A NEW METHOD OF CLASSICAL CONDITIONING IN THE RAT: COMPARISONS WITH AN INSTRUMENTAL CONDITIONING TECHNIQUE USING THE SAME RESPONSE

Thesis for the Degree of Ph. D
MICHIGAN STATE UNIVERSITY
Ronald G. Weisman
1964

This is to certify that the

thesis entitled

A NEW METHOD OF CLASSICAL CONDITIONING IN THE RAT: COMPARISONS WITH AN INSTRUMENTAL CONDITIONING TECHNIQUE USING THE SAME RESPONSE

presented by

Ronald G. Weisman

has been accepted towards fulfillment
of the requirements for

Ph. D. degree in Psychology

M. Roy Denny
Major professor

Date August 3, 1964

O-169

JI

ABSTRACT

A NEW METHOD OF CLASSICAL CONDITIONING IN THE RAT: COMPARISONS WITH AN INSTRUMENTAL CONDITIONING TECHNIQUE USEING THE SAME RESPONSE

by Ronald G. Weisman

Operationally there is one difference between the instrumental and classical conditioning procedures: In instrumental procedures the reinforcement is response contingent, in classical procedures the reinforcement is delivered independent of response. The purpose of this study was to compare the two conditioning paradigms under procedures that eliminated confounding by differences in response topography (bar press vs. salivation), or stimulus control (free-operant vs. discrete trial).

EXPERIMENT I

A new method for classical conditioning of licking in rats was presented. During conditioning, water (US) was delivered independent of response, but signalled by the onset of a light (CS). Generalized responding and pseudoconditioning were tested by US only trials and unpaired CS and US trials respectively. Classical conditioning and extinction were observed, but the pseudoconditioning procedure yielded the same low level of responding as US only trials.

EXPERIMENT II

The classical conditioning procedure of Experiment I was compared to an instrumental procedure having similar temporal parameters and requiring the same response (licking), under conditions that have been reported to yield superstitious operant responding. Specifically, the comparisons were made under temporal conditioning (three min. between US presentations) and lengthening CS-US intervals (up to one min. in duration). Neither of these operations was detrimental to the maintenance of instrumental responding, but both operations had profoundly detrimental effects on the rate of classical responding. If the classical procedure yielded adventitiously reinforced operant responding then these operations should not have differentiated between it and the instrumental procedure.

EXPERIMENT III

Comparisons between the conditioning procedures were made with respect to resistance to extinction. Both a regularly alternating and an irregular pattern of extinction and reconditioning sessions were given after original conditioning stablized. In neither case were differences between the conditioning procedures apparent in resistance to extinction.

RONALD G. WEISMAN

EXPERIMENT IV

The Ss from Experiment III continued under the classical and instrumental conditioning procedures during this investigation of the effects of intermittent reinforcement. The percentage of reinforcement was varied in a more or less decreasing order from 100% S^R to 10% S^R, with 75% S^R, 50% S^R, 25% S^R, and 10% S^R interpolated between sessions of continuous reinforcement. Extinction sessions were given after responding stablized at each percentage of reinforcement, and after each session under continuous reinforcement. The results showed the expected increases in resistance to extinction with intermittent reinforcement. But no differences between the conditioning procedures were observed: either in conditioning or extinction.

Approved,
M. Ray Denny
Major professor

A NEW METHOD OF CLASSICAL CONDITIONING IN THE RAT: COMPARISONS WITH AN INSTRUMENTAL CONDITIONING TECHNIQUE USING THE SAME RESPONSE

By

Ronald G. Weisman

A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

Department of Psychology

1964

TABLE OF CONTENTS

Page

Chapter

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Many learning psychologists consider instrumental conditioning and classical conditioning to be two distinctly different processes (Kimble, 1961; Mowrer, 1960; Soloman and Wynne, 1954; and Skinner, 1938). Operationally, of course, the two procedures are different in one main respect. In classical conditioning reinforcement is presented independently of _S_'s responses, while in instrumental conditioning reinforcement is dependent upon _S_'s response, or responses. Thus, in instrumental conditioning reinforcement is response contingent, while in classical conditioning it is not.

CHAPTER I

COMPARISONS OF THE EFFECTS OF INSTRUMENTAL AND CLASSICAL CONDITIONING PROCEDURES

The Extent to Which the Procedures Display Common Basic Phenomena or Processes

Certain basic behavioral phenomena have been investigated separately in both instrumental and classical conditioning experiments. Kimble (1961) has listed phenomena which he states appear in both situations, and other phenomena that apparently do not appear in both situations; Table 1 summarizes his conclusions. Variables not listed by Kimble are: the similar effects of massing and spacing of trials, the similar effects of combined CS's and S^D's, and the analogous effects of length of the CS-US interval and delay of reinforcement. Obviously, similarities are considerably more numerous than differences.

Partial reinforcement apparently has differential effects on instrumental and classical conditioning. Pavlov (1927) found that a drop from 33% to 25% reinforced trials in a well trained S̲ made maintenance of the conditioned response impossible. Razran (1955) contrasts this to the effect of partial reinforcement in operant conditioning, where responding can be maintained with ease at FR 100 in

Table 1.--Summary of similarities and differences between Effects found via instrumental and classical conditioning procedures (Kimble, 1961, pp. 81-104).

Similar Effects	Different Effects
1. Acquisition	1. Resistance to Extinction
2. Extinction	2. Partial Reinforcement
3. Spontaneous Recovery	
4. External Inhibition	
5. Disinhibition	
6. Inhibition of Delay	
7. Summation	
8. Response Generalization	
9. Stimulus Generalization	
10. Generalization of Extinction	
11. Discrimination	
12. Conditioned Inhibition	
13. Induction	
14. Higher-Order Conditioning	

a well trained S. While this, admittedly, is a striking difference, no comparable results have ever been reported for discrete-trial instrumental conditioning. In fact, 16.7% is the lowest percentage reinforcement reported in discrete-trial instrumental conditioning (Winstock, 1958). Perhaps the differential effects of partial reinforcement stem from differences between operant and discrete trial procedures rather than between instrumental and classical conditioning.

Instrumental conditioning may result in considerably greater resistance to extinction than classical conditioning (Razran, 1955). A comparison of the results of Pavlov's (1927) experiments with those of Skinner (1938) would certainly support this conclusion. In a recent study of resistance to extinction in the pigeon after classical conditioning, Longo, Milstien, and Bitterman (1962) failed to obtain asymptotic extinction performance after 180 extinction trials. Clearly extinction is not necessarily rapid after classical conditioning.

A problem inherent in the "cross-literature" comparisons found in this section is the lack of comparability between different instrumental conditioning procedures and between different classical conditioning procedures. Thus marked differences, supposedly existing between instrumental and classical conditioning, may in fact be the result of differences between the responses conditioned, the reinforcement used, or the species of the subjects. At best the comparisons are analogies (at worst catastrophies).

Concurrent Instrumental and Classical Conditioning of Different Responses in the Same Subjects

Advances in technique have permitted investigators to take very accurate measures of salivation (.01 ml.), in dogs using a simple "walking" harness, allowing unrestricted movement within an 81 sq. ft. enclosure. Shapiro (1961) used this technique to investigate concurrent conditioning of lever press and salivation in dogs. He observed both responses under FI 2 min. reinforcement and concluded that a direct correlation between the responses exists. In fact, cumulative records of salivation show the scallop typical of operant fixed interval performance. An accidental failure in the feeding mechanism in Shapiro's (1961) study resulted in experimental extinction for a 30 min. period in one dog. The extinction of lever pressing and salivation appeared to follow the same course: again a direct correlation.

Kintsch and Witte (1962) replicated Shapiro's results and also studied concurrent performance on fixed ratio reinforcement. They switched one group of Ss directly from CRF to FI 90 sec. to study further development of fixed interval performance. Both responses underwent some extinction during the first session of fixed interval, but thereafter considerable parallel between the two responses was observed. Typically, FI scallops appeared earlier in the lever press response than in salivation, but the "terminal" performances (after 10 sessions) were almost identical. Fixed ratio performance (FR 25) developed in much the same manner, except that some lever pressing almost invariably preceded conditioned salivation.

Shapiro (1962) has also observed concurrent performance under DRL schedule. On DRL 2 min. conditioned salivation is most probable in the 5 sec. period just preceding a lever press. Observation of the Ss indicated that several other responses besides salivation, precede lever pressing regularly, e.g.: tail wagging. If these unrecorded responses may be considered part of a conditioned sequence that terminates in a lever press, it is reasonable to suspect that these same behaviors also provide conditioned stimuli for salivation as well.

The studies of concurrent instrumentally and classically conditioned responses suggest that the "normal" outcome of conditioning procedures is not simply a change in the topography of a single response, but rather a modification of the entire behavior pattern given to the unconditioned, or reinforcing stimulus. This is evidenced by the finding that the same operations capable of producing operant lever press yield relatively similar patterns of conditioned salivation as a part of the overall procedures. The concurrent method of comparison represents a considerable advance in precision over cross-literature comparisons. However, the addition of an explicit S^D (or CS) in experiments in which concurrent comparisons are made would be an aid in the interpretation of further results. For without an explicit cue there is little assurance that stimulus control is always comparable. In the studies already cited, salivation sometimes preceded and sometimes followed the onset of lever pressing, apparently as a function of the schedule of reinforcement.

Although the concurrent conditioning method eliminates many of the difficulties inherent in cross-literature comparisons, direct comparison is impossible because different response modalities must be used. We have no way of reducing the results to a common unit of measurement. How many drops of saliva equal one lever press, or vice-versa? While this problem certainly does not render the method useless, it does place some constraint upon the conclusions that can be drawn from its use.

Direct Comparisons: Conditioning the Same Response by Instrumental and Classical Conditioning Procedures

Perhaps the ideal method for assessing similarities and differences would be to compare the procedures directly. That is, to condition the same responses to the same stimuli: contingent in one case, non-contingent in the other. Such comparisons have in fact been attempted in the case of aversive stimuli. The first of these comparisons (Schlosberg, 1936) was between "avoidant" and "non-avoidant" leg withdrawal in the rat. His results did not give clear evidence of a difference in the effectiveness of the two procedures, but Schlosberg indicated that the instrumental procedure sometimes interfered with stable conditioning.

Brogden, Lipman, and Culler (1938) ran guinea pigs in revolving cages; *S*s in the nonavoidant group received buzzer paired with shock irrespective of their behavior, *S*s in the avoidance group did not receive shock if they responded during the buzzer. Under these conditions only the avoidant group learned the wheel turn response; however, it was noted that the buzzer elicited "agitated" behavior regularly in the nonavoidant group, while only infrequently in the avoidant group. It would appear that any decision regarding the efficiency of the two procedures would depend upon the response being considered: agitated behavior or wheel running.

Kimble (1961) has argued that instrumental and classical procedures are not comparable in situations in which aversive stimuli are present. The reason is that the onset of an aversive stimulus reinforces classically conditioned behavior, but termination and continued termination reinforce instrumentally conditioned responses. This line of reasoning could also be applied to the studies of avoidant and nonavoidant eyelid conditioning (Moore and Gormezano, 1961). Thus, in studies using aversive stimuli, comparison of instrumental and classical conditioning does not seem possible since no procedure has yet been developed that equates the reinforcing stimuli or the responses being reinforced.

