PARTIAL REINFORCEMENT EFFECTS IN PAVLOVIAN (CER) CONDITIONING: BETWEEN- AND WITHIN-SUBJECTS

by

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INTRODUCTION

Kimble (1961) has argued that the distinction between Pavlovian and instrumental conditioning is purely operational. The basic distinction is the degree to which the subject's response affects the incidence of the unconditioned stimulus (UCS). In the Pavlovian conditioning situation, responses on the part of the subject do not affect the presentation of the UCS, reinforcement. In the instrumental case the occurrence of reinforcement is determined by the behavior of the subject. A question that has arisen from this analysis concerns the degree to which these operationally distinct paradigms lead to different empirical and theoretical generalizations. A test of this question rests in a comparison of the effects of specific variables upon the behavior of subjects in both the instrumental and Pavlovian conditioning situations.

A comparison of a number of conditioning variables (intertrial interval, conditioned stimulus (CS) intensity, UCS intensity) suggests that many of the most frequently employed learning parameters have similar effects in Pavlovian and instrumental conditioning (see Marx, 1969 for a review of this literature). However, the available data on the effects of partial reinforcement in the two situations suggests that different effects may arise from similar experimental procedures depending upon the paradigm studied. In the Pavlovian conditioning paradigm, partial reinforcement may be defined as the omission of the UCS following CS presentations on a number of trials. Under Pavlovian procedures the acquisition of the conditioned response (CR) is impaired under a partial reinforcement schedule (Grant & Schipper, 1952;

Humphreys, 1939). Conversely, in the instrumental conditioning paradigm, partial reinforcement initially impairs acquisition of the instrumental response. However, terminal acquisition performance under partial reinforcement has been shown to be better than or comparable to that under continuous reinforcement (Goodrich, 1959; Haggard, 1959; Hulse, 1958; Wagner, 1961).

From comparisons of Pavlovian conditioning with instrumental conditioning, the data on the effects of partial reinforcement on extinction is quite puzzling. In instrumental conditioning partial reinforcement leads to increased resistance to extinction relative to continuous reinforcement (Hulse, 1958; Wagner, 1961, also see Jenkins & Stanley, 1950 and Lewis, 1960 for reviews). This finding, commonly referred to as the partial reinforcement effect (PRE), is observed in a majority of instrumental conditioning studies which employ partial reinforcement in between-groups comparisons. Exceptions to the commomly observed PRE may be observed in some studies which utilized single groups or within-subjects designs.

In a within-subjects design a single subject is exposed to at least two discrete stimuli each of which is associated with a separate reinforcement schedule during acquisition. Resistance to extinction is then evaluated in the presence of the individual stimuli. The typical pattern of results which are produced by this manipulation is called the reversed PRE, that is, increased resistance to extinction in the presence of the cue associated with continuous reinforcement as opposed to partial reinforcement (Pavlik & Carlton, 1965; Pavlik, Carlton, Lehr &

Hendrickson, 1967; Pavlik & Collier, 1977). Evidence of this general type has not been reported in the literature on Pavlovian conditioning with infrahuman subjects. However, a single study (Newman, 1967) exists in which human subjects were employed in a differential eyelid conditioning paradigm. The acquisition and extinction of the conditioned eyeblink response was examined as a function of the probability of reinforcement. The design allowed for 56 CS_1 and 56 CS_2 presentations to each subject. The number of reinforced CS occurrences defined the ten experimental groups. The individual groups represented the total number of combinations of 100%, 75%, 50%, 25%, and 0% reinforcement, such that the percentage of CS_1 reinforcement was greater than CS_2 reinforcement within each group. The results, presented in terms of between and within-subjects effects showed that a conventional between-subjects PRE was obtained. Numerical evidence for a within-subjects reversed PRE failed to reach statistical significance.

In Pavlovian conditioning involving between-subjects comparisons, the data on partial reinforcement extinction effects are unclear. In the original demonstration of the PRE (Humphreys, 1939), human subjects were administered classical defense conditioning under continuous or partial reinforcement. The results showed that resistance to extinction was greater under partial reinforcement. A further study by Grant and Schipper (1952) showed that resistance to extinction was not a sole function of reinforcement schedule but depended to a great extent upon the level of conditioning which had been obtained during acquisition.

Human subjects were administered classical defense conditioning under

100%, 75%, 50%, 25%, or 0% reinforcement. The results showed that acquisition performance varied directly with increasing percentage of reinforcement; the percentage of CR's was greatest under continuous reinforcement and least under 0% and 25% partial reinforcement. However, resistance to extinction was greater under 50% and 75% partial reinforcement than under continuous reinforcement. In addition, the PRE may be abolished, or a reversed PRE produced, by masking the Pavlovian task during acquisition in Pavlovian conditioning studies with human subjects (see Spence, 1966 for a review).

