES X	61576.13	566978.37	628554.50
DEGREES OF FREEDOM FOR ADJUSTED SUM OF SQUARES	5.00	29.00	34.00
VARIANCE ESTIMATES	12315.22	19550.97	

F = 0.629

TABLE e

MEAN OF Y = 30.0000 MEAN OF X = 306.6666

MEAN OF Y = 26.6666 MEAN OF X = 201.6666

MEAN OF Y = 26.6666 MEAN OF X = 243.3333

MEAN OF Y = 45.0000 MEAN OF X = 251.6666

MEAN OF Y = 36.6666 MEAN OF X = 220.0000

MEAN OF Y = 35.0000 MEAN OF X = 185.0000

ADJUSTED MEANS = 313.2748; 214.8830; 256.5497; 228.5379; 213.3918; 181.6958.

TABLE e

HOMOGENEITY OF REGRESSION COEFFICIENTS

GROUP	SUM OF SQUARES		SUM OF PRODUCTS	ADJ. SUM OF SQUARES
	Y	X		FOR X
1	2000.00	85333.34	6400.00	64853.33
2	4733.33	102483.34	10033.33	81215.50
3	1933.33	86733.34	11066.66	23386.20
4	2350.00	140883.34	3350.00	136107.78
5	1933.33	114600.01	-2900.00	110250.00
6	4150.00	104150.01	5950.00	95619.28
TOTAL	17100.00	634183.37	33900.00	511432.00

A = 511432.00; B = 566978.12; F = 0.52.

STUDY 4

OVERTRAINING TRIALS VS. EXT. TRIALS...NO LT

TABLE e'

ANALYSIS OF COVARIANCE

	SOURCE OF VARIATION		
	BETWEEN	WITHIN	TOTAL
SUM OF SQUARES Y	5430.54	13150.00	18630.55
SUM OF SQUARES X	37858.19	216216.84	254075.03
SUM OF PRODUCTS	13324.98	166.68	13491.66
DEGREES OF FREEDOM	5.00	30.00	35.00
ADJUSTED SUM OF SQUARES X	28090.06	216214.71	244304.78
DEGREES OF FREEDOM FOR ADJUSTED SUM OF SQUARES	5.00	29.00	34.00
VARIANCE ESTIMATES	5618.01	7455.67	

F = 0.753

TABLE e'

MEAN OF Y = 55.0000 MEAN OF X = 141.6666

MEAN OF Y = 38.3333 MEAN OF X = 100.0000

MEAN OF Y = 45.0000 MEAN OF X = 151.6666

MEAN OF Y = 15.0000 MEAN OF X = 51.6666

MEAN OF Y = 33.3333 MEAN OF X = 108.3333

MEAN OF Y = 31.6666 MEAN OF X = 101.6666

ADJUSTED MEANS = 141.4307; 99.9753; 151.5575; 51.9377; 108.3720; 101.7265.

TABLE e'

HOMOGENEITY OF REGRESSION COEFFICIENTS

GROUP	SUM OF SQUARES		SUM OF PRODUCTS	ADJ. SUM OF SQUARES
	Y	X		FOR X
1	3750.00	82683.34	-750.00	82533.34
2	4083.33	10000.00	1900.00	9115.91
3	1350.00	20083.33	2350.00	15992.59
4	350.00	2483.33	-50.00	2476.19
5	1733.33	76683.34	-1166.66	75898.07
6	1883.33	24283.33	-2116.66	21904.42
TOTAL	13149.99	216216.65	166.66	207920.50

A = 207920.50; B = 216214.53; F = 0.19.

STUDY 4

N-RE VS. EXT. TRIALS...LT

TABLE f

ANALYSIS OF COVARIANCE

	SOURCE OF VARIATION		
	BETWEEN	WITHIN	TOTAL
SUM OF SQUARES Y	10342.79	427.50	10770.30
SUM OF SQUARES X	55913.47	634183.87	690097.25
SUM OF PRODUCTS	-261.98	3398.37	3136.38
DEGREES OF FREEDOM	5.00	30.00	35.00
ADJUSTED SUM OF SQUARES X	82014.64	607169.25	689183.87
DEGREES OF FREEDOM FOR ADJUSTED SUM OF SQUARES	5.00	29.00	34.00
VARIANCE ESTIMATES	16402.92	20936.86	

F = 0.783

TABLE f

MEAN OF Y = 47.0000	MEAN OF X = 306.6666
MEAN OF Y = 46.3333	MEAN OF X = 201.6666
MEAN OF Y = 28.6666	MEAN OF X = 243.3333
MEAN OF Y = 0.0000	MEAN OF X = 251.6666
MEAN OF Y = 48.0000	MEAN OF X = 220.0000
MEAN OF Y = 28.8333	MEAN OF X = 185.0000

ADJUSTED MEANS = 196.4808; 96.7804; 278.8842; 515.0966; 101.8650; 219.226.

TABLE f

HOMOGENEITY OF REGRESSION COEFFICIENTS

GROUP	SUM OF SQUARES		SUM OF PRODUCTS	ADJ. SUM OF SQUARES
	Y	X		FOR X
1	136.00	85333.34	960.00	78556.85
2	127.33	102483.34	2626.66	48299.75
3	107.33	86733.34	686.66	82340.37
4	0.00	140883.34	0.00	140883.34
5	20.00	114600.01	-1140.00	49620.00
6	36.83	104150.01	265.00	102243.45
TOTAL	427.50	634183.37	3398.33	501943.75

A = 501943.75; B = 607168.87; F = 1.00.

