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CS INTENSITY AND EXTINCTION OF

THE CER IN RATS

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CS INTENSITY AND EXTINCTION OF THE CER IN RATS

INTRODUCTION

Reviews (Champion, 1962; Gray, 1965; Marx, 1969) of studies pertinent to the effects of CS intensity on response strength have frequently supported a positive relationship with acquisition measures but have consistently failed to demonstrate any effect when extinction measures have been used. In those studies (e.g., Grant & Schneider, 1948, 1949; Kamin & Schaub, 1963; Kessen, 1953; Walker, 1960) which included response measures obtained during extinction, a counterbalanced factorial design has typically been used presumably to provide a definitive means of separating the effects of CS intensity on associative processes from those on nonassociative processes. Several reviewers of the CS intensity literature (Champion, 1962; Kamin & Schaub, 1963; Marx, 1969; Woodard, 1966) have pointed out that despite the logical advantage of equalizing CS intensity levels between groups during extinction, several sources of confounding from within-*S* shifts in CS intensity are necessitated with the use of counterbalanced factorial procedures. The two sources most frequently cited and demonstrated in these factorial procedures are (a) an exaggeration of the CS intensity effect such that within-*S* CS intensity effects were as much as five times as great as between-*S* effects (Grice & Hunter, 1964) and (b) a decrement in performance for groups shifted in either direction due to generalization decrements (Kamin & Schaub, 1963).

The Estes-Skinner conditioned emotional response (CER) technique has proved to be a very sensitive methodology for demonstrating relationships that were typically difficult to observe with traditional classical and instrumental procedures. Leaf and Muller (1963) have substituted operant drinking for lever pressing in a CER method which has the advantage of reliably demonstrating stimulus relationships with a one trial test procedure. An application of the Leaf & Muller technique to a design including experimental and pseudoconditioning groups makes possible a separation of CS intensity effects on associative (i.e., CS-US contingent behavior changes) from nonassociative processes (i.e., noncontingent CS-UCS behavior changes) without the confounding effects of within-S shifts in intensity values during extinction sessions.

The purpose of the present experiment was twofold (a) to test for an effect of CS intensity during extinction of licking suppression and (b) to distinguish between associative and nonassociative effects. Acquisition and extinction effects were based upon comparisons of experimental (paired CER trials) and control group (random, unpaired CER trials) suppression ratios during the first trial of extinction and repeated extinction trials respectively.

Method

Subjects. The Ss were 24 experimentally naive male albino rats of the Sprague-Dawley strain, approximately 90-100 days old at the start of the experiment.

Apparatus. The apparatus consisted of a conditioning and a testing chamber. The conditioning chamber, a BRS Foringer Skinner box (Model RC-004) with levers and food cup removed, was housed in a BRS Foringer ventilated sound attenuating test cubicle (Model RCH-001). The Skinner box was continuously illuminated by two 4.75 w. bulbs located on the back panel of the box 22.5cm. above the stainless steel grid floor. The 9 sec. white noise CS (58 db or 82 db) was produced by means of a noise generator (Grason-Stadler Model 901B) and was delivered to the experimental chamber via a 2½-in., 8 ohm speaker located on a panel 25-cm. from the Skinner box. The US was a scrambled electric shock (1-ma., 1 sec. duration) provided by a Grason-Stadler Model E6070B shock generator.

The subjects (Ss) were tested in a galvanized steel box measuring 24x18x18 cm. which had a wire mesh front, a plexiglas cover, and a brass rod grill floor. The test box was housed in a ventilated sound resistant shell and was continuously illuminated by two 4.75 w. bulbs mounted at the far end of the plexiglas test chamber cover. The end of a drinking tube (3-mm. orifice) which made available a 20% by weight sucrose solution was positioned 6 cm. above the grid floor adjacent to the wire mesh so that the S could contact the solution only with its tongue. Each tongue contact with the drinking tube closed the circuit of a drinkometer and was recorded on a cumulative digital print-out counter (Grason-Stadler, Model 1238) and on an event marker (Ralph Gerbrands, Model P2C). The ambient noise level in both the conditioning and test chambers with exhaust fans operating was 84 db as measured by a Bruel and Kjaer TYPE 2604 microphone amplifier. The CS intensity levels measured with the fans disconnected had values of 58 and 82 db for the weak and strong CSs respectively. The weak CS was clearly audible through the background noise of the exhaust fans.

The conditioning and test chamber were located in a separate room from the automatic programming and recording equipment. Finally, stimuli for all phases of the experiment were programmed with commercially available relay, timing and counting equipment.

Procedure. The Ss were randomly assigned to four groups of six Ss each. The factors in the experimental design were (a) the presentation of a 58 db vs. an 82 db white noise CS during acquisition and extinction trials and (b) CS-US acquisition contingency (i.e., paired vs random CS-US acquisition trials).

CER training. The CER training phase began immediately following three daily 10-min. handling sessions and consisted of 10 delay conditioning trials with a variable intertrial interval average of two minutes for the two experimental groups E-1 (58 db white noise CS) and E-2 (82 db white noise CS). The two control groups C-1 (58 db white noise CS) and C-2 (82 db white noise CS) were administered the CS and US in an explicitly unpaired random order with a 1-min. average interstimulus interval during the CER acquisition session.