The conclusion that the two conditioning paradigms yield different effects in the case of aversive stimuli does not necessarily hold for positive reinforcing stimuli, particularly in view of the fact that it is generally the onset of a positive stimulus that is reinforcing. However, if a direct comparison is to be made, not only should the reinforcing stimuli be equated, but also the modality and topography of the reinforced responses. One possible method would be to reinforce salivation in the presence of a CS or S^D with food: in one group food would be contingent upon salivation, in the other group it would not. As an alternative to this procedure the present investigator undertook to develop a conditioning technique that would yield comparable responses and reinforcements under both paradigms.

Are the Two Conditioning Paradigms Invariably Associated with Different Kinds of Unconditioned Responses?

Kimble (1961) suggests that a physiological difference exists between the innervation of classically and instrumentally conditioned responses, classically conditioned responses being mediated by the autonomic nervous system, with the central nervous system mediating instrumentally conditioned responses. This hypothesis implies that "unconditioned" behavior is clearly separable into two categories, in Skinner's (1938 and 1953) terms: those responses that *operate* upon the animal's environment, and those responses that do not. Actually, little, if any, of the behavior observed in animals is without consequences. Can an animal's heartbeat be said to operate upon its internal environment any less than its locomotor responses operate on its external environment? Salivation operates to make digestion possible no less than courtship patterns operate to make mating possible.

Even if one were naive enough to consider an animal's skin as the proximal limits of its environment, the hypothesis is still not necessarily tenable, for responses normally without external consequences have been instrumentally conditioned. Hefferline and Keenan (1963) were able to increase the rate of a minute thumb twitch in the 10-20 microvolt range by reinforcing its occurrence with money. On the other hand, motor behavior (this is normally said to operate upon an animal's external environment), has regularly been observed in classical conditioning. Examples include leg flexion and head movements in sheep (Liddell, James, and Anderson, 1939), general activity in the pigeon (Longo, Milstien, and Bitterman, 1962), motor behavior accompanying salivation in the dog (Parlov, 1927; Zenner, 1939), and locomotor responses in the earthworm (Ratner and Miller, 1959). It is unlikely that pseudoconditioning can account for these results, since controls have been reported for all the above experiments except those involving salivation.

Salzinger and Waller (1962) were able to demonstrate operant conditioning of a vocal response (barking) in the dog. Previously, it was believed that only classical conditioning of vocalization in "infrahuman" animals was possible (Mowrer, Palmer, and Sanger, 1948; and Skinner, 1957). It is very possible that as our understanding of the stimuli that directly elicit behavior increases, the choice of conditioning paradigm used with any response will become more a matter of taste than of necessity.

A Method of Specifying the Same Responses and Reinforcement for Classical and Instrumental Conditioning Procedures

Wyckoff, Sidowski, and Chambliss (1958) have demonstrated in the rat that licking can serve as an instrumental response. More specifically, their results show that instrumental licking can be brought under the control of a stimulus (buzzer) that signals a contingency between licking the dry dipper and obtaining water.

On the other hand, studies of consummatory licking suggest that the response is highly reflexive or innate (a good unconditioned response). For example, Davis and Keehn (1959), and Keehn and Arnold (1960) found a mean licking rate in adult rats of between 6 and 7 licks per second, with a range of 5-8 licks per second. The mean lick rate was constant in both sexes, over various levels of thirst, and for water, sucrose, saccharin, and saline solutions. Schaeffer and Premack (1961) report that the lick rates of weanling rats (18 or 24 days old), that had not previously had an opportunity to lick water, were within the same range, even at first contact, as those of adult rats; they conclude that consummatory licking in the rat appears to be organized on a genetic-maturational basis.

Thus, the licking response should lend itself to either conditioning procedure. The reinforcing stimulus (water) would elicit the same behavior in either procedure.

Since the classical conditioning procedure has not previously been attempted with the licking response (nor with any other response to water as far as can be determined) the present investigator undertook pilot work on classically conditioned licking responses in rats. The details of the general procedure and apparatus are described in the method section of Experiment I.

Four grey hooded rats of the Long-Evans strain were used in the pilot research. Under conditions identical to those of the proposed studies, asymptotic performance with 90% reinforcement ranged from 87%-100% conditioned responses on test trials (trials on which the CS was presented alone). Even at 50% reinforcement high performance was maintained (range: 86%-100%CR). After conditioning had reached a high level, as a test of the discriminative function of the CS, the CS was discontinued for three sessions. The result was a drop to zero in the rate of licking occurring during the interval in which the CS normally preceded the U.S. Performance returned to its previous high level after the CS was restored, and no indication of habituation to the U.S. or decrement over trials was observed in the following 18 sessions of pilot work.

Experimental Comparisons of Classical and Instrumental Conditioned "Lick" Responses

Purpose.--Considering the evidence thus far presented, the hypothesis that classical and instrumental conditioning procedures always yield similar effects seems untenable. But it is still reasonable to assert that classical conditioning is best viewed as a class of reinforcement scheduals rather than a separate process of conditioning. After all, no psychologists has yet suggested that each class of schedules (FI, VI, FR, VR, and DRL) is based upon a different conditioning process.

The view that classical conditioning is a class of reinforcement schedules is consistent with the material presented earlier in the review of the conditioning literature. More important it suggests how differences and similarities between operant and classical procedures may arise. Classical conditioning is a time based procedure and as such is probably comparable only to other time based schedules of reinforcement. Also classical conditioning training is typically given in conjunction with some stimulus (CS), and comparison in situations where stimulus control is not explicit is usually difficult.

The present experiments supply parametric comparisons of classical conditioning with discrete-trial and free operant schedules. The comparisons assess similarities and differences in the results of the two procedures when response topography and stimulus control of responses are as similar as possible. Response topography, in this context, refers to the form or actual movements involved in the specific response measured. Classical and instrumental procedures are compared with respect to extinction and partial reinforcement. The choice of these two closely related phenomena was dictated by the fact that the two conditioning procedures appear to yield divergent effects for these phenomena. Before extinction and partial reinforcement are investigated, however, it is necessary to answer an important methodological question. Namely, is the noncontingent conditioned lick procedure, already described, distinct from nondiscriminated responding, pseudoconditioning, superstition, or some other operant behavior either operationally or in its effect?

CHAPTER II

EXPERIMENT I--PSEUDOCONDITIONING

Experiment I establishes the noncontingent procedure to be used in the other experiments as classical conditioning rather than either pseudoconditioning or nondiscriminated response modification. Toward that end, it compares the effects of three procedures: presentation of the US alone, pseudoconditioning (CS and US presented unpaired), and classical conditioning.

Method

Subjects.--The *S*s were eight experimentally naive male grey hooded rats of the Long-Evans strain. This strain was selected because of its vigor and relatively good vision. The *S*s had access to water a half hour daily for three weeks prior to the experiment. During the experiment *S*s had access to water for only 5 minutes after each daily session. A given *S* was run at approximately the same time each day.

Apparatus.--The apparatus consisted of two matched systems. Each experimental box was 8 in. long, 3 1/2 inches wide, and 4 inches high, and constructed of plexiglas with a 1/8 inch stainless steel grid floor. At one end a 1 1/2 inch enclosed drinking well extended out of the box. Water was presented in small quantities, controlled by a solenoid valve, from a #11 hypodermic needle (ground flat and smooth) which projected through a small opening at the bottom of the well. A small copper ring encircled this opening to prevent gnawing and to measure licking.

The CS and S^D was 10 watt (55-50ft. c.) light bulb mounted on the outside of the box next to the well. Licking was measured by a resistance sensitive Hunter relay, and recorded on a Gerbrands event recorder and on counters. Each of the two boxes was enclosed in a converted refrigerator containing an exhaust fan (60 cu. ft. per min.), and a white noise speaker (50 db.). The general level of illumination in the box was 5-10 ft. c. (depending on S's position). Hunter timers and a Gerbrands punch tape timer provided all temporal intervals.

Procedure.--All Ss had four sessions during which the US (water) was presented alone on a 90 sec. variable intertrial interval. The first session served as habituation to the apparatus and water delivery system. In Experiment I 40 trials were given in each daily session. During the remaining three sessions, responses were recorded during the 3 sec. period just preceding water presentation. After the three "US only" sessions an extinction session was given.

The Ss were then divided randomly into two groups of 4 Ss each. Group A received 8 days of classical conditioning. The interval between light onset and water presentation (CS-US interval) was 3 sec. and the light remained on for an additional 2 sec. (an overlapping CS). The intertrial interval was variable with a mean of 90 sec. and a range of 60-120 sec. Group B received 8 days of a pseudoconditioning procedure. That is, water and light were presented in a random sequence with the restrictions that neither follow itself more than twice and that water and light presentations be separated by at least 30 sec. Each stimulus, independently, had a 90 sec. variable intertrial interval. Both groups received an extinction session following pseudoconditioning or classical conditionin. Both groups were then given acquisition training (classical conditioning) and subsequently extinguished.

Results and Discussion

In Experiment I the response measure was the percentage of light presentations (or periods during which light would later be scheduled) on which lick responding occurred. The percentage measure was divided into conditioned response (CR), licks in the 3 sec. test period but no licks in the 3 sec. just before, and Pre-CR response, licks during both the 3 sec. just prior to and during the CS-US interval.

Figure 1 shows the results for the Ss in Group A. These data show relatively smooth acquisition and reconditioning with a minimum Pre-CR. The results for three Ss in Group B are presented in Fig. 2. As with Group A the level of Pre-CR and "US only" responding was low. The psuedoconditioning procedure in Group B yielded a comparable number of "CRs" to the "US only" procedure. In Group B the classical conditioning procedure appeared to yield slightly slower acquisition as compared to Group A.

The results for the fourth S in Group B are presented in Fig. 3. This S showed approximately the same low response rate throughout "US only" and pseudoconditioning sessions. But with the beginning of classical conditioning a high frequency of Pre-CR developed. A decrease in the length of the intertrial interval failed to improve the situation. However, when the intertrial interval was lengthened to 120 sec. the amount of Pre-CR decreased rapidly.

Prior pseudoconditioning sessions may account for the relatively slower rate of conditioning and high frequency of Pre-CR in B-4. Since CS and US are never paired in pseudoconditioning procedure it can also be interpreted as inhibition training. Thus Ss in Group B may have learned not to respond to the CS during pseudoconditioning.