STUDY 4

N-RE VS. EXT. TRIALS...NO LT

TABLE f'

ANALYSIS OF COVARIANCE

	SOURCE OF VARIATION		
	BETWEEN	WITHIN	TOTAL
SUM OF SQUARES Y	8969.79	989.17	9958.97
SUM OF SQUARES X	37858.19	216216.84	254075.03
SUM OF PRODUCTS	11974.14	4151.68	16125.83
DEGREES OF FREEDOM	5.00	30.00	35.00
ADJUSTED SUM OF SQUARES X	29171.84	198791.78	227963.62
DEGREES OF FREEDOM FOR ADJUSTED SUM OF SQUARES	5.00	29.00	34.00
VARIANCE ESTIMATES	5834.36	6854.88	
F = 0.851			

TABLE f'

MEAN OF Y = 42.1666	MEAN OF X = 141.6666
MEAN OF Y = 45.6666	MEAN OF X = 100.0000
MEAN OF Y = 30.1666	MEAN OF X = 151.6666
MEAN OF Y = 0.0000	MEAN OF X = 51.6666
MEAN OF Y = 44.3333	MEAN OF X = 108.3333
MEAN OF Y = 26.8333	MEAN OF X = 101.6666

ADJUSTED MEANS = 97.0141; 40.6576; 157.3793; 183.9919; 54.5871; 121.3697.

TABLE f'

HOMOGENEITY OF REGRESSION COEFFICIENTS

GROUP	SUM OF SQUARES		SUM OF PRODUCTS	ADJ. SUM OF SQUARES
	Y	X		FOR X
1	274.83	82683.34	3158.33	46388.35
2	509.33	10000.00	-100.00	9980.36
3	46.83	20083.33	-581.66	12859.07
4	0.00	2483.33	0.00	2483.33
5	91.33	76683.34	1233.33	60028.83
6	66.83	24283.33	441.66	21364.58
TOTAL	989.16	216216.65	4151.66	153104.53

A = 153104.53; B = 198791.53; F = 1.43.

STUDY 4

R/RE VS. EXT. TRIALS...LT

TABLE g

ANALYSIS OF COVARIANCE

	SOURCE OF VARIATION		
	BETWEEN	WITHIN	TOTAL
SUM OF SQUARES Y	32.53	0.79	33.33
SUM OF SQUARES X	53846.42	493300.31	547146.75
SUM OF PRODUCTS	-684.92	15.21	-669.71
DEGREES OF FREEDOM	4.00	25.00	29.00
ADJUSTED SUM OF SQUARES X	40682.69	493008.87	533691.62
DEGREES OF FREEDOM FOR ADJUSTED SUM OF SQUARES	4.00	24.00	28.00
VARIANCE ESTIMATES	10170.67	20542.03	

F = 0.495

TABLE g

MEAN OF Y = 1.2383 MEAN OF X = 306.6666

MEAN OF Y = 1.8549 MEAN OF X = 201.6666

MEAN OF Y = 3.6699 MEAN OF X = 243.3333

MEAN OF Y = 1.8666 MEAN OF X = 220.0000

MEAN OF Y = 3.7833 MEAN OF X = 185.0000

ADJUSTED MEANS = 330.4987; 213.6880; 220.5928; 231.7979; 160.0889.

TABLE g

HOMOGENEITY OF REGRESSION COEFFICIENTS

GROUP	SUM OF SQUARES		SUM OF PRODUCTS	ADJ. SUM OF SQUARES
	Y	X		FOR X
1	0.01	85333.34	-32.53	10180.57
2	0.00	102483.34	-16.25	70084.75
3	0.40	86733.34	139.59	38850.50
4	0.03	114600.01	14.49	107933.50
5	0.33	104150.01	-90.10	79826.28
TOTAL	0.79	493300.00	15.21	306875.56

A = 306875.56; B = 493008.62; F = 3.03.

STUDY 4

R/RE VS. EXT. TRIALS...NO LT

TABLE g'

ANALYSIS OF COVARIANCE

	SOURCE OF VARIATION		
	BETWEEN	WITHIN	TOTAL
SUM OF SQUARES Y	31.80	0.28	32.08
SUM OF SQUARES X	14053.23	213733.46	227786.68
SUM OF PRODUCTS	79.14	30.43	109.57
DEGREES OF FREEDOM	4.00	25.00	29.00
ADJUSTED SUM OF SQUARES X	16986.25	210426.21	227412.46
DEGREES OF FREEDOM FOR ADJUSTED SUM OF SQUARES	4.00	24.00	28.00
VARIANCE ESTIMATES	4246.56	8767.75	

F = 0.484

TABLE g'

MEAN OF Y = 1.2766 MEAN OF X = 141.6666

MEAN OF Y = 1.8366 MEAN OF X = 100.0000

MEAN OF Y = 3.7766 MEAN OF X = 151.6666

MEAN OF Y = 1.8783 MEAN OF X = 108.3333

MEAN OF Y = 3.6616 MEAN OF X = 101.6666

ADJUSTED MEANS = 273.0767; 170.5586; 11.4185; 174.3643; -26.0851.

TABLE g'

HOMOGENEITY OF REGRESSION COEFFICIENTS

GROUP	SUM OF SQUARES		SUM OF PRODUCTS	ADJ. SUM OF SQUARES
	Y	X		FOR X
1	0.00	82683.34	-14.66	47607.23
2	0.02	10000.00	8.69	7347.87
3	0.14	20083.33	-0.46	20081.78
4	0.03	76683.34	18.28	67046.45
5	0.07	24283.33	18.58	19385.29
TOTAL	0.28	213733.31	30.43	161468.62

A = 161468.62; B = 210427.96; F = 1.51.