CER extinction. Immediately following CER acquisition trials all Ss were water deprived for 24 hrs. and received their water rations in two sessions 24 hrs. apart in the test chamber. Each session lasted for 600 sec. following the twentieth lick from the drinking tube. The first extinction session began 24 hrs. following the last lick training session. Four presentations of the same CS received during CER acquisition trials were administered to each S during each of the eight extinction sessions. The first CS presentation began immediately following the 100th lick response. Each subsequent CS presentation occurred immediately following either a 60 sec. interval from the previous CS or immediately following the 20th lick after a 60 sec. time period had elapsed since the previous CS presentation. Each of the eight daily extinction sessions had a duration of 10 minutes since a pilot study had indicated that recovery of the operant following suppression to each of four CS test trials did not exceed a 10 minute time period. The US was never presented in the test chamber.

Results and Discussion

A 2x2 factorial analysis of variance (ANOVA) was performed on licking suppression to the white noise CS on the first extinction trial. An assumption was made that on the first extinction trial the differences in suppression ratios between experimental and control groups at different CS intensity levels could only have been attributed to acquisition intensity effects since no trials at this point had been received without shock. The first extinction trial thus constituted a test trial of CS intensity effects on acquisition.

Individual suppression ratios were calculated by the suppression ratio B/A+B where A is the number of responses occuring during the 9 sec. period immediately preceding CS onset and B is the number of responses occurring during the 9 sec. period of the CS presentation. Using this ratio a value of .50 represents no effect of the CS on response rate while a ratio of .00 indicates complete suppression of responding during CS presentation. A summary of the analysis of variance for test trial acquisition effects is shown in Table 1.

The analysis shows significant main effects for CS intensity level ($F=11.51$, $df=1/20$, $p<.005$) and CER acquisition contingency ($F=23.87$, $df=1/20$, $p<.005$) but no significant interaction of CS intensity level x CER acquisition contingency ($F<1$).

Support for the assumption that CS intensity influences associative processes in acquisition could only have been gained by obtaining a significant

TABLE 1

Summary of 2 x 2 Analysis of Variance on First-Trial Extinction Suppression Ratios

Source	df	MS	*F*
Total	23	--	--
A (CS intensity)	1	1,520	11.51 **
B (Acquisition contingency)	1	3,151	23.87 **
A x B	1	4	.03
Error	20	--	--

** $p < .005$

interaction between CS intensity and acquisition contingency. The failure to find this interaction indicated that while the main effect of CS intensity was significant, the differences were obtained in the pseudoconditioning control groups as well as in the experimental groups. These data in conjunction with previous reports using counterbalanced factorial designs fail to support the assumption that CS intensity affects associative processes. The differences found in suppression ratios between groups is therefore most adequately interpreted as nonassociative effects of CS intensity.

The principle purpose of this investigation, however, was to determine if CS intensity differences observed in acquisition would persist during an extended extinction procedure. A significant difference in group suppression ratios during extinction sessions, whether supporting an influence of CS intensity on associative or nonassociative processes, would be a contradiction to the findings of previous investigations which have used factorial procedures (e.g., Grant & Schneider, 1948, 1949; Kamin & Schaub, 1963; Kessen, 1943; Walker, 1960).

Mean daily suppression ratios for the paired groups (E-1 and E-2) and the unpaired groups (C-1 and C-2) are plotted as a function of each daily extinction session in Fig. 1. A repeated measures ANOVA with the following factors was performed on the suppression ratios (a) CS intensity, (b) CER acquisition contingency, and (c) extinction sessions. A summary of this analysis can be found in Table 2.

The main effects for CS intensity ($F=32.34$, $df=1/20$, $p<.005$), CER acquisition contingency ($F=53.69$, $df=1/20$, $p<.005$) and extinction session ($F=22.90$, $df=7/140$, $p<.005$) were all significant. The effects of CS intensity level x CER acquisition contingency ($F=7.30$, $df=1/20$, $p<.025$) and CER