Another explanation of the high Pre-CR rate by B-4 in Experiment I is that responding was adventitiously reinforced. In fact, might not the CRs in Experiment also be a product of

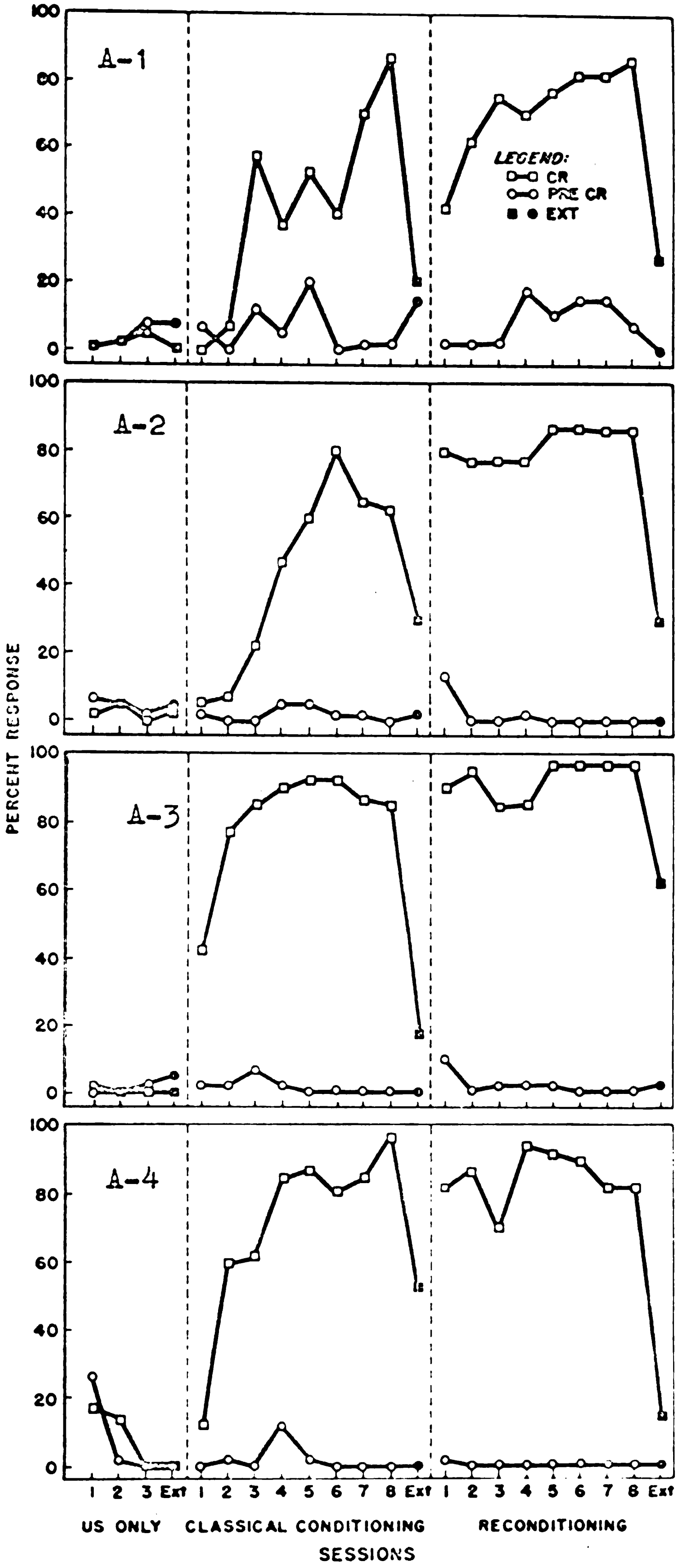

Figure 1. Percent CR and Pre CR for four

Ss in Group A.

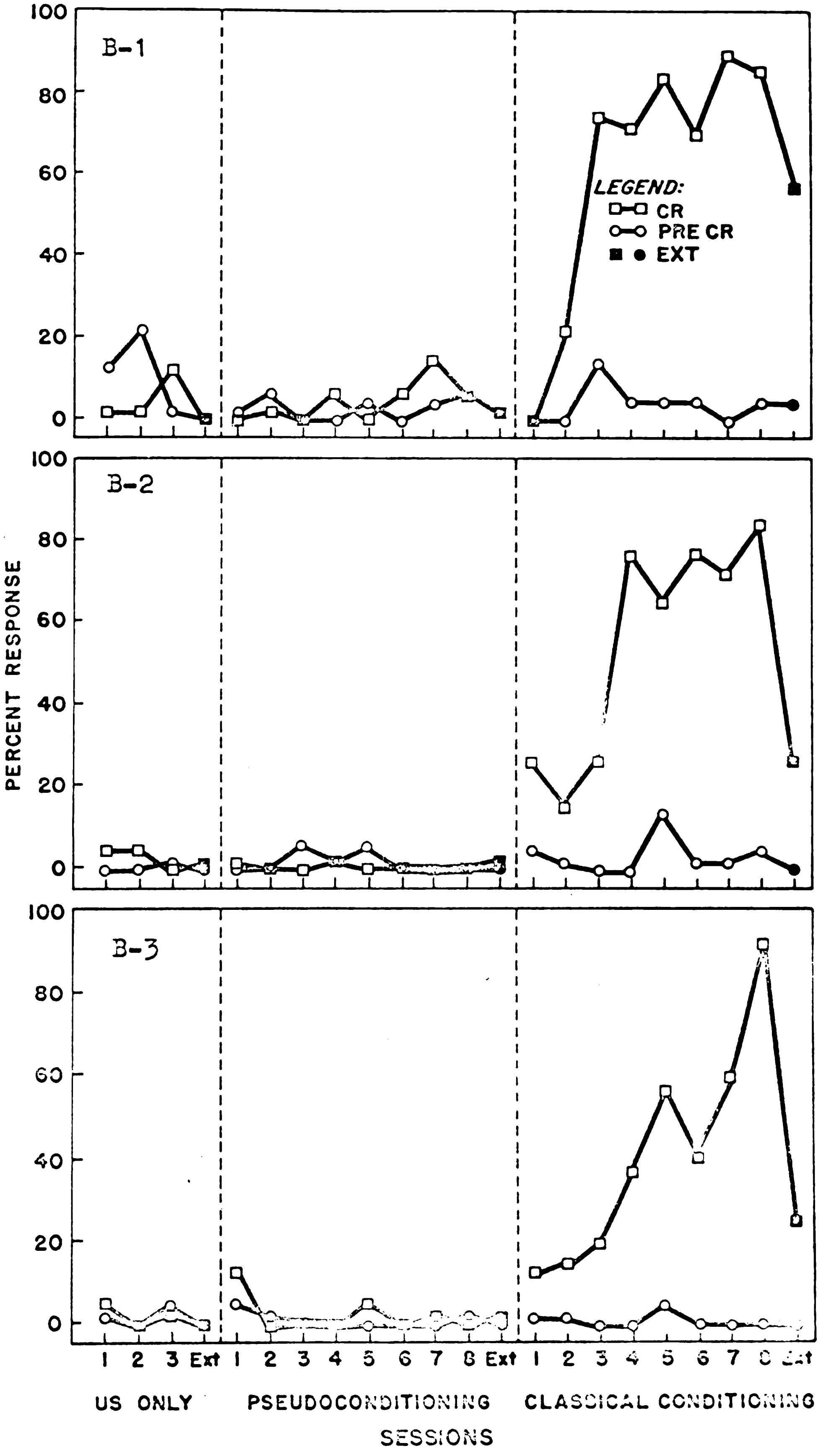

Figure 2. Percent CR and Pre CR for three of four

Ss in Group B.

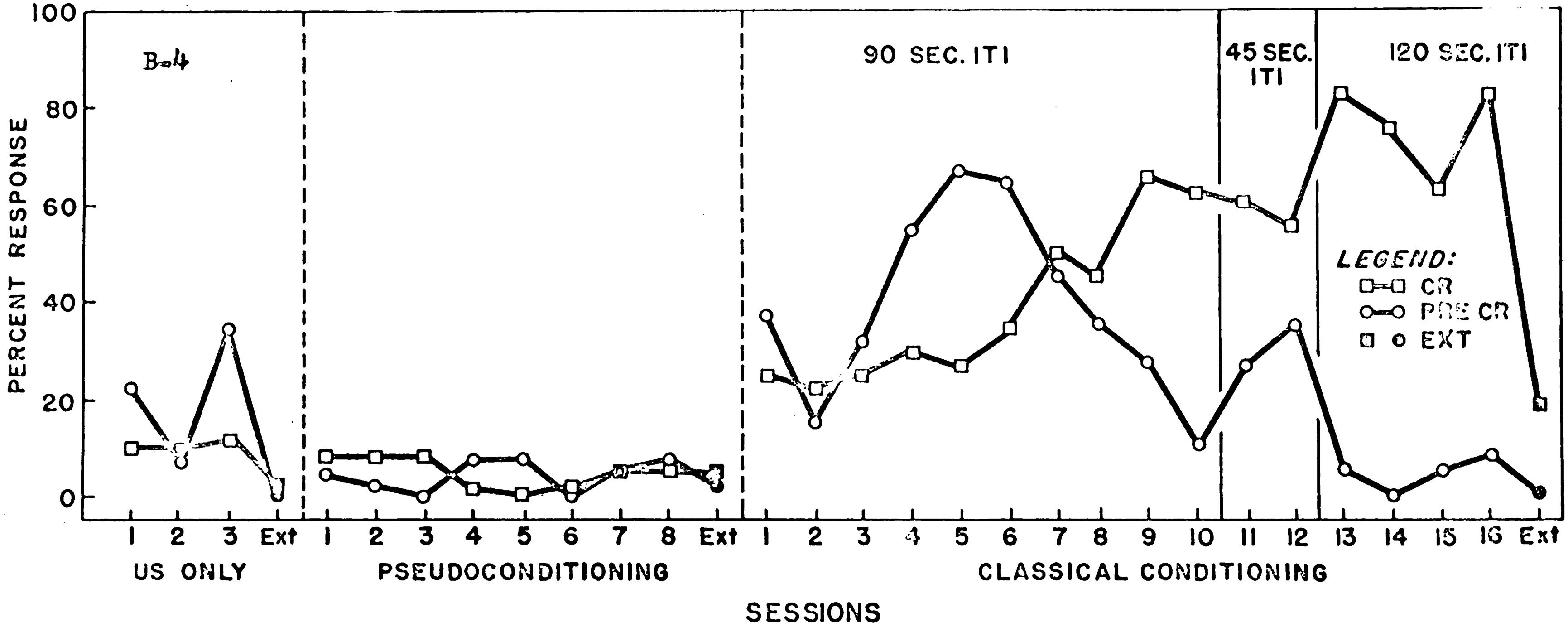

Figure 3. Percent CR and Pre CR for B-4.

some form of operant conditioning? Operationally, classical conditioning and adventitiously reinforced operant behavior (superstition) are quite similar (Kimble, 1961). But there are some important differences in the effects of these procedures. Operant discriminations usually involve the extinction of unreinforced responding in the S^{Δ} while the level of intertrial responding in classical conditioning usually differs little from its original level. Of the 8 Ss conditioned in Experiment I, and the 4 Ss reported on earler in pilot work only one, B-4 had any appreciable rate of Pre-CR to be extinguished. Furthermore, superstition has been described as a highly individualistic affair (Skinner, 1948) in which the response topography tends to be unstable: often changing over sessions or in reconditioning (Sidman, 1958): in marked contrast to classical conditioning where a stable response is the rule. The topography of the lick response in Experiment I was quite stable both from S to S and over sessions.

The results of Experiment I differentiate the noncontingent conditioning procedure from nondiscriminated responding and pseudoconditioning. The results also suggest that classical conditioning rather than adventitiously reinforced operant conditioning is involved.

CHAPTER III

EXPERIMENT II--SUPERSTITIOUS BEHAVIOR

The conclusion that the noncontingent procedure developed in Experiment I is a form of classical conditioning rather than superstition was based in part on the species-specific, as opposed to the subject-specific, nature of the topography of the conditioned response. Not all investigators developing new classical onditioning techniques deal with responses as easily defined as licking or salivation (Bitterman, 1964; Pliskoff, Hawkins, and Wright, 1964). In these cases the problem of operationally differentiating operant and classical conditioning procedures has been more acute. This problem is not without theoretical interest (Keller and Schoenfeld, 1950; Kimble, 1961).