The PRE has also been reported in studies using infrahuman subjects. For example, Kimmel and Yaremko (1966) used planaria as subjects and conditioned movement as the dependent variable and Wyers, Peek and Herz (1964) used earthworms as subjects and withdrawal as the conditioned response. Both studies report equal terminal acquisition following continuous and partial reinforcement and greater resistance to extinction following partial reinforcement.

Additional evidence in support of the occurrence of the PRE in studies on Pavlovian conditioning employing infrahuman subjects may be gleaned from a number of studies with goldfish (Berger, Yarczower, & Bitterman, 1965), pigeons (Slivka & Bitterman, 1966), dogs (Fitzgerald, 1963; Fitzgerald, Vardaris, & Teyler, 1966), and rats (Hilton, 1969). There are however, a sizeable number of studies which report results which either do not support those cited above or offer evidence that is contradictory. Gonzales, Longo, and Bitterman (1961) reported that resistance to extinction of an activity response in the goldfish is not affected by the schedule of reinforcement employed in acquisition.

Longo, Milstein, and Bitterman (1966) and Thomas and Wagner (1964) reported the absence of a differential effect of schedules of reinforcement on the resistance to extinction of a movement response in the pigeon and the eyeblink response in the rabbit, respectively.

There is, in addition to what has already been cited, another avenue of investigation that has been used to study the effect of partial reinforcement in Pavlovian conditioning; namely, research on the conditioned emotional response (CER) paradigm (Estes & Skinner, 1941; Hunt & Brady, 1951). The design of the prototypic CER experiment has three phases. In the first phase subjects are trained to perform an instrumental response, such as bar pressing to obtain food reinforcement. The second phase permits pairings between a discrete CS and a noxious UCS (e.g., shock). Finally, in the third phase, the CS, presented without the UCS, is superimposed on the instrumental behavior. The basic assumptions of this design are that (A) in the second phase the UCS presentations elicit an unobservable emotional response (e.g., fear) which is conditioned to the CS by Pavlovian procedures, and (B) subsequent presentation of the CS in phase three will elicit the CER which will interfere with the performance of the instrumental behavior.

Omitting the UCS following some of the CS presentations in the second phase of the CER paradigm permits another examination of the effect of partial reinforcement in Pavlovian conditioning. In the earliest report of an experiment involving partial reinforcement of the CER (Brimer & Dockrill, 1966) three groups of subjects were used. The partial reinforcement group received 20 CS presentations, one-half of which

(10) were paired with shock. The continuous reinforcement group formed the two additional subgroups which differed in the number of CS-UCS pairings administered. One continuous reinforcement group received 20 CS-UCS pairings and the other continuous reinforcement group received 10 CS-UCS pairings. The purpose of these groups was to control for the number of CS and the number of UCS presentations administered to the partial reinforcement group. The results indicated bar press suppression was greatest in the partial reinforcement condition. Further evidence for the existence of the PRE in Pavlovian (CER) conditioning has been reported by Wagner, Siegal, and Fein (1967) and Hilton (1969). However, the results showed that the Pavlovian conditioning procedure may effect the PRE (see Method).

There is, however, a brief report by Scheuer (1969) which appears to question the broad conclusion that the PRE is obtainable in Pavlovian conditioning. Scheuer initially administered CS-UCS pairings to each subject until a suppression ratio criterion was reached. Pavlovian conditioning continued and a gradual reduction in the number of UCS (shock) presentations resulted in five groups trained with 100%, 66%, 26%, 20%, and 13% reinforcement at the close of acquisition training. Extinction of the CER was evaluated by presenting the CS, without the UCS, superimposed upon the instrumental behavior. The results, showed that bar press suppression during extinction was greatest for subjects trained with 100% CS-UCS pairings.

A possible reason for the findings obtained by Scheuer could be that each subject was, during training, exposed to at least two different schedules of reinforcement (i.e. 100% and 66%, for the group which ended

acquisition with a 66% reinforcement schedule). Broadly speaking, this situation appears analagous to that which occurs in the context of within-subjects designs, and this analogy seems to hold at least as far as exposure to multiple reinforcement probabilities is concerned.