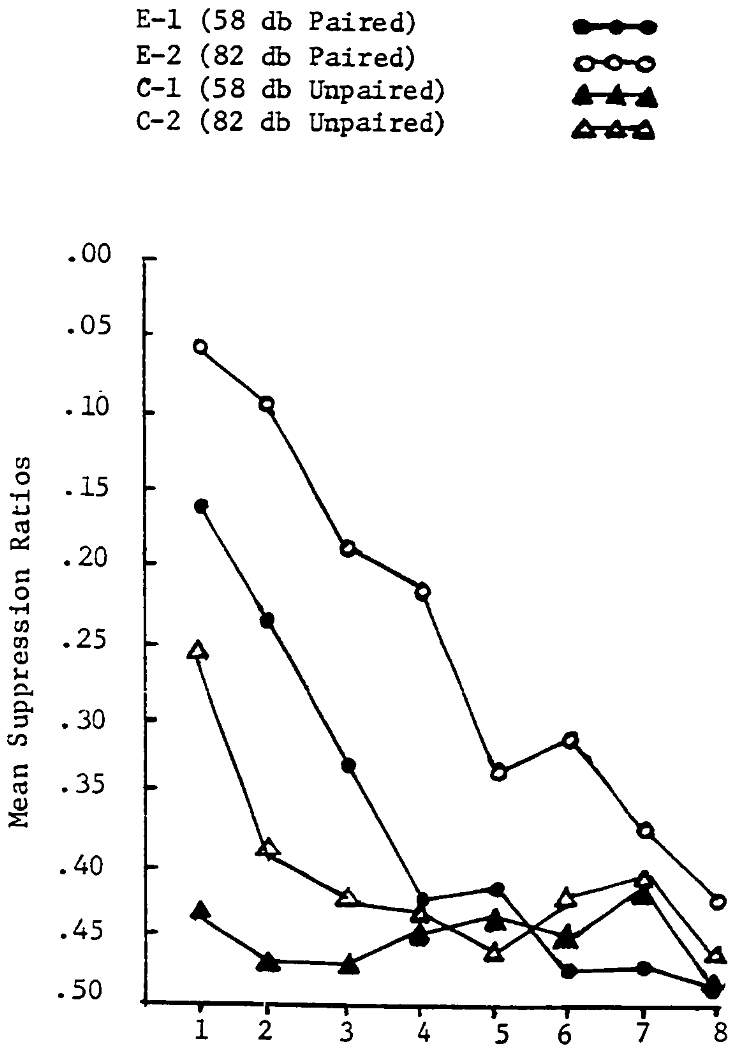

Fig.1 Group suppression ratios in extinction

TABLE 2

Summary of Analysis of Variance on Group Suppression ratios during extinction sessions

Source	df	MS	*F*
<u>Between subjects</u>	23	--	--
A (CS intensity)	1	3,790	32.34**
B (Acquisition contingency)	1	6,291	53.69**
A x B	1	854	7.29*
Subject w. groups error between	20	--	
<u>Within subjects</u>	168	--	--
C (Extinction session)	7	1,418	22.90**
A x C	7	97	1.57
B x C	7	607	9.80**
A x B x C	7	103	1.66
C x subjects w. groups	140	--	--

** $p < .005$

* $p < .025$

acquisition contingency x extinction session ($F=9.80$, $df=7/140$, $p<.005$) were also significant. All other interactions were not significant.

A series of Tukey's tests for differences among the treatment means (Kirk, 1968) was performed on the extinction data and indicated the following: (a) Group E-1 Ss suppressed significantly more than did Group C-1 Ss ($q=4.60$, $df=4/20$, $p<.05$, (b) Group E-2 Ss suppressed significantly more than did Group C-2 Ss ($q=10.04$, $df=4/20$, $p<.01$), (c) Group E-2 Ss suppressed significantly more than did Group E-1 Ss ($q=8.40$, $df=4/20$, $p<.01$) and (d) Group C-1 Ss did not differ significantly from Group C-2 Ss ($q=2.99$, $df=4/20$, $p<.05$).

The significant trials effect in the analysis of variance measures across extinction sessions indicated a change or reduction of mean suppression ratios for all groups combined across days. This change may be interpreted as "extinction" of associational effects or "habituation" of nonassociational effects. In contrast to the acquisitional test-trial analysis, the repeated measures analysis included a significant CS intensity x CER acquisition contingency interaction. At first glance the significant AxB interaction and the trend toward a triple interaction ($F=1.66$, $df=7/140$, $p<.125$) support the assumption that CS intensity affects associative as well as nonassociative processes during the extinction sessions. A failure to find a difference between the two control groups when means were compared for all eight days of extinction is misleading however since asymptotic levels of extinction were obtained for control groups after the first extinction session. In the ANOVA the AxB interaction is dependent upon group means collapsed across days. If, for example, the repeated measures had been arbitrarly terminated after four sessions (see Figure 1) the CS intensity x acquisition contingency would not have reached the .05 level of significance. Termination of the extinction sessions, however, was based upon the attainment of a mean suppression ratio of at least .40 for all groups and the number of sessions was necessarily extended to eight although three of the four groups had attained the extinction criterion on the fourth daily session. Since the significance of the AxB interaction is subject to an arbitrary decision of the experimenter, the obtained significance may not be taken as support for the assumption that CS intensity affects associative processes. Thus, the data on repeated measures is most consistent with the assumption that CS intensity affects nonassociative processes.

Perkins-Logan hypothesis. Two theories have been proposed which predict a monotonic relationship between stimulus intensity and conditioned response strength. The dynamogenic model (Hull, 1951, 1952) predicts response strength to vary directly with the absolute energy level of the conditioned stimulus. Perkins (1953) and Logan (1954) on the other hand have suggested, in a differential conditioning model, that CS intensity effects are based upon the relative difference between the energy level of the CS and weaker inhibitory intertrial or "background" stimuli.

The differential conditioning model, in contrast to the dynamogenic model, predicts that the offset of stimulus energy is as effective as the onset of stimulus energy in establishing a conditioned response and that response strength should vary with the relative intensity of stimulus energy regardless of the direction of energy change. Two additional groups of subjects were administered paired CS-US trials with the CS changed to offset of either a 58 db or 82 db white noise. The results indicated a significant difference between the suppression ratios for the two groups across eight extinction sessions ($F=8.67$, $df=7/70$, $p<.005$) and thereby supported the Perkins-Logan model.