As was shown earlier in this paper, there are few, if any, variables that separate the procedures in all species. However, temporal variables, such as the interstimulus interval might serve the purpose in some situations. For example, operant conditioning in the rat using inter-reinforcement intervals of 3 minutes or more FI 3 min. is common, while Pavolvian temporal conditioning (no CS) in the rat using intervals of this length is rare indeed.

With superstition, or any operant behavior, a change from FI 15 sec. to FI 60 Sec. hardly disrupts responding at all (Skinner, 1948). In the Pavlovian paradigm a precipitous jump from a 15 sec. CS-US interval to a 60 sec. CS-US interval is usually quite disruptive (Pavlov, 1927). Although data are not available in the rat for positive URs, it would seem reasonable to expect the frequency of CRs in a classical conditioning situation to decline during a 60 sec. CS-US interval from the level attained during a 15 sec. CS-US interval.

Method

Subjects.--Six male grey rats of the Long-Evans strain were used. Four of the Ss were experimentally naive and two Ss (C-3 and NC-3) were from Group A of Experiment I. The deprivation conditions were the same as in Experiment I.

Apparatus.--This consisted of the experimental boxes, programming equipment and recorder from Experiment I, in addition to a Grason-Stradler print-out counter that recorded the temporal distribution of responses.

Procedure.--On the first two days of training "US only" habituation was given to all Ss. The Ss were then matched, approximately, on the basis of consummatory licking. One S from each pair was randomly assigned to each condition: contingent (C), and noncontigent (NC) reinforcement.

During the first phase of Experiment II proper, contingent Ss had 20 daily sessions of 25-30 reinforcements each on FI 3 min. Noncontingent Ss received reinforcements at the same time, but independent of response (yoked subject technique).

In the second phase of Experiment II, Ss were switched to a multiple schedule approximating discrete trials. A multiple schedule is a schedule under which reinforcement (or nonreinforcement) is programmed by two or more schedules each being accompanied by a controlling stimulus. The schedule was mult FI limited hold ext. The FI limited hold component was programmed during light-on periods. The limited hold was a 3 sec. period during which a reinforcement, programmed under FI, was held available. Thus if S failed to respond during the last 3 sec. of a light-on period the reinforcement was lost. The second component was extinction (ext) programmed during the light-off periods, varying from 150-210 sec. with a mean of 180 sec. Yoked noncontingent Ss, in effect, had training with an overlapped CS and a 180 Sec. variable intertrial interval.

The plan of the second phase of Experiment II was to vary the interval between light onset and reinforcement: the CS-US interval, or the FI component. Table 2 shows

Table 2.--Number of Sessions at each CS-US interval in the Second Phase of Experiment II.

Ss	3 sec.	5 sec.	10 sec.	15 sec.	60 sec.
C-1	6	2	2	3	3
NC-1	6	2	2	3	3
C-2	6	2	2	3	3
NC-2	6	2	2	3	3
C-3	6	2	2	3	3
NC-3	6	2	2	3	3

the conditions for each S. For example, C-1 began with six sessions of mult FI 3 sec. limited hold 3 sec. ext VI 180 sec, while the yoked S (NC-1) had an equivalent 3 sec. CS-US interval and a 180 sec. variable intertrial interval during these six sessions.

Results and Discussion

Figure 4 shows the mean number of responses in successive .5 min. compartments of the 3 min. inter-reinforcement interval over the 1st, 5th, 10th, 15th, and 20th sessions of the first phase of Experiment II. The data for the contingent Ss (C-1, C-2, and C-3) illustrate the development of typical fixed interval responding, with the consummatory response predominating only in the earliest compartments. On the other hand, the data from the noncontingent

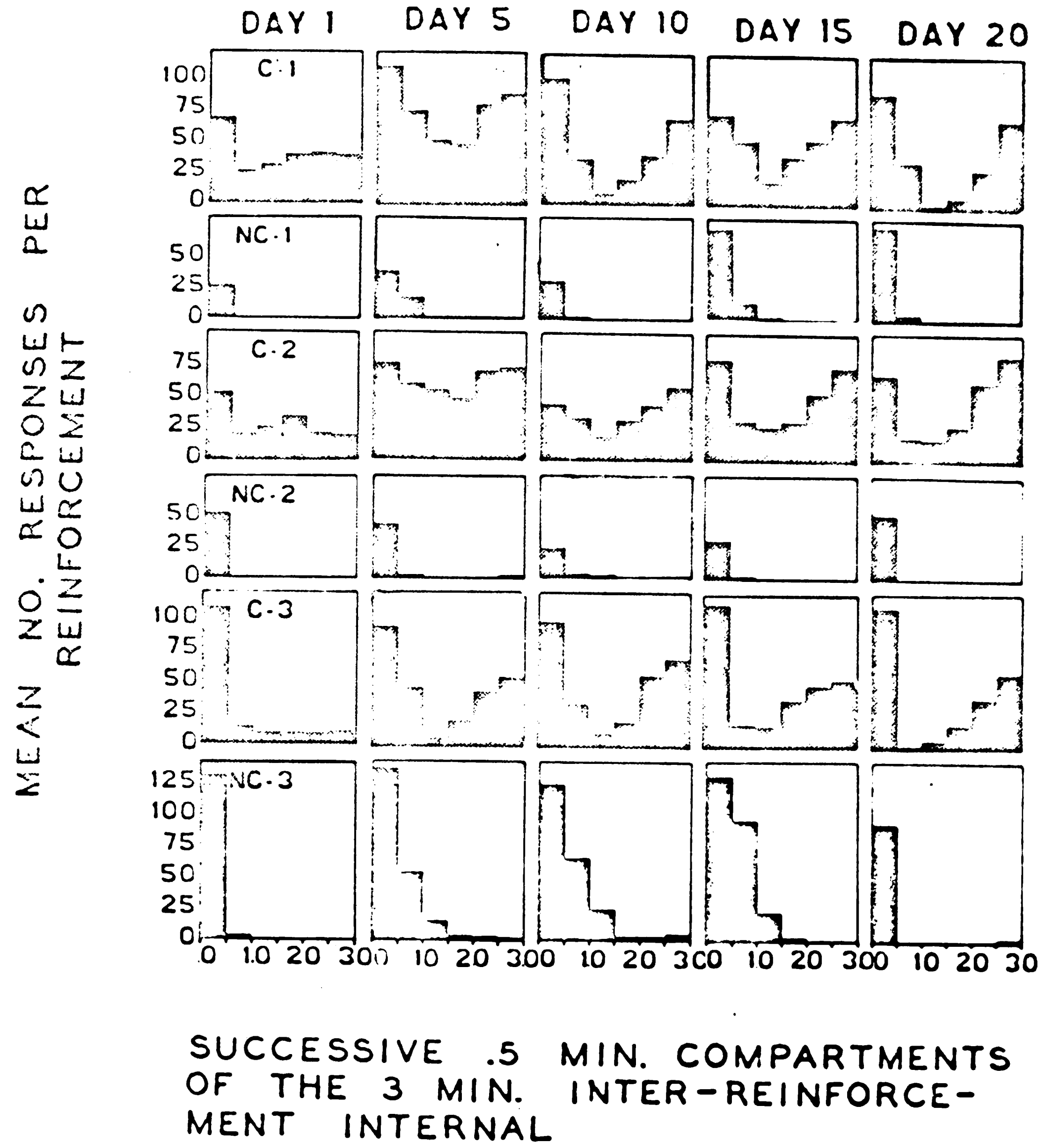

Figure 4. Temporal distribution of inter-reinforcement responses on FI 3 min. (C) or Pavlovian temporal conditioning (NC).

Ss (NC-1, NC-2, NC-3) show no evidence of any temporal conditioning over the 20 sessions; except for consummatory responses, inter-reinforcement responding was negligible.

Table 3 gives the per cent CR for each S during the final session at each CS-US interval in the second phase of Experiment II. All Ss showed excellent maintenance of the conditioned response at the 3, 5, 10, and 15 sec. intervals. But only the contingent Ss continued at this level with the 60 sec. interval.

Table 3.--Per cent conditioned response during the final session at each CS-US interval.

Ss	3 sec.	5 sec.	10 sec.	15 sec.	60 sec.
C-1	97.5%	100.0%	100.0%	97.5%	100.0%
NC-1	97.5%	90.0%	92.5%	90.0%	30.0%
C-2	95.0%	95.0%	100.0%	97.5%	97.5%
NC-2	95.0%	95.0%	90.0%	97.5%	45.0%
C-3	100.0%	100.0%	100.0%	100.0%	97.5%
NC-3	95.0%	97.5%	95.0%	95.0%	55.0%

Figure 5, showing the mean number of lick responses per trial (amount CR), illustrates the differences in the effects of the two procedures in the second phase even more clearly. The 60 sec. interval fails to support

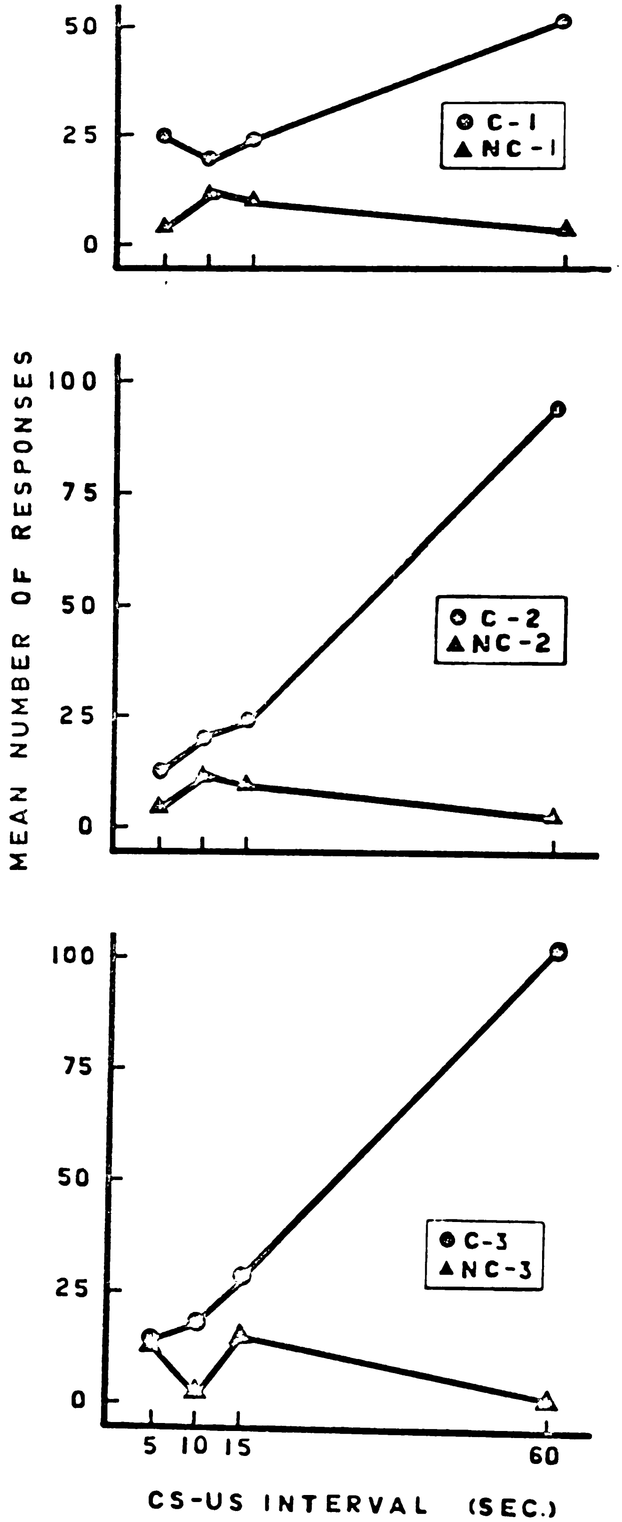

Figure 5. Mean amount CR (licks per trial) as a function of the CS-US interval for contingent (C) and noncontingent (NC) Ss.

noncontingent responding, and the amount CR by noncontingent Ss is lower at the other intervals as well.