Since a comparison of the behavioral effects of similar experimental procedures employed in Pavlovian and instrumental paradigms should bear upon a decision regarding their distinctiveness, a further examination of the role of partial reinforcement in Pavlovian conditioning seems warranted. The present study was designed to clarify the role of partial reinforcement in the extinction of a response (CER) established by Pavlovian conditioning procedures. This was accomplished by factorially combining two schedules of reinforcement with two discrete conditioned stimuli in such a way as to permit both between- and within-subjects comparisons to be made.

Specifically, the present study contained two groups which provided for the between-subjects comparisons. During Pavlovian conditioning one group received 100% reinforcement for each of two CS's and the other group 50% reinforcement for each of two CS's. Two additional groups provided for within-subjects comparisons of the effect of schedule of reinforcement. In each group one CS was paired with shock on 50% of its occurrences and the other CS was paired with shock on 100% of its occurrences. Evidence regarding the effect of partial reinforcement in Pavlovian conditioning should accrue from an analysis of the suppression ratio data in terms of between- and within-subjects schedule effects.

Two other groups were also run. One received random CS and UCS presentations. The second group was designed to contrast with the

partial reinforcement group. Specifically, this group, labeled EUCS received the same number of CS-UCS pairings as the partial reinforcement group, but UCS only presentations when the CS only was presented in the partial reinforcement group.

Method

Subjects

Subjects were 48 male hooded rats from the animal colony maintained by the Psychology Department at Virginia Polytechnic Institute and State University. The rats' weights ranged between 300g and 485g at the start of the experiment.

Apparatus

The apparatus consisted of four operant chambers, equipped with retractable levers and enclosed in sound-attenuated boxes. The appropriate controlling, recording, and timing devices were located adjacent to the operant chambers. Care was taken to counterbalance experimental conditions across operant chambers.

The CS_L consisted of a 10/sec. flashing house light and the CS_T was an 85-90 db continuous white noise produced by a Grason-Stadler white noise generator. The sound level was measured inside the operant chambers with the sound-attenuated boxes closed and the ventilation fans on. The white noise was maintained at 15 db above the ambient noise level which varied from 70 db - 75 db. Shock of 1.0 mA intensity and 0.5 sec. duration was provided through the grid floors of the operant chambers.

Preliminary Training

The rats were first reduced to 80% of their ad libitum body weight. The rats were fed the amount of food necessary to maintain their individual weights at 80% of the ad libitum level, not less than one-half hour after the conclusion of each daily session. This feeding regimen

remained in effect throughout the experiment. Reduction to 80% of the rats ad libitum weight was followed by 2-3 one-hour sessions of bar press training under continuous food reinforcement. All rats then were given 5 one-hour sessions of bar training under a VI 30-sec. schedule of reinforcement. A one-hour session was given each day, and five sessions were sufficient to produce a relatively high, stable rate of responding (Range=608-2389 B.P./hr.).

CER Conditioning

After preliminary bar press training, all rats were given 4 one-hour Pavlovian conditioning sessions, off baseline and with the levers retracted. (This off baseline procedure was used to prevent any adventitious punishment of the instrumental response during on baseline conditioning. See Wagner, Siegal, and Fein (1967) and Hilton (1969) for a comparison of on and off baseline procedures.) Each one-hour session consisted of 12 presentations of the CS's, 6 CS_L's and 6 CS_T's, except in group EUCS (see below). The duration of each CS was 1 min.

The subjects were randomly assigned to six groups (n=8). Group 100L-100T received a shock (UCS) following each CS presentation; Group 50L-50T received the UCS following only one-half of the CS_L and one-half of the CS_T presentations; Group 100L-50T received the UCS following each CS_L presentation and one-half of the CS_T presentations; Group 50L-100T received the UCS following one-half of the CS_L presentations and following each CS_T presentation. Group Random (Rescorla, 1967) received the same number of shock presentations as 100L-100T group; however, the temporal spacing of the shock presentations was random with respect to CS presentations. (This resulted in 5 CS-UCS pairings during the

Pavlovian conditioning sessions.) Group Extra-UCS (EUCS) received only 6 CS's, 3 CS_L's and 3 CS_T's, each of which was paired with shock, during each Pavlovian conditioning session. Further, 6 additional shocks which were not preceded by a CS were delivered during each session. Unsignaled shocks occurred when unpaired CS's occurred in the 50L-50T condition.

Immediately following each Pavlovian session, the retractable levers were reinserted into the operant chambers and bar pressing proceeded for 0.5 hr. under the VI 30 sec. schedule of food reinforcement. The additional training session was intended to maintain the level of bar press performance which was attained in the preliminary training situation.