In summary, the results were interpreted as support for a monotonic relationship between CS intensity, whether using an increase or decrease of stimulus energy as a CS, and response strength. These data, however, add to previous findings since measures of extinction of acquisition effects also reproduce the monotonic effect obtained with acquisition measures. Attempts to distinguish between associative and nonassociative effects of CS intensity were not successful largely because differences were found between control group suppression ratios and the interpretation of the analyses was therefore restricted to an effect on nonassociative processes. Such attempts to separate associative from nonassociative effects of CS intensity may be considered as a topic restricted to philosophical speculation since there appears to be no universally acceptable operational basis for establishing null association (i.e., see Seligman, 1969) and since control group procedures may inherently contribute to the differences between experimental and control groups.

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APPENDICES

Appendix I

Dissertation Prospectus

The first systematic investigation of the effects of conditioned stimulus (CS) intensity upon the acquisition and subsequent strength of a conditioned response (CR) were performed in Pavlov's laboratory. As a result of these investigations Pavlov (1906) formulated the "law of strength" or "law of force" which subsequently became one of the basic laws of higher nervous activity (Cole & Matlzman, 1970). Pavlov's statements with regard to the "law of strength" as written in Conditioned Reflexes demonstrates the prominent role he assigned to this variable at both the neurological and the behavioral levels:

> Successful transformation of the unconditioned stimulus for one reflex into the conditioned stimulus for another reflex can be brought about only when the former reflex is physiologically weaker and biologically of less importance than the latter...
>
> While, as we have seen, very strong and even specialized stimuli can under certain conditions acquire the properties of conditioned stimuli, there is on the other hand, a minimum strength below which stimuli cannot be given conditioned properties.
>
> Similarly, while with the help of a very strong unconditioned stimulus, it is possible to convert a very unsuitable stimulus--for example, one which naturally evokes a different unconditioned reflex--into a conditioned stimulus, it is exceedingly difficult or even impossible with the help of only a weak unconditioned stimulus to transform even a very favorable neutral stimulus into a conditioned stimulus. (pp. 30-31)

The theory, confidently called the "law of strength" by Russian investigators due to a considerable number of confirmations by Pavlov's co-workers, states that other conditions being equal the magnitude of a CR is positively correlated with increases in intensity of the CS up to a point beyond which further increases in intensity of the CS leads to a decrease in the magnitude of a CR. This decrease presumably occurs because of "transmarginal" or "protective" inhibition of the cortical cells (e.g., a level of excitation beyond which cortical cells are destroyed (Bykov, 1958).

One additional aspect of Pavlov's theory is his report that a CR could be developed to either the cessation or to a decrease in the physical intensity of a CS as well as to the presence or onset of a stimulus:

> So far we have considered only one broad group of conditioned stimuli namely those derived from the appearance of any natural agency, but the disappearance also of such an agency may become the stimulus to a conditioned reflex...
>
> Not only can the cessation of a stimulus be made the signal to a conditioned reflex, but also a diminution in its strength, if this diminution is sufficiently rapid (Pavlov, 1927, pp. 38-39).

In summary, three major aspects of the "law of strength" determine the relationship between the CS and the subsequent response strength of a CR: a) there is a minimum stimulus intensity value at or below which stimuli cannot be given conditioned properties; b) there is a maximum stimulus intensity beyond which a decrement in response strength occurs; and c) a CR can be established to either the occurrence, cessation, or to the diminution of a stimulus.

Razran (1957) in an extensive review of 300 Russian animal studies and ten human studies which involved variations in CS intensity found that the "law of strength" was generally supported in that the uniform general characteristics of curves plotted from 161 of these studies demonstrated slow ascending gradients followed by rapidly descending ones with corresponding increases from low to high CS intensity values.

Although considerable support for the CS intensity effect described by Pavlov was found in both animal and human studies in the Russian laboratories, early studies conducted in American laboratories either failed to find any support for the phenomenon or else produced inconsistent findings with respect to the effect of this variable upon the conditioning process. Conclusions from these studies were that conditioned response strength varies directly with CS intensity (e.g., Barnes, 1956; Beck, 1963; Brown, 1942; Castaneda, 1956; Hull, 1948, 1949; Kamin & Brimer, 1963; Kamin & Schaub, 1963; Kessen, 1953; Kimble, 1961; Walker, 1960), inversely with CS intensity (e.g., Kimble, 1961; Kimmel, 1959; Miller, 1967; Wickens & Cochran, 1960), or that CS intensity has little or no effect on response strength (e.g., Carter, 1941; Grant & Schneider, 1948, 1949; Hansche & Grant, 1960; Hovland, 1937; Passey & Herman, 1955; Heymen, 1957; Solomon & Brush, 1962).