An analysis of amount CR is successive thirds of the 15, and 60 sec. CS-US intervals is presented in Figure 6. At the 15 sec. interval all Ss show inhibition of delay or fixed interval scallop. At the 60 sec. interval this pattern is maintained at an even higher level in the contingent Ss, but responding is negligible for the noncontingent Ss.

The clear cut differences in the effects of contingent and noncontingent procedures in Experiment II suggest that it is possible to distinguish between operant and classical conditioning procedures without recourse to supposed differences in the UR (operant vs. respondent, or voluntary vs. involuntary, etc.). Since superstition is operant behavior, the manipulation in Experiment II should have resulted in similar effects of temporal variables on contingent and noncontingent Ss alike. Instead the noncontingent Ss did not show fixed interval performance with an FI 3 min. schedule, nor did their response rates (amount CR) approximate those of contingent Ss in the second phase of Experiment II. In fact the CS-US interval function obtained for the noncontingent Ss is more similar to Pavlov's findings (1927) than American studies of eyelid or GSR conditioning.

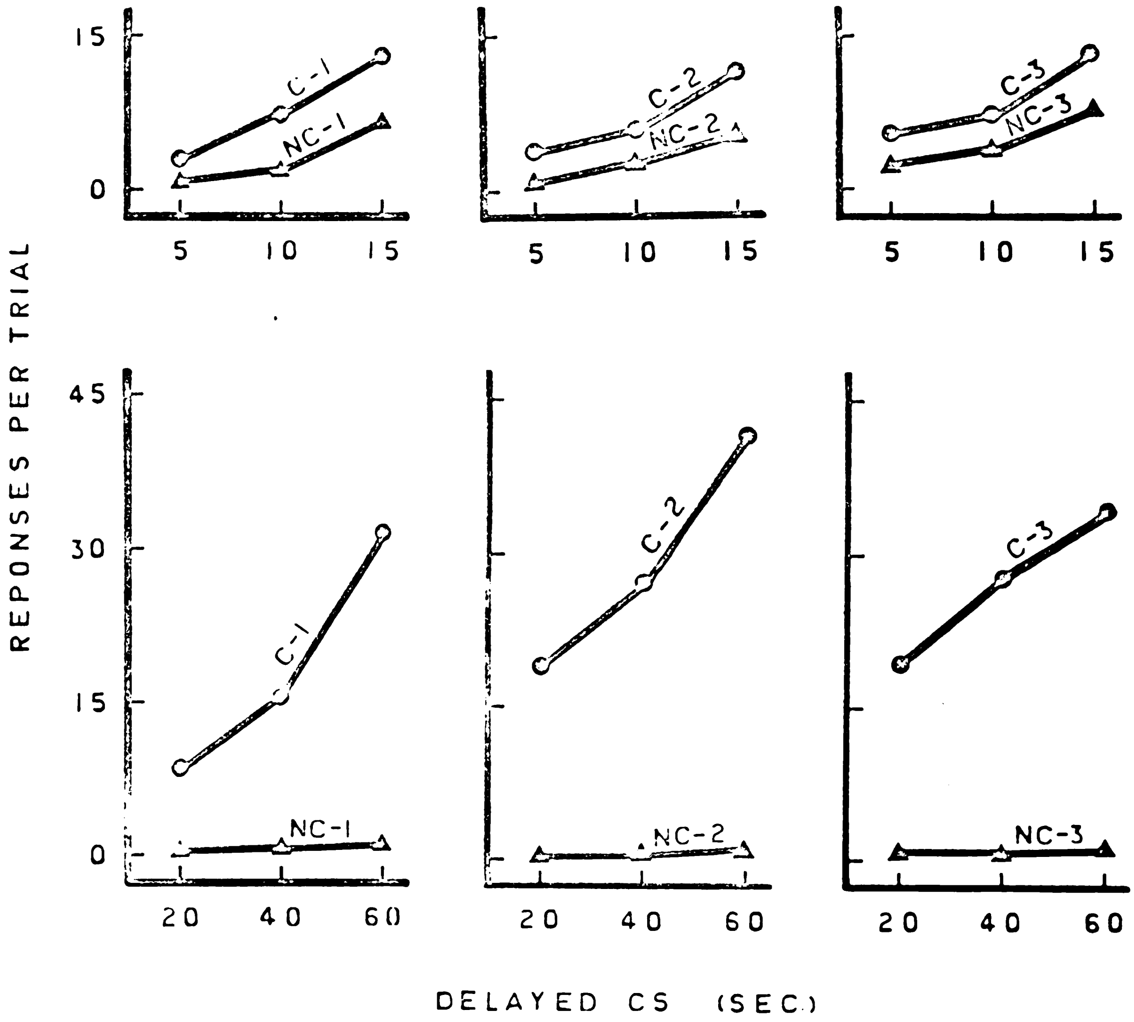

Figure 6. Mean amount CR (licks per trial) per third of a 15 sec. and 60 sec. CS-US interval for contingent (C) and noncontingent (NC) Ss.

CHAPTER IV

EXPERIMENT III--REPEATED EXTINCTION AND RECONDITIONING

As already indicated, classical conditioning has usually been found to be less resistant to extinction than instrumental conditioning. The cross-literature comparisons on which this conclusion is based were made between free-operant and classical procedures. It is possible that differences in response topographies and between discrete trial and free-operant procedures contribute at least as much to the observed differences in extinction as the difference in conditioning paradigms.

The purpose of Experiment III was to compare the resistance to extinction (RTE) of responses producing reinforcement only in the presence of S^D with that of responses elicited by a Pavlovian CS. Rather than draw conclusions from a single extinction session, a method of repeated acquisitions and extinctions was used (Bullock and Bitterman, 1963). This allowed for the extended assessment of both permanent and short term differences in RTE and reconditioning.

Method

Subjects.--The Ss were ten experimentally naive, female, grey, Long-Evans rats, between 120-150 days old at the beginning of the experiment. The deprivation conditions were the same as in Experiment I and II.

Apparatus.--The apparatus was the same as that used in Experiment I and II.

Procedure.--During the first two days of pre-training the Ss had "US only" presentations. On the third day a yoked procedure was begun for four Ss. A mult FI 3 sec. limited hold 3 sec. ext schedule, similar to that used in Experiment II, was in effect for the contingent Ss. The intertrial interval or extinction component had a range 60-180 sec. with a mean of 120 sec. During six 40 trial sessions these Ss failed to give more than two CR's in any session. Thus, it simply was not possible to condition Ss on the limited hold schedule directly; that is, without previous regular FI training as in Experiment II. Apparently the operant level of the lick response is not sufficient for acquisition on the stringent limited hold schedule.

As an alternative to prolonged regular FI reinforcement training, all Ss had classical conditioning training with a 3 sec. CS-US interval and a 120 sec. variable intertrial interval. After responding stablized (5% or less deviation in per cent CR from one session to the next for three successive sessions), two Ss (OP.-1 and OP.-2) were shifted to the mult FI 3 sec. limited hold 3 sec. ext operant schedule, and two Ss (Cl.Y.-1 and Cl.Y.-2) were yoked classical conditioning controls. The remaining two Ss (Cl.-1 and Cl.-2) continued as before on the classical conditioning procedure. Training was continued until performance stablized. In this manner, it was possible to assess the transition from classical to operant procedures.

All Ss then had alternating sessions (40 trials each) of extinction and reconditioning for 20 sessions: 10 extinction and 10 reconditioning. Finally, five extinction and five reconditioning sessions were given on a Gellerman series. The reconditioning sessions were programmed in the same manner as the conditioning sessions described above. No reinforcements were during extinction sessions.

Table 4 shows the transition from classical to operant conditioning procedures for OP.-1 and OP.-2, with data over the same sessions for yoked (Cl.Y.) and nonyoked (Cl.) classically conditioned Ss. The effects of the transition are evident in both the temporary drop in per cent CR, and the later stable increase in the amount CR. This increase in amount CR supports the findings of Experiment II where higher amount CR was observed for the operant (contingent) Ss.

Table 4.--Median and Range Per Cent and Amount CR during transition from classical to operant conditioning paradigms.

Subject	Response Measure	Classical Conditioning Base Line	Operant (OP.) Ss switched to mult FI limited hold ext Days		
			1	2-6	7-9
OP.-1	% CR	97.5(95.0-100.0)	72.5	100.0(95.0-100.0)	----------------
	Am't CR	8.4(7.5-9.7)	9.1	12.1(10.0-12.4)	----------------
Cl.Y.-1	% CR	85.0(85.0-95.0)	92.5	92.5(90.0-95.0)	----------------
	Am't CR	6.8(5.5-9.7)	6.6	7.1(6.5-7.5)	----------------
OP.-2	% CR	95.0(87.5-97.5)	52.5	67.5(65.0-77.5)	90.0(85.0-95.0)
	Am't CR	3.9(3.6-4.8)	4.0	8.0(6.3-8.4)	10.5(9.6-10.9)
Cl.Y-2	% CR	87.5(85.0-92.5)	60.0	75.0(72.5-75.0)	82.5(77.5-85.0)
	Am't CR	4.4(3.8-5.1)	4.8	5.2(4.6-5.6)	4.4(4.0-5.1)
Cl.-1	% CR	95.0(87.5-97.5)	90.0	92.5(85.0-95.0)	----------------
	Am't CR	7.2(6.7-8.3)	7.5	6.9(6.3-7.8)	----------------
Cl.-2	% CR	90.0(87.5-92.5)	97.5	90.0(90.0-95.0)	----------------
	Am't CR	4.6(3.8-5.1)	4.8	5.2(4.6-5.6)	----------------

The increase in amount CR is evidence that the Ss discriminated the change in conditioning procedure. But even taking into account the initial drop in per cent CR, the effect is hardly profound enough to indicate the extinction of a classical conditioning "process" and acquisition by an operant conditioning "process." Also the drop in per cent CR by Cl.Y.-2 suggests that lost reinforcements may play some role in the initial result.

The effects of repeated extinctions and reconditionings are shown in Figure 7. For extinction, two frequency measures are given: the per cent CR during the CS-US interval and the per cent CR during the entire CS, including the overlapping portion where the UR occurs during conditioning. As reported by Ellison (1964) for salivary conditioning, the response was strongest at the time the US was normally presented in conditioning.

The extinction data reported in Fig. 7 give no evidence that operant and classical procedures differed in RTE either after original learning or after repeated reconditioning. Perhaps the differences in response topography and stimulus control cited earlier in this paper account for the differences commonly observed in RTE between the two procedures.