CER Testing

Testing consisted of superimposing the CS's without the UCS on food-reinforced bar pressing bahavior. Five one-hour test sessions were given during which the CS's were presented in a manner identical to that in which they were presented during the Pavlovian conditioning sessions, 6 CS_L's and 6 CS_T's per session. The UCS was omitted throughout this phase of the experiment.

Suppression of bar press behavior was measured by a suppression ratio, B/(A+B) (Kamin, 1961), in which B equals the number of bar press responses made during the presentation of the CS and A equals the number of responses made in a equal time period (1 min.) immediately prior to the onset of the CS. A ratio of .50 would indicate that the CS had no effect upon the bar pressing behavior while a ratio of .00 would indicate total suppression of the bar pressing response in the presence of

the CS. A mean suppression ratio was computed for each subject for each of the five test sessions for both CS_L and CS_T.

Results

Figure 1 presents the mean suppression ratios for the experimental and control groups, collapsed across stimuli, for each of the five test sessions. The upper portion of Figure 1 shows that in each of the five test sessions bar press suppression in the between-subjects comparisons was greater following continuous reinforcement than following partial reinforcement in the Pavlovian session. Bar press suppression decreased over test sessions for both reinforcement schedules.

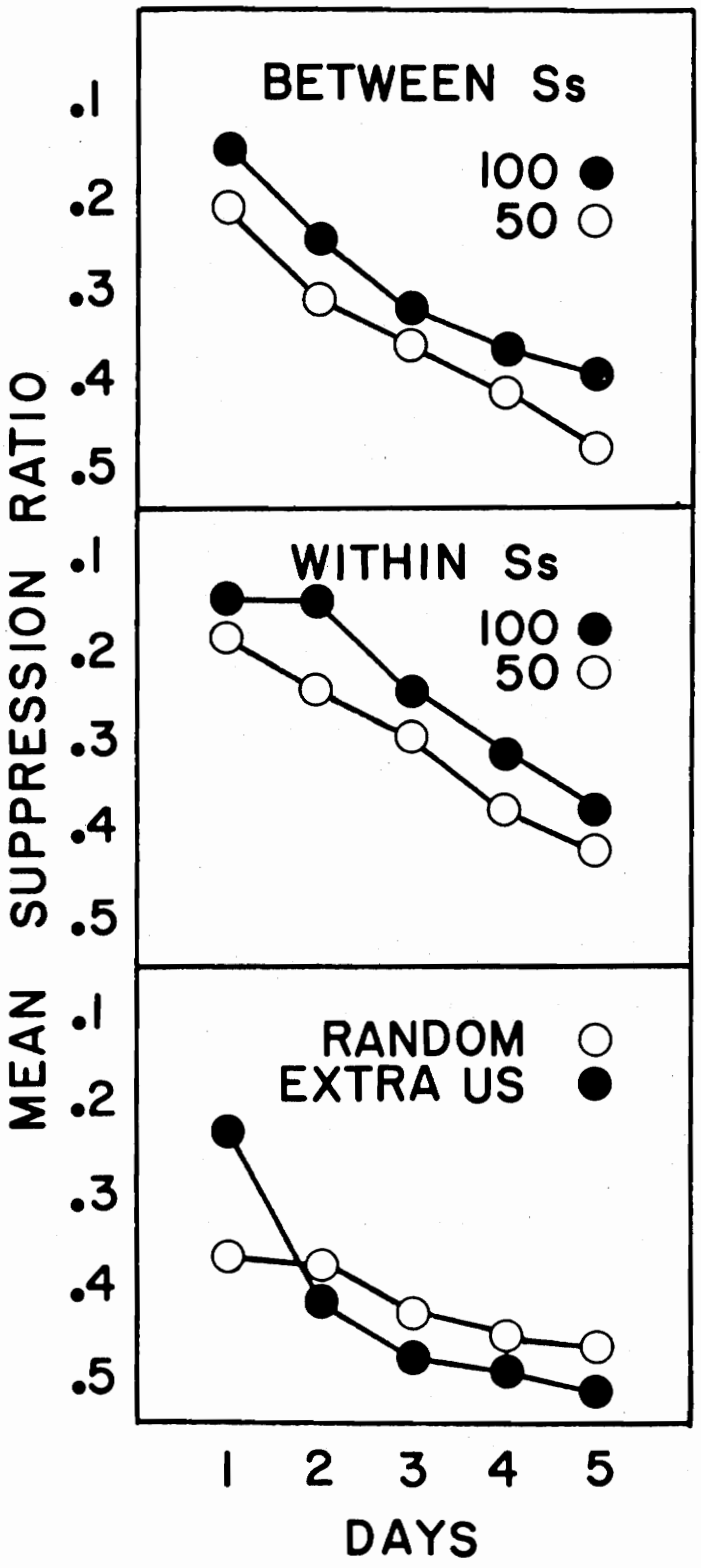
The middle portion of Figure 1, shows that in each test session bar press suppression in the presence of the continuously reinforced CS's was greater than that in the presence of the partially reinforced CS's. Bar press suppression decreased over test sessions in a manner similar to that shown for the between-subjects comparisons.