An attempt to account for the apparently conflicting results found in the Russian and American laboratories was made by Gray (1965) in what is still viewed as the most comprehensive review of the CS intensity literature to date. The major conclusion of Gray's review was that CS intensity has a reliable effect on conditioning processes. Furthermore, Gray attributed the conflict in findings between Eastern and Western laboratories to the use of certain procedures and measures such as extinction and the GSR which tended to obscure the manifestation of the effect in American laboratories. Kamin & Schaub (1963) have pointed out that an additional reason for the discrepancy in results may possibly be due to the fact that a majority of the Russian studies have used within-S experimental designs to test the effects of CS intensity upon conditioning processes while a majority of the studies conducted in American laboratories have used between-S designs to test for a CS intensity effect.

Learning theorists now widely accept the fact that CS intensity affects the conditioning process. A majority of the research which has been conducted subsequent to Gray's review has been concerned with variables (i.e., drive level, drugs, and individual differences) which may interact with CS intensity rather than merely attempting to produce the phenomenon per se. Gray, however, has also emphasized that empirical support for the CS intensity phenomenon is somewhat ambiguous. While support is typically observed with acquisition measures, extinction measures of the CS intensity effect have failed to yield such findings. A lack of correlation between acquisition and extinction measures of the CS intensity effect may not be considered as sufficient reason to cast doubt on the phenomenon (Gray, 1965) but may be considered a curiosity since most independent variables that affect the conditioning process yield similar results with both acquisition and extinction measures (e.g., CS duration, UCS intensity and CS-UCS interval). Studies which have used extinction measures have done so primarily in order to examine two questions of importance to learning theorists: a) what are the effects of stimulus intensity on stimulus generalization gradients, and b) does CS intensity influence learning (i.e., associative processes), performance (i.e., nonassociative processes) or both learning and performance. A third and directly related question which has been of particular interest to learning theorists is the question of which stimulus properties are sufficient or necessary in order for a stimulus intensity effect to be observed during the course of the conditioning process. The remainder of this review is intended to be a thorough analysis of the theoretical and empirical literature pertaining to the above cited questions with the exceptions that the review of the literature with regard to the effects of CS intensity on stimulus generalization gradients will not be reviewed since this research area has been the subject of excellent reviews by Mednick & Freedman (1960) and by Gray (1965). Furthermore, they do not provide a direct means of studying the effects of CS intensity on CR magnitude in any case. The only other exception to the scope of this review is that only studies which have used factorial designs in an attempt to make a distinction between variables affecting learning from those affecting performance will be reviewed here since a majority of the studies attempting to make such a distinction have used a factorial procedure.

Theories of Stimulus Intensity Effects

Hull (1951, 1952) was the first learning theorist to incorporate a factor of stimulus intensity into a formal or deductive theory of behavior. He introduced the factor into his theory as an intervening variable (V) which acted multiplicatively with other intervening variables in the determination of reaction potential. Formally stated in Postulate VI and named by Hull "stimulus intensity dynamism" (SID), the effect of stimulus intensity upon reaction potential was stated as follows:

> Other things constant the magnitude of the stimulus component (V) of reaction potention ($_SE_R$) is a monotonic increasing logarithmetic function of S, i.e., $V=1-10^{-.44}$ Logs.

In *Essentials of Behavior* (1951), Hull first mentions that there are two dynamism variables; V_1, the dynamism of the learning process and V_2, the dynamism of the evocation process. The intervening variables V_1 and V_2 are both formally stated in Postulate IX:

Where $_SE_R = D \times V_2 \times K \times J \times {_S\bar{H}_R}$

$$_S\bar{H}_R = {_SH_R} \times V_1$$

and where V_1 is that involved in the original learning.

In addition to number of reinforced trials (N), stimulus intensity dynamism (V_1) as indicated in the above equation represents the only other intervening variable that affects habit strength. However, in A Behavior System (1952), although Hull once again points out that there is a distinct difference between V_1 and V_2, he apparently shifts his theory that V_1 affects S^HR and makes it a determinant of reaction potential:

> Next we proceed to estimate from the S^ER values, as they stand, the corresponding V_1's of the learning process, which are carefully to be distinguished from the evocation processes (V_2's). By equation 8'
>
> $S^ER = D \times V_2 \times K \times S_1{}^HR \times V_1$.

Koch (1954) in a thorough critical analysis of Hull's theory states the following with regard to the V_1 construct:

> This V_1 of original learning is apparently to be distinguished from the V of action evocation which directly enters S^ER and which later is designated as V_2. What is especially curious here is that V_1 represents a second factor which apparently determines S^HR (in addition to N) but this fact is not registered in "the law of habit formation" (Postulate IV) or any related law. At first blush, this seems like an oversight. A little speculation will show, however, that this assumption cannot possibly find a place within the postulate set as a direct determinant of S^HR on the basis of the present technique of postulate construction. The equational analysis of S^ER curves can only reveal V_2 not V_1. V_1 could be rationally assumed (as it has been), and possibly verified in terms of its indirect determinant of S^HR within the law of habit formation, where it seems to belong, without becoming a glaring example of departure from the "quantative" methodology. It therefore becomes a glaring example of a construct which is at once in the theory and out of it.