In contrast to the RTE functions in Fig. 7, the reconditioning functions (also Fig. 7) generally show a differential effect of the conditioning procedures. Using the

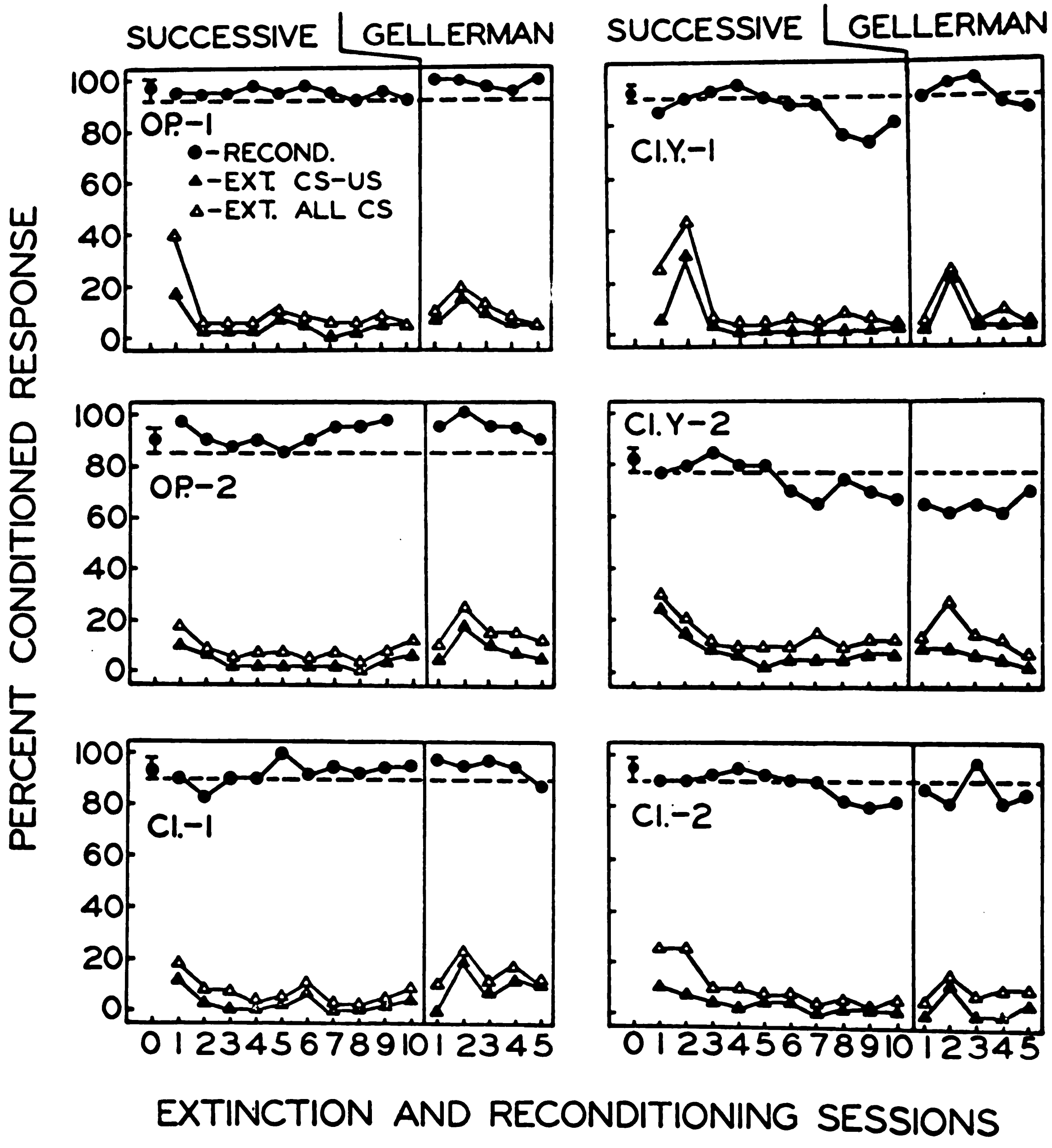

Figure 7. Percent conditioned response during extinction and reconditioning sessions for operant (OP.), classical yoked (Cl.Y.), and classical (Cl.) Ss.

last three sessions of original learning as baseline (the median and range of these sessions are at 0) the classical conditioning procedure yielded poorer reconditioning, especially after several extinctions and reconditionings. This finding should be regarded as tentative, however, since one S (Cl.-1), only dropped below the baseline twice in 15 reconditioning sessions.

The effect of successive extinction and reconditioning sessions for all Ss is decreasing RTE and rapid reconditioning. These results conform with the bulk of the data on successive extinction and reconditioning with both classical (Pavlov, 1927; Hilgard and Marquis, 1935; Finch and Culler, 1935) and instrumental (Bullock and Smith, 1953; Bullock and Bitterman, 1963) procedures. When the order of extinction and reconditioning sessions is changed from successive to a Gellerman series (ERREERERREE,R= Reconditioning, E= Extinction) the Ss show a distinct increase in RTE. The random, but "unfortunate," choice of a single alternation at the beginning of the Gellerman series accounts for the delay in the increase in RTE until the second extinction session. This finding suggests that the decreasing function obtained under successive extinction and reconditioning is explained, at least in part, by the development of a discrimination between successive sessions. That all the Ss showed this effect is further evidence that the two conditioning procedures can, under appropriate conditions, yield similar RTE functions.

CHAPTER V

EXPERIMENT IV--INTERMITTENT REINFORCEMENT

Contrasts between response based free-operant schedules of reinforcement (Ferster and Skinner, 1957) and discrete trial intermittent reinforcement in classical conditioning are not necessarily comparisons between the two conditioning paradigms. Instead, they may only represent comparisons between free-operant and discrete trial procedures. For it has yet to be shown that Ss will run a maze 100 times for one reinforcement, or that an S^D can be maintained by only one reinforcement per 100 presentations (Lewis, 1960). And, on the other side of the coin, it has been shown that acquisition of a conditioned salivation response is possible with 25% S^R (Fitzgerald, 1963).

Another important difference between intermittent reinforcement procedures in classical conditioning and most instrumental situations is that the S^D is often response terminated in instrumental experiments. Response termination of the S^D provides secondary reinforcement not present in classical conditioning experiments, but it is not a necessary part of the instrumental procedure. For example, the multiple schedule used in Experiment II and

III did not involve response termination of the S^D. Experiment IV compared this multiple schedule to a classical conditioning procedure under discrete trial intermittent reinforcement. These comparisons were made with respect to maintenance of the CR under intermittent reinforcement and in extinction (RTE).

The within _S_s design of Experiment IV also made it possible to assess the effects of interpolated intermittent reinforcement on RTE _after_ continuous reinforcement. In light of recent findings (Jenkins, 1962; Theios, 1962) it was expected that sessions under intermittent reinforcement would increase RTE after later sessions under continuous reinforcement.

Method

Subjects.--The six _S_s in Experiment III were used in Experiment IV. This made baseline extinction and reconditioning data available for comparison.

Apparatus.--The apparatus from the other three experiments was modified to allow intermittent reinforcement.

Procedure.--In Experiment IV the contingent _S_s continued on the mult FI limited hold ext schedule used in Experiment III, and the corresponding classical procedures, except that reinforcement was witheld on some proportion of the light presentations or trials. A random schedule programmed the sequence of reinforced and nonreinforced trials at each percentage of reinforced trials.

The Ss had daily conditioning sessions at a given percentage of intermittent reinforcement until responding stablized (5% or less deviation in per cent CR in three successive sessions). After this criterion was met by both Ss in a pair an extinction session of 50 trials was given. The Ss then had successive sessions of continuous reinforcement and extinction (40 trials) until RTE fell within the baseline established in the last three extinction sessions of Experiment III. This procedure was repeated in a descending order: 75% S^R, 50% S^R, 25% S^R, 10% S^R for four Ss (OP.-1, Cl.Y-1, Cl.-1, Cl.-2). For OP.-2 and Cl.Y.-2 this order was altered slightly: 50% S^R, 25% S^R, 75% S^R, 10% S^R.

Results and Discussion

Two frequency measures were used in Experiment IV: the data for CS-US interval responses (for all trials) and "all CS" responses (for nonreinforced trials only) are summarized in Table 5. These data show that the strength of conditioning was reduced by decreases in the per cent reinforcement for three of the classically conditioned Ss (Cl.Y.-1, Cl.Y.-2, and Cl.-2) and one instrumentally conditioned S (OP.-2). This finding is in general agreement with Fromer's study (1963); he found little or

Table 5.--Median and range per cent CR under intermittent reinforcement and during extinction.

		75% S^R		50% S^R		25% S^R		10% S^R	
Ss	Measure	Conditioning	Ext.	Conditioning	Ext.	Conditioning	Ext.	Conditioning	Ext.
OP.-1	CS-US	95.0 (95.0-100.0)	22.5	97.5 (95.0-97.5)	60.0	97.5 (97.5-97.5)	40.0	85.0 (85.0-87.5)	45.0
	All CS	100.0 (100.0-100.0)	50.0	100.0 (95.0-100.0)	72.5	96.9 (96.9-100.0)	70.0	87.0 (87.0-91.3)	55.0
Cl.Y.-1	Cs-US	85.0 (85.0-97.5)	7.5	77.5 (75.0-77.5)	10.0	10.0 (7.5-10.0)	20.0	22.5 (20.0-25.0)	15.0
	All CS	100.0 (80.-100.0)	17.5	95.0 (85.0-95.0)	20.0	19.9 (19.9-23.3)	30.0	36.1 (33.3-36.1)	30.0
Cl.-1	CS-US	97.5 (97.5-100.0	42.5	92.5 (90.0-95.0)	32.5	92.5 (92.5-95.0)	72.5	87.5 (85.0-90.0)	70.0
	All CS	100.0 (100.0-100.0)	57.5	100.0 (100.0-100.0)	40.0	100.0 (100.0-100.0)	81.5	100.0 (100.0-100.0)	80.0
Cl.-2	CS-US	77.5 (75.0-82.5)	32.5	90.0 (87.5-95.0)	35.0	60.0 (57.5-65.0)	57.5	32.5 (27.5-35.0)	53.3
	All CS	80.0 (80.0-90.0)	55.0	95.0 (90.0-100.0)	47.5	73.3 (73.3-76.6)	62.5	50.0 (41.6-56.7)	80.0

Table 5.--Continued

		75% S^R		50% S^R		25% S^R		10% S^R	
Ss	Measure	Conditioning	Ext.	Conditioning	Ext.	Conditioning	Ext.	Conditioning	Ext.
OP.-2	CS-US	87.5 (87.5-90.0)	80.0	55.0 (52.5-57.5)	55.0	87.5 (85.0-90.0)	32.5	47.5 (45.0-50.0)	22.5
	All CS	95.0 (90.0-95.0)	87.5	63.3 (59.9-63.3)	72.5	80.0 (65.0-80.0)	40.0	57.7 (55.5-71.1)	52.5
Cl.Y-2	CS-US	77.5 (75.0-82.5)	60.0	30.0 (27.5-32.5)	32.5	80.0 (75.0-80.0)	5.0	10.0 (7.5-10.0)	15.0
	All CS	95.0 (90.0-95.0)	72.5	46.6 (43.3-53.3)	47.5	80.0 (70.0-80.0)	7.5	23.3 (16.6-33.3)	17.5

no difference between the instrumental and classical procedures in the acquisition of a conditioned vasomotor response, either with the number of nonreinforced trials (intermittent reinforcement) equated or not equated.