The lower portion of Figure 1 shows that bar press suppression in the EUCS condition was initially as great as that in the 50L-50T condition; but suppression in the EUCS condition dissipated more rapidly. Further, for the random condition bar press suppression was slight to begin with and dissipated rapidly over test sessions.

An analysis of variance over all the data of Figure 1 yielded a significant Groups x Stimulus interaction ($F = 3.06$, $df = 5/42$, $p < .019$) and a significant Stimulus x Trials interaction ($F = 4.53$, $df = 4/168$, $p < .002$). The main effects for Groups, Trials, and Stimulus were also significant.

These overall effects were further subjected to a number of simple-

Figure 1. Mean suppression ratios, collapsed across stimuli, for the experimental and control groups, for each of the five test sessions.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DAYS

effects analyses. The trend toward a between-subjects reversed PRE was evaluated by comparing the suppression ratios obtained in the 50L-50T and 100L-100T groups, collapsed across stimuli. Neither the Groups effect nor the Groups x Trials interaction reached significance ($F = 1.26$, $df = 1/14$, $p > .28$ and $F < 1.0$, $p > .94$, respectively).

The within-subjects reversed PRE was evaluated by comparing the suppression ratios obtained in the 50L-100T and 100L-50T, collapsed across stimuli for each reinforcement schedule. A significant Trials effect ($F = 27.89$, $df = 4/4$, $p < .0001$) and a significant Schedules effect ($F = 10.76$, $df = 1/1$, $p < .005$) was obtained. The significant Schedules effect in the within-subjects comparisons resulted from a differential change in the suppression ratios between the 100% and 50% reinforcement conditions. Following roughly equivalent suppression ratios in the first test session, suppression in the 50% reinforcement condition dissipated more rapidly than in the 100% reinforcement condition. The significant Schedules effect was taken as evidence for a significant within-subjects reversed PRE.

Additional evidence supporting the occurrence of the reversed PRE was obtained by correlating the number of CS-UCS pairings with the magnitude of the overall suppression ratio for each group (except Group Random) collapsed across stimuli (stimulus condition was ignored in this comparison). A significant ($p < .05$) negative relationship ($r = -.70$) was shown between the number of CS-UCS pairings and the overall suppression ratio. That is, the greater the number of CS-UCS pairings the greater the bar press suppression. Further simple-effects analyses comparing the EUCS and Random groups showed that the EUCS and Random control

groups did not differ significantly ($F<1$, $p>.84$). A significant Trials effect ($F = 19.95$, $df = 4/56$, $p<.0001$) and a significant Groups x Trials interaction ($F = 5.69$, $df = 4/56$, $p<.0009$) was obtained. In addition, a significant difference between both the EUCS and Random control groups, and each of the experimental groups was observed with the exception of the 50L-50T group ($F = 2.90$, $df = 1/14$, $p>.10$).