Champion (1962) has pointed out that in addition to giving the appearance of allowing for the effect of stimulus intensity on amount learned by distinguishing between V_1 and V_2, Hull's concept of the molar stimulus trace limited SID effects to the onset of stimuli and to short latency responses.

Perkins (1953) and Logan (1954) working independently of one another both produced similar alternative explanations of Hull's stimulus intensity dynamism theory and therefore their theories have typically been combined by reviewers of stimulus intensity effects (Champion, 1962; Gray, 1965; Marx, 1969) and referred to as the Perkins-Logan "generalization" or "differential" conditioning hypothesis. These investigators have suggested that stimulus intensity effects are deductible from Hull's concepts of excitatory and inhibitory gradients and need not be ascribed to a separate concept in the theory.

The Perkins-Logan hypothesis is based upon the assumption that the critical variable relating CS intensity to response strength is the degree of stimulus change between the experimental situation with the CS present and the CS absent. According to their hypothesis inhibition accrues to nonreinforced responses occuring during intertrial intervals and generalizes to CRs occuring to the CS presented during conditioning trials. Therefore, the SID effect depends not upon the absolute intensity of the eliciting stimulus but rather upon the degree of similarity between the experimental situation when the CS is present as contrasted with the situation when it is not present. In other words, according to Perkins and Logan the SID effect occurs due to the fact that the classical conditioning procedure is similar to the instrumental discrimination procedure in that it involves a positive, excitatory, situation-plus-CS and an inhibitory, situation-minus-CS conditioning procedure.

The "discriminability" theory does not alter Hull's prediction of a monotonic relationship between CS intensity and CR strength but it is at odds with Hull's SID theory on two major points: a) stimulus intensity effects are ascribed to the relative intensity of a stimulus rather than being dependent upon the absolute intensity of a stimulus and b) the Perkins-Logan hypothesis predicts that stimulus offset is as effective as stimulus onset as a CS. One aspect of the Perkins-Logan hypothesis that is of importance to the study to be proposed is the assumption implied by the hypothesis that stimulus offset is as effective as stimulus onset as a CS. Hanche & Grant (1960) varied the interval between CS onset or CS termination and the occurrence of the UCS in a 2x4 factorial eyelid conditioning experiment. The factors in their design were onset vs. offset of the CS and either .15, .35, .55 or .75 CS-UCS intervals. The principle findings of the study were that the termination of the CS was as effective as its onset in serving as a CS in eyelid conditioning and that both onset and termination CS-UCS intervals had the same functional relationship to rate of conditioning.

Kish (1955) conducted four experiments with 72 albino rats in a wheel turning avoidance learning situation in order to test the hypothesis that onset of stimulus energy is as effective as offset of stimulus energy as a cue in learning an avoidance response. The first study contrasted the effectiveness of a light coming on with a light going off as the cue for the avoidance response while a second study replicated the first study with the one exception that a buzzer was used instead of a light as a CS. A third study tested the effect of interstimulus interval and the effectiveness of the light-on and light-off conditions. In all three studies the onset of stimulus energy was superior to the offset of stimulus energy in the acquisition of the avoidance response. The final study in the series compared the effects of light-on with light-off under a low and high intensity UCS condition. The main finding of the study was that the light-off conditioning was enhanced by a <u>decrease</u> in shock intensity.

In order to extend and partially replicate the findings of the study conducted by Kish, Schwartz (1955) tested the effects of varying the direction of change of CS energy, the rate at which the change was effected, the absolute amount of the change and the CS-UCS interval in a shuttlebox avoidance apparatus. The Ss were 32 albino rats and the CS was a change in illumination of the avoidance chambers. The main finding of the study was that avoidance response strength varied directly with the degree of change in CS intensity regardless of the direction of change in energy and the rate (slow or fast) at which the change was effected. The discrepancy in his findings and those by Kish with regard to the effectiveness of onset and offset of stimulus energy as a CS was attributed to the differences in the responses required of the Ss in the different avoidance procedures. In the wheel-turning apparatus, typical behavior under massed acquisition trials consists of "hanging on" the wheel and rarely moving away from it. Also, numerous spontaneous responses are found in the wheel-turning situation while few spontaneous responses occur in the shuttlebox apparatus. Schwartz concluded that the response required and the procedure used were probably of greater importance in determining performance differences than were the differences due to the direction of the change in CS energy.

Myers (1960), in an attempt to clarify the effects of CS intensity onset vs. offset in the avoidance conditioning situation, introduced control groups in his experimental design in order to assess effects due to the frequency of intertrial responding and pseudoconditioning or sensitization. Onset of a tone and buzzer was compared with offset of a tone and buzzer as cues for rats given 200 massed training trials on a wheel-turning shock avoidance response. An analysis of the last 100 trials for avoidance-conditioning groups showed that tone CS onset and offset resulted in a comparable frequency of avoidance responses for both conditions and that no difference in responding was observed in the pseudoconditioning groups. However, in contrast to the results found with the tone as a CS, the buzzer-onset avoidance conditioning group made significantly more avoidance responses than did the buzzer-CS offset conditioning group and furthermore conditioning was found in the buzzer-onset pseudoconditioning group.