After intermittent reinforcement sessions, 50 trial extinction sessions were given to insure that some extinction (no response trials) would occur (Ss rarely responded during the last 10 trials in the 50 trial extinction sessions). The RTE data given in Table 5 are for the first 40 trials in each extinction session. All of the Ss showed the expected increase in RTE after intermittent reinforcement. But, because of the decreasing strength of conditioning and the possibility of sequence effects, a functional relationship between the per cent of intermittent reinforcement and RTE is not apparent from Table 5.

A tentative assessment of relative RTE was made. The relative measure of RTE was constructed by subtracting from the per cent CS-US response in extinction that obtained in the last conditioning session at a given percentage of reinforcement. This relative measure "adjusted" RTE for differences in the strength of conditioning. The relative measure of RTE was probably not an allowable operation if one adhered strictly to scaling principles, but the resulting orderliness made up for this deficiency. A summary of the results using the relative measure of RTE is given in Figure 8. Figure 8 shows the RTE measure to be a generally

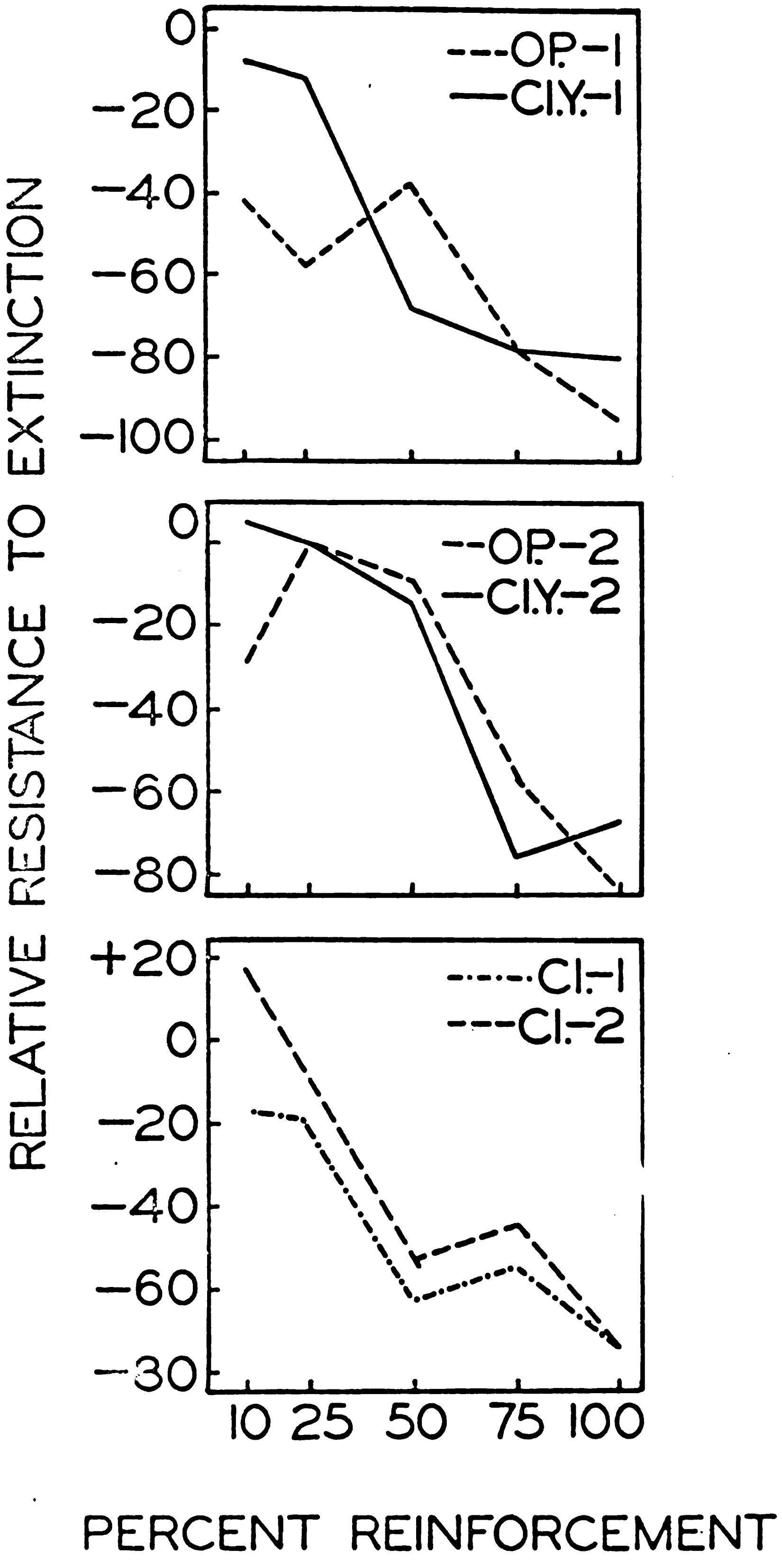

Figure 8. Relative RTE (% Extinction CR-% Acquisition CR) as a function of percent reinforcement.

decreasing function of the per cent reinforcement, with minor reversals at 10% S^R, and elsewhere as effected by sequence, i.e. at 50% S^R for OP.-2 and Cl.Y.-2, and at 75% S^R for Cl.-1 and Cl.-2. Neither measure of RTE allowed clear cut differentiation between the two conditioning procedures.

One part of the results of Experiment IV is still left to consider: This is the effect of interpolated intermittent reinforcement on RTE after reconditioning under continuous reinforcement. Figure 9 presents the per cent CR under continuous reinforcement and in extinction after interpolated intermittent reinforcement at the percentage listed at the top of each panel. Just as RTE increased when the sequence of extinction and reconditioning sessions was shifted from an alternating to a Gellerman series in Experiment III, RTE increased when blocks of intermittent reinforcement and extinction were interpolated between successive sessions of extinction and continuous reinforcement in Experiment IV. The increase was evident in the extinction data of all of the <u>S</u>s, and occurred at more than one level of per cent reinforcement for four of the six <u>S</u>s. For five of the <u>S</u>s RTE was greater after continuous reinforcement in Experiment IV than after original learning (see Fig. 7), although 16-20 extinction sessions intervened.

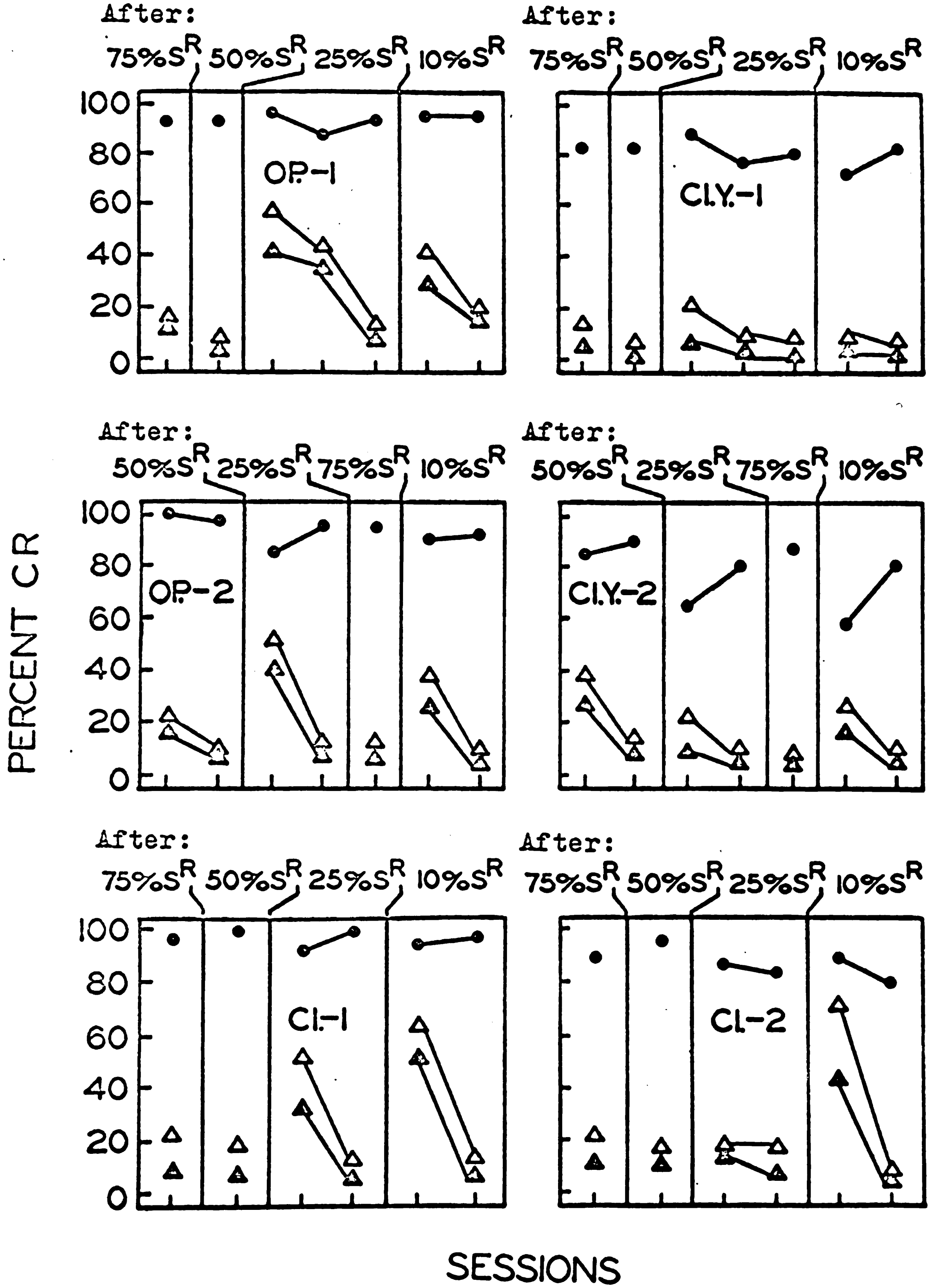

Figure 9. Percent CR under 100% S^R and in extinction after interpolated intermittent S^R and extinction. (Legend is the same as for Fig. 7.)

Jenkins (1962) and Theios (1962) found increased RTE after interpolated intermittent reinforcement, even when continuous reinforcement was given just prior to extinction. The results of Experiment IV support those findings and extend them in that the Ss in Experiment IV had extensive histories of extinction following both intermittent and continuous reinforcement. The previous investigators also found that increases in the amount of continuous reinforcement training reduced the partial reinforcement effect; an analogous decrease in RTE after successive sessions of continuous reinforcement and extinction is shown in Figure 9. For example, the decrease in RTE after 50% S^R, 25% S^R, and 10% S^R for OP.-2, and after 25% S^R, and 10% S^R for Cl.-1 in Figure 9.