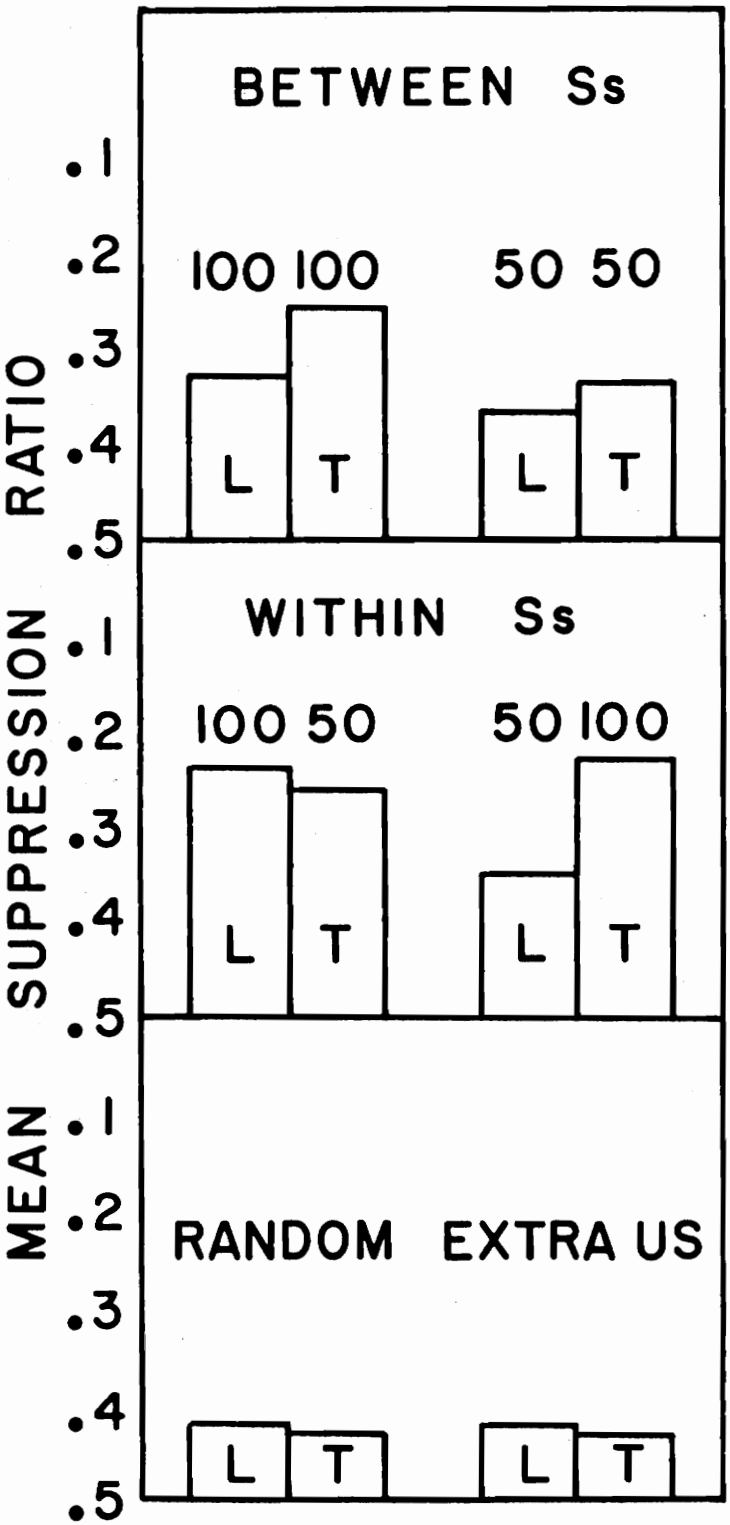
The presence of a reliable interaction involving stimuli in the overall analysis prompted additional analyses on the relative effects of CS_L and CS_T on bar press suppression. Figure 2 presents the mean suppression ratio for each CS in each experimental and control group; the results are collapsed across test sessions.

In the upper portion of Figure 2 a comparison of the suppression ratios in the presence of CS_L and CS_T shows that greater suppression in the presence of CS_T occurred during both partial and continuous reinforcement.

In the middle portion of Figure 2, in the 50L-100T group, bar press suppression was greater in the presence of CS_T than CS_L. In the 100L-50T within-subjects comparison bar press suppression was greater in the presence of the CS_L than CS_T. The difference between the bar press suppression in the presence of CS_T and CS_L in the 100L-50T comparison is less than the difference observed in the 50L-100T comparison. However, a meaningful comparison of the effectiveness of CS_T and CS_L in producing bar press suppression is difficult since the schedule of reinforcement is confounded with the stimulus effects.

In the lower portion of Figure 2 bar press suppression in the presence of CS_T is roughly equivalent to that in the presence of the CS_L

Figure 2. Mean suppression ratios for the tone (T) and light (L) conditioned stimuli in each experimental and control group. The suppression ratios are collapsed across test sessions.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in both groups. However, the absence of stimulus effects may be expected since relatively little bar press suppression was observed in the Random and EUCS groups.

The effect of CS_T and CS_L on bar press suppression in the individual groups was evaluated statistically. In the 100L-100T comparison a significant Stimulus effect ($F = 7.75$, $df = 1/7$, $p < .026$) was obtained. In the 50L-50T comparison a marginally significant Stimulus x Trials interaction ($F = 2.52$, $df = 4/26$, $p < .063$) was obtained. These results indicated that bar press suppression was reliably greater for CS_T than for CS_L.

In the 50L-100T comparison a significant Stimulus effect ($F = 15.39$, $df = 1/7$, $p < .006$) was obtained; but in the 100L-50T comparison neither the Stimulus effect nor the Stimulus x Trials interaction was significant ($F < 1$, $p > .64$ and $F < 1$, $p > .96$, respectively). However, in the 50L-100T comparison the more effective Schedule effect (100%) is in concert with the more effective CS (Tone), while in the 100L-50T comparison, the more effective Schedule is opposed to the Stimulus effect.