Logan and Wagner (1962) tested the Perkins-Logan hypothesis in an eyelid conditioning experiment in which they compared an increase with a decrease in the intensity of a light CS from two nonzero values which were treated symmetrically. The CS was a milk glass disc which was illuminated by neon bulbs. The onset of the CS was an increase from the use of two bulbs to the use of four bulbs while the offset of the CS consisted of a decrease from the use of four bulbs to the use of two bulbs. During 60 conditioning trials, the CS for half of the Ss was an increase in illumination of the disc while for the other half it was a decrease in illumination of the disc. All Ss were then administered 20 additional conditioning trials with the opposite CS. Logan and Wagner found that an increase and decrease in intensity were equally effective as CSs in the conditioning of an eyelid response and that a high degree of transfer occurred when the direction of the intensity variable was reversed.

Champion (1962), in the first experiment of a four part study, tested the Hullian implication that offset of stimulus energy would not be effective as a conditioned stimulus and that effective conditioned stimuli are limited to short latency responses. A long latency galvanic skin response (GSR) was conditioned to the offset of either an 80 db or a 60 db tone and an electric shock (UCS). The dependent measure was the amplitude of the GSR response on test trials (tone offset alone) which were interspersed with the conditioning trials (tone offset and shock). Subjects in the experiment were 24 male and 24 female volunteer students. The principle finding of the study was that offset of a stronger (80 db) tone elicited a stronger response during acquisition than did the offset of a weaker tone (60 db). Champion concluded that the Perkins-Logan hypothesis provided a more satisfactory explanation of his findings than did Hullian theory.

Finally, Kamin (1965) used the conditioned emotional response procedure in order to test an implication of the Perkins-Logan hypothesis that better conditioning should occur to greater reductions in background noise intensity. Five groups of rats were trained to bar press for food pellets on a 2.5-min. variable interval schedule with an 80 db white noise continuously present in a Skinner box. The CS was a reduction of this noise for a three minute period, to either 70, 60, 50, 45 or 0 (ambient level) db. Kamin found a monotonic effect of CS intensity with the greater degree of stimulus energy reduction producing the most suppression.

The various and numerous additional tests of the Perkins-Logan hypotheses have been reviewed in several accounts of the stimulus intensity literature (Gray, 1965; Marx, 1969) and will therefore not be reviewed here, however, confirmations of various other implications of the hypothesis may be found in the following studies (Champion, 1962; Birkimer & Drane, 1968; Birkimer & James, 1967; Bragiel & Perkins, 1954; Mansche & Grant, 1960; James & Mostoway, 1969; Johnsgaard, 1957; Kamin, 1965; Logan & Wagner, 1962; Mattson & Moore, 1964; Nygaard, 1958).

Although the Perkins-Logan hypothesis has received considerable confirmation in a wide range of experimental situations, Grice & Hunter (1954) and Grice (1968) have suggested that an alternative conceptualization of the SID effect in terms of adaptation level or decision models may provide a more precise interpretation of the data in the stimulus intensity literature. In the first of a series of investigations in Grice's laboratory, Beck (1963) studied the effects and interactions of three variables--CS intensity, UCS intensity and emotionality in an eyelid conditioning situation. The general procedure consisted of selecting two groups of subjects (Ss) on the basis of high and low emotional responsiveness and then subdividing each group and presenting paired CS-UCS trials under two combinations of strong or weak CS and UCS intensity levels. The CS intensity variable was included in the factorial design as a within-S effect since all Ss were administered both CS intensity values (30 and 80 db tone) in a random order during 100 conditioning trials. The main findings of the study were that all three variables were positively related to CR magnitude and that the CS intensity effect was much greater than that obtained in previous studies which had used a between-S design.

Grice & Hunter (1954), in a follow-up of Beck's study, directly compared the effects of CS intensity in a between Ss design with that of a within-S design in two different experimental situations. In the first investigation, two groups of Ss were given 100 paired trials with a tone CS (i.e., either 50 or 100 db) and a 1-psi air puff UCS, while two additional groups were administered 50 conditioning trials with each tone presented in a random order. Twenty female students served as Ss in each group. The major finding of the investigation was that the two groups which had received both CS intensities demonstrated a CS intensity effect which was more than five times as great as the magnitude of the intensity effect for the groups which had received only one value of the CS during conditioning trials. A second study investigated the generality of the effect by using two intensity values (40 or 100 db) of an auditory CS in a simple reaction time experiment. The experimental groups in this study were analogous to those of the first experiment. Although the results were not entirely the same as those found in the eyelid conditioning study they did demonstrate that the CS intensity effect was significantly more pronounced in the within-S condition than in the between-S condition.

Grice & Hunter concluded that neither Hull's SID theory nor the Perkins-Logan hypothesis could account for the results they obtained. Hull assumed that V was a simple function of stimulus energy but Grice & Hunter found that the dynamogenic property of a given energy depends largely upon the total stimuli in the environmental situation. Furthermore, they suggested that the Perkins-Logan hypothesis was also unable to explain their findings that the addition of a weak stimulus to a strong stimulus resulted in increased rather than decreased response strength. The Perkins-Logan model would have predicted that such an addition would result in a weaker response strength because the inhibitory gradient from the background intensity should have started from a higher level.