CHAPTER VI

GENERAL DISCUSSION

If the classical conditioning procedure described in these experiments was actually some form of instrumental conditioning then the Ss under both procedures in Experiment II should have shown similar temporal conditioning and CS-US interval functions. Such was not the case. Instead, the instrumental Ss had a higher lick rate in the S^D than the classical Ss and maintained this rate at the 60 sec. interval. While the response rates of the classical Ss declined markedly at the 60 sec. CS-US interval. This is not to imply that classical conditioning with a 60 sec. CS-US interval is impossible (Pavlov, 1927; Kamin, 1961). It is possible that continued sessions with the 60 sec. interval would have resulted in a recovery of the CR for the classical Ss, since inspection of the tape records suggests that profound inhibition of delay, rather than extinction was responsible for the decrease in CR's.

One weak point in Experiment II was the omission of control Ss under a superstitious operant procedure. This would involve giving Ss extensive training with the operant procedure followed by a shift to the noncontingent procedure. Under these conditions it is unlikely that Ss would discriminate the change in contingencies, and the performance would therefore parallel that of the contingent Ss in Experiment II.

The results of Experiment II demonstrate the clear-cut superiority of the instrumental procedure in situations involving long temporal intervals, but they do little to explain the finding. Perhaps, it is the response contingency itself that facilitates mediation of temporal intervals; that is, the animals mediate the interval by responding. Some evidence for this notion is given by the increased response rates of the instrumental Ss in Experiment II and replicated in Experiment III.

Early in this paper it was suggested that reported differences in RTE and the effects of intermittent reinforcement between the two conditioning paradigms were probably due to differences in response topography and stimulus control. Free-operant procedures and the response termination of S^D were the specific aspects of stimulus control suspected of accounting for the differences. The results of Experiment III and IV demonstrate that when these procedural aspects of instrumental conditioning are elimnated, little difference in effect remains to be accounted for by the contingency relationship. It would be interesting to discover which of the three (similar response topography, discrete trial procedure, or the elimination of S^r from response termination of the S^D) contributed the most to results that were obtained. The three are capable of being manipulated independently, and it should be an easy matter to assess their relative contributions.

Independent of the results of the comparisons of instrumental and classical procedures, Experiments III and IV yielded data of interest in their own right, namely, the effect of changing the alternating sequence of extinction and reconditioning sessions and the effect of interpolated intermittent reinforcement. In both cases the result was a temporary increase in RTE which dissipated with repeated sessions under continuous reinforcement and extinction.

It is possible to explain the results of Experiment III on the basis of the generalization of extinction gradients, most recently studied by Jenkins and Harrison (1962). The generalization gradients for extinction appear as the reverse of typical generalization gradients in that the point of maximum decrement, rather than maximum response, is at the S^D or CS, thus responding increases, rather than decreases, from that point outward on the gradient. Extinction gradients, like positive gradients, are affected by prior discrimination training (Jenkins and Harrison, 1962). In Experiment III the Ss learned a discrimination between successive sessions of extinction and reconditioning. This resulted in the maximum decrement in the extinction gradient during the session following each reconditioning session. When the order of reconditioning and extinction sessions was shifted, what might be described as generalization "increment" occurred. Of course, under continuous reinforcement the effect could be expected to be short-lived since reinforcement and nonreinforcement provide more potent cues than the conditions on the previous day.

To explain the effect of interpolated intermittent reinforcement in Experiment IV and the Jenkins (1962) and Theios (1962) experiments we must take into account the positive generalization gradients developed during conditioning. If we assume, with Sheffield (1950), that the pattern of intermittent reinforcement provides a "CS" for continued responding, we can often explain increased RTE after intermittent reinforcement on the grounds that extinction is less of a change after intermittent reinforcement than after continuous reinforcement. Responding to nonreinforced trials as CSs for later reinforced trials is acquired gradually under intermittent reinforcement. It is not unreasonable to expect the extinction of such behavior to require prolonged exposure to continuous reinforcement. That is, for the CS for continued responding to shift from a pattern of reinforced and nonreinforced trials to series of reinforced trials. Viewed in this manner, the decrease in RTE after prolonged continuous reinforcement traces the shift from one CS to another.

This explanation leads to an easily tested hypothesis: If blocks of sessions under intermittent and under continuous reinforcement are given successively for a prolonged period a point will be reached where "reversal learning" will be complete within the first session with respect to the CS for continued responding. Therefore, RTE will not be greater than if the entire series of sessions had been under continuous reinforcement.

CHAPTER VII

CONCLUSIONS

1. The noncontingent lick conditioning procedure was shown to be classical conditioning rather than pseudoconditioning or superstitious operant conditioning.
2. The instrumental lick conditioning procedure yielded higher response rates than the classical conditioning procedure. But differences between the instrumental and classical Ss in the number of trials on which responding occurred were only apparent at extended CS-US intervals. Thus it appears that the mediation of temporal intervals was facilitated by the response contingency in the instrumental procedure.
3. With response topography and stimulus control equated, little difference in resistance to extinction was observed between the instrumental and classical conditioning procedures. Resistance to extinction for the two paradigms was similar after original conditioning sessions, after repeated reconditioning and extinction sessions, and after intermittent reinforcement sessions.

4. In general, the results of these experiments give little support to theories that postuate two distinct processes of conditioning. The data suggest that the classical paradigm is another schedule of reinforcement instead of another process of conditioning.

REFERENCES

Brodgen, W. J., Lipman, E. A., and Culler, E. 1938. The role of incentive in conditioning and extinction. *Amer. J. Psychol.*, *51*, 109-117.

Bullock, D. H., and Smith, W. C. 1953. The effect of repeated conditioning--extinction upon operant strength. *J. exp. Psychol.*, *46*, 349-352.

Bullock, D. H., and Bitterman, M. E. 1963. Successive extinctions in the pigeon. *Amer. J. Psychol.*, *76*. 1-7.

Davis, J. D. and Keehn, J. D. 1959. Magnitude of reinforcement and consummatory behavior, *Science*, *130*, 269.

Ellison, G. D. 1964. Differential salivary conditioning to traces. *J. comp. physiol. Psychol.*, *57*, 373-380.

Ferster, C. B. 1953. Sustained behavior under delayed reinforcement, *J. exp. Psychol.*, *45*, 218-224.

Ferster, C. B. and Skinner, B. F. *Schedules of Reinforcement*. New York: Appleton-Century-Crofts, 1957.

Finch, G. and Culler, E. 1935. Relation of forgetting to experimental extinction. *Amer. J. Psychol.*, *47*, 656-662.

Fitzgerald, R. D. 1963. Effects of partial reinforcement with acid on classically conditioned salivary response in dogs. *J. comp. physiol. Psychol*; *56*, 1056-1060.

Fromer, R. 1963. Conditioned vasomotor responses in the rabbit. *J. comp. physiol. Psychol.*, *56*, 1050-1055.

Hefferline, R. F. and Keenan, B. 1963. Amplitude-induction gradient of a small scale (covert) operant, *J. exp. anal. Behav.*, *6*, 307-315.

Hilgard, E. R. and Marquis, D. G. 1935. Acquisition, extinction, and retention of conditioned lid responses in dogs. J. comp. Psychol., 19, 29-58.

Jenkins, H. M. 1962. Resistance to extinction when partial reinforcement is followed by regular reinforcement. J. exp. Psychol., 64, 441-450.

Jenkins, H. M. and Harrison, R. H. 1962. Generalization gradients of inhibition following auditory discrimination learning. J. exp. Anal. Behav., 5, 435-441.

Kamin, L. J. 1963. Trace conditioning of the conditioned emotional response. J. comp. physiol. Psychol; 54, 149-153.

Keehn, J. D. and Arnold, E. M. M. 1960. Licking rates in albino rats, Science, 132, 739-741.

Kimble, G. A. 1961. Hilgard and Marquis' Conditioning and Learning. New York: Century-Croft.

Kintsch, W. and Witte, R. S. 1962. Concurrent conditioning of bar press and salivation responses, J. comp. physical. Psychol., 55, 963-968.

Lewis, D. J. 1960. Partial reinforcement: a selective review of the literature since 1950. Psychol. Bull., 57, 1-28.

Liddel, H. S., James, W. T., and Anderson, O. D. 1934. The comparative physiology of the conditioned motor reflex: based on experiments with the pig, dog, sheep, goat, and rabbit. Comp. Psychol. Monogr., 11, No. 51.

Longo, N., Milstien, S., and Bitterman, M. E. 1962. Classical conditioning in the pigeon: Exploratory studies of partial reinforcement. J. comp. physiol. Psychol., 55, 983-986.

Moore, J. W. and Gormezano, J. 1961. Yoked comparisons of instrumental and classical eyelid conditioning. Paper read at M. P. A.

Mowrer, O. H. 1960. Learning theory and behavior. New York: Wiley.

Mowrer, O. H., Palmer, Florence, and Sanger, Marjorie D. 1948. Individual learning and "racial experience" in the rat, with special reference to vocalization. J. genet. Psychol., 73, 29-43.

Pavlov, I. P. 1927. Conditioned reflexes. London: Oxford University Press.

Ratner, S. C, and Miller, K. R. 1959. Classical conditioning in earthworms, Lumbricus terrestris. J. comp. physiol. Psychol, 52, 102-105.

Razran, G. 1955. Operant vs. classical conditioning. Amer. J. Psychol., 68, 489-490.

Roberts, W. A., Bullock, D. H., and Bitterman, M. E. 1963. Resistance to extinction in the pigeon after partially reinforced instrumental training under discrete-trial conditions. Amer. J. Psychol., 75, 353-365.

Salzinger, K. and Waller, M. B. 1962. The operant control of vocalization in the dog. J. exp. Anal. Behav., 5, 383-389.

Schoeffer, R. W. and Premack, D. 1961. Licking rates in infant albino rats. Science, 134, 1980-1981.

Scholsberg, H. 1936. Conditioned responses in the white rat: II Conditioned responses based upon shock to the foreleg. J. genet. Psychol, 49, 107-138.

Shapiro, M. M. 1961. Salivary conditioning in dogs during fixed internal reinforcement contingent upon lever pressing. J. exp. anal. Behav., 4, 361-364.

______. 1962. Temporal relationship between salivation and lever pressing with differnetial reinforcement of low rates. J. comp. physiol. Psychol., 55, 567-571.

Sheffield, Virginia F. 1950. Resistance to extinction as a function of the distribution of extinction trials. J. exp. Psychol., 40, 305-313.

Skinner, B. F. 1938. Behavior of organisms. New York: Appleton-Century.

______. 1953. Science and human behavior. New York: The MacMillan Co.

______. 1957. Verbal behavior. New York: Appleton-Century-Crofts.

Solomon, R. L. and Wynne, L. C. 1954. Traumatic avoidance learning; the principles of anxiety conservation and partial irreversibility, Psychol. Rev., 61, 353-385.

Theios, J. M. 1962. The partial reinforcement effect sustained through blocks of continuous reinforcement. J. exp. Psychol., 64, 1-6.

Weinstock, S. 1958. Acquisition and extinction of a partially reinforced running response at a 24-hour intertrial interval. J. exp. Psychol., 58, 151-158.

Wyckoff, L. B., Sidowski, J., and Chambliss, D. J. 1958. An experimental study of the relationship between secondary reinforcing and cue effects of a stimulus. J. comp. physiol. Psychol., 51, 103-109.

Zener, K. 1939. The significance of behavior accompanying conditioned salivary secretion for theories of the conditioned response. Amer. J. Psychol., 50, 384-403.