A comparison of the suppression ratios obtained under CS_T and CS_L in the EUCS group resulted in a significant Stimulus x Trials interaction ($F = 3.68$, $df = 4/28$, $p < .015$). A closer inspection of the data revealed that in the first and second test session bar press suppression in the presence of CS_T was greater than that in the presence of CS_L. Similar comparisons in the Random group did not yield any statistically significant stimulus effects.

Further, a correlation analysis between the number of CS-UCS pairings and the suppression ratio for each CS within each group (except

Group Random) also yielded a significant negative relationship ($r = -.686$). This result also showed that the greater the number of CS-UCS pairings, the greater the bar press suppression.

Discussion

The present study examined the effects of schedules of CS-UCS pairings in Pavlovian conditioning on the suppression of bar press behavior in between- and within-subjects comparisons. Differences in bar press suppression over test sessions and as a consequence of the individual group manipulations were taken as indices of the amount of fear elicited by each CS presentation. The major findings were: (A) in the within-subjects comparisons resistance to extinction was significantly greater following continuous reinforcement than partial reinforcement in the Pavlovian conditioning situation -- a within-subjects reversed PRE, (B) resistance to extinction was numerically, but not significantly greater following continuous reinforcement than partial reinforcement in the between-subjects comparisons, a suggestion of a reversed PRE, and (C) bar press suppression in the presence of CS_T was generally greater than that for the CS_L.

The reversed PRE observed in the within-subjects analysis is in keeping with the findings reported in studies on instrumental conditioning that employ similar within-subjects designs (Pavlik & Carlton, 1965; Pavlik & Collier, 1977). On the basis of these data, it is quite tempting to suggest a further commonality between instrumental and Pavlovian conditioning paradigms. However, the failure to obtain a between-subjects PRE in Pavlovian conditioning weakens this conclusion, especially because in instrumental conditioning the between-subjects

PRE is a highly robust finding. In fact, the presence of a numerical between-subjects reversed PRE in the present study is a finding that is contradictory to that typically observed in instrumental conditioning (Hulse, 1958; Wagner, 1961). However the present results are consistant with other findings in studies on Pavlovian conditioning (e.g.,Newman, 1967; Scheuer, 1969).

An adequate explanation of the extinction of the CER observed in the present study does not easily follow from traditional theories of extinction (Amsel, 1958; Capaldi, 1966) which are derived from studies on instrumental appetitive conditioning. According to Amsel (1958), resistance to extinction is thought to be a function of the strength of the bond between the instrumental response and frustration-induced internal cues (s_f). The transition from the instrumental appetitive situation to the Pavlovian CER paradigm appears to be unjustified for Frustration Theory. It seems difficult to conceive of the ommission of the UCS (shock) in the CER paradigm as an elicitor of frustration, in the same manner as non-reward following reward of the instrumental response elicits frustration. Further, it is unclear that Frustration Theory can be applied to Pavlovian conditioning situations where the reinforcing event (UCS) is not response contingent.

Sequential Theory (Capaldi, 1966, 1967) explains resistance to extinction as a function of the pairing of the stimuli associated with non-reward (S^N) with subsequent instrumental responding on reinforced trials. In extinction (N, N, N, ...), the performance of the instrumental response persists longer following partial reinforcement than following continuous reinforcement since the bond between S^N and

reinforced responding is greater in the former condition.

At present, it appears unlikely that Capaldi's theoretical mechanisms function in the Pavlovian conditioning situation. For example, Capaldi (1967) suggests that in single alternation training, the outcome of trial T forms part of the stimulus complex on trial T+1, and that instrumental responding comes to be controlled by the stimulus events of the previous trial. In Pavlovian (CER) conditioning, shock (UCS) paired with only the odd numbered CS presentations in a series would be analogous to single alternation training. However, patterned suppression ratios as a function of this type of training are absent in the literature.

One adequate explanation of the data obtained in the present study is offered by a wide variety of theoretical positions (Capaldi, 1976; Mackintosh, 1975; McAllister & McAllister, 1971; Rescorla & Wagner, 1972). The available literature on fear conditioning (McAllister & McAllister, 1971) suggests that the pairing of a neutral CS with a noxious UCS results in the conditioning of fear or anxiety to the CS. Further, the strength of conditioning is thought to be a function of the number of CS-UCS pairings. Assuming that fear provides the mechanism for instrumental response suppression in the third phase of the CER paradigm, it follows from fear theory that greater instrumental response suppression will occur in the presence of the CS associated with the greater percentage (frequency) of reinforcement. Thus a reversed PRE would result. The results of the present study support this prediction, a significant relationship existed between the number of CS-UCS pairings during Pavlovian conditioning and the instrumental response

suppression observed in the third phase of the study.

The Rescorla-Wagner model (Rescorla & Wagner, 1972) and the Mackintosh (1975) model are predictability models. Their basic premise is that the change in the associative strength of a CS is a joint function of the CS's existing strength (due to prior conditioning) and the outcome of each conditioning trial. Associative strength involves both excitatory and inhibitory components. On trials in which a CS-UCS pairing occurs, presumably there is an increase in the excitatory component, the amount being a constant fraction of the difference between the existing associative strength and the maximum associative strength possible. On trials where the CS is not paired with a UCS an increment to the inhibitory component (and a decrease in the net associative strength) will occur, the amount of increment to the inhibitory component being a constant fraction of the existing associative strength. In the present study, a reversed PRE should be obtained in all of the relevant comparisons as continuous reinforcement should result in greater net associative strength than partial reinforcement.

The reinforcement level hypothesis (Capaldi, 1976) represents a cognitive expectancy notion that is quite similar to the Rescorla-Wagner model as far as the concept of associative strength is concerned. For Capaldi, reinforced trials increase the expectancy of reinforcement and greater increases in expectancy presumably accrue to stimuli possessing greater predictive value at the onset of each trial. Therefore, continuous reinforcement in the present study would result in greater shock expectancy on subsequent trials than partial reinforcement. Assuming that bar press suppression is greater in the presence of a

greater expectancy of shock, a reversed PRE should be obtained.

An analysis of the present data in terms of the predictability models suggests that as a result of repeated CS-UCS pairings (continuous reinforcement) the CS becomes a perfect predictor of shock. Conversely, in partial reinforcement the CS is an effective, but not a perfect, predictor of shock. (i.e., Although all UCS's are predicted by the CS, some CS's are not followed by UCS's.) Clearly, the prediction stemming from the predictability models is for a reversed PRE in both between- and within-subjects comparisons. Support for this prediction was provided in the present study by a significant reversed PRE in the within-subjects comparisons and a numerical reversed PRE in the between-subjects comparison.

Further evidence dealing with the predictability models may be obtained from a comparison of the EUCS group and the 50L-50T group. The EUCS group received the same number of CS-UCS pairings as the 50L-50T group did, but the EUCS group received additional unpaired UCS presentations. The CS's in the 50L-50T group predicted shock 50% of the time. The CS's in the EUCS group were perfect predictors of shock in the sense that each CS was followed by a UCS. However, since a number of shock presentations in each Pavlovian conditioning session were not preceded by a CS, the CS's in the EUCS group may be viewed as imperfect predictors of shock (do not predict all shocks). A comparison of the bar press suppression in the 50L-50T and EUCS groups showed that suppression in the first test session was roughly equivalent; but in successive test sessions, the suppression in the EUCS group diminished more rapidly than did that in the 50L-50T group. In the initial test session bar press

suppression appears to be controlled by the previous number of CS-UCS pairings for the EUCS and 50L-50T groups. However, in subsequent sessions, the greater predictive value of the CS in the 50L-50T group appears to have exerted a greater influence on the suppression of the instrumental responding.

Finally, for whatever reason, bar press suppression in the presence of CS_T was greater than that in the presence of CS_L. However, it will be recalled that the difference in the bar press suppression in the presence of the two stimuli was greater in the 100L-100T group than in the 50L-50T group. It seems possible that the differences observed could have resulted from a difference in the types of behaviors elicited by the two stimuli, a finding that has been reported in the Pavlovian appetitive situation (Holland, 1977).

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PARTIAL REINFORCEMENT EFFECTS IN PAVLOVIAN (CER) CONDITIONING: BETWEEN- AND WITHIN-SUBJECTS

by

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(ABSTRACT)

Rats were used in an experiment which investigated the effects of partial and continuous reinforcement of the CER. A 2 x 2 mixed design provided for the factorial combination of 100% and 50% reinforcement schedules with two discrete conditioned stimuli. Analysis of bar press suppression revealed a significant within-subjects reversed PRE. A numerical, but not significant reversed PRE was obtained in the between-subjects comparisons. Further, suppression in the presence of the tone CS was greater than that in the presence of the light CS. The results were discussed in terms of a fear conditioning model and a predictability model.