The CS intensity phenomenon was interpreted in terms of a dynamogenic effect by Grice and Hunter, however, they attributed the occurrence of the phenomenon to a contrast effect and suggested that Helsons' adaptation level concept was particularly well able to explain the findings of their experiments. The application of Helson's theory to the results obtained in Grice's laboratory has been well summarized by Beck:

> As Helson (1959) points out, when an S experiences several stimuli, the adaptation level (AL) is an integration of both present and residual stimulation. The attainment of this AL also establishes a bipolarity of behavior in such a way that stimuli above the AL tend to elicit one kind of response and those below the AL elicit the opposite type of response. If it is true that the probability of a CR to a stimulus is dependent on the distance of that stimulus from the adaptation level, introduction of two widely dispersed stimuli shifts the AL to some point intermediate between the two. This would further heighten CR responsiveness to the stimulus above adaptation level and further reduce CR responsiveness to the stimulus below adaptation level. This results in greater response differentiation and thereby maximized performance to the stimuli presented.

A series of subsequent experiments conducted in Grice's laboratory (e.g., Grice, Hunter, Kohfield & Masters, 1967; Grice, Masters & Kohfield, 1966; Kohfield, 1968; Murray, 1968; and Murray & Kohfield, 1965) suggested to him that a decision model provided a more adequate explanation of the superior within-S vs. between-S CS intensity effect than did the A-L model he had previously used. Grice adopted the decision model as a replacement for the A-L model primarily because he found it difficult to integrate the details of A-L concepts into a behavior theory and because of the fact that A-L theory does not contain a principle of response evocation. McGills (1963) decision model, based upon simple reaction time and stimulus intensity effects, provided Grice with a model which did not have the shortcomings of the A-L model and which had the added advantage of having been based upon stimulus intensity effects from the outset. Only a brief account of the model and its use will be reviewed below since an extensive discussion of the model and its similarities to Hull-Spence behavior theory and signal detection theory has been the subject of a recent review (Grice, 1968).

Briefly, according to McGill's model a sensory input may be regarded as a series of impulses. When the cumulative count reaches a predetermined number (i.e., the decision criterion) the S will respond. The time required for the count to reach the criterion is the reaction latency. The impulse rate is probabilistic and increases with stimulus intensity. McGill's model was based upon the assumption that the criterion for responding remained constant for large blocks of trials under experimental conditions. Grice's revision of McGill's model was based upon the theory that sensory input is a rather stable process determined by stimulus energy and that the variability found in reaction time experiments resided not so much in stimulus input rate as in flucuations in the criterion of responding. Grice's model is similar to Hullian theory in that his input functions are essentially similar to the rise of reaction potential in the input segment of the stimulus trace in Hull's theory and the criterion is a concept analogous to Hull's reaction threshold.

In order to explain the difference between within-S CS intensity and between-S CS intensity effects with the model the only assumption needed is that the criterion adopted by the S be determined by the degree of all stimuli to which the S is exposed. Subjects who receive only a weak stimulus will adopt a lower criterion than Ss who receive a strong CS intensity value in a between-S procedure. On the other hand, Ss in a within-S design receive both weak and strong stimuli in an irregular unpredictable order and since it is necessary for them to respond to both stimuli with a single criterion, the contrast effect is much more pronounced for these Ss and a greater intensity effect is therefore observed than is found in a between-S design. Grice has used his model to explain findings in both reaction time experiments and the eyelid conditioning situation, however, as Grice has pointed out the ultimate utility of the model will depend upon the range of experimental phenomena to which the model can be usefully extended.

The distinction between learning and performance and the factorial procedure.

Lashley (1929) and Elliott (1930) were among the first authors to suggest that a distinction be made between learning and performance. However, it was Tolman's research and analysis of the latent learning phenomenon that was primarily responsible for bringing attention to the distinction between these two constructs. The acceptance of the distinction by S-R theorists is clearly demonstrated in Hull's distinction between habit strength and reaction potential and by both Hull (1943) and Spence (1945) in their statements concerning the belief that habit strength may not immediately manifest itself in discrimination training (Thistlethwaite, 1961).

Hall (1966) has pointed out that perhaps the primary reason for making a distinction between the two constructs is that it allows investigators to isolate and identify those variables which contribute to learning as contrasted to those variables which contribute only to performance. Finding criteria which will allow a distinction to be made between learning and performance independent of confounding effects had been difficult. The criterion most commonly accepted for distinguishing between the two constructs is based upon the definition of learning as a relatively permanent change in behavior which occurs as a result of practice while performance is defined as changes in behavior which are more temporary and which may occur without practice (Kimble, 1961).

A factorially designed experiment has been the standard procedure for attempting to distinguish between the effects of CS intensity upon learning as contrasted with effects upon performance based upon the above cited definitions of the two constructs. In factorial studies two or more groups of subjects are administered acquisition trials with different levels of CS intensities. In the test situation (e.g., usually extinction) however, each group is subdivided and subgroups of subjects trained with each CS intensity levels are administered extinction trials under all of the CS intensity levels used during acquisition trials.

The logic for using the factorial design is based upon the fact that any significant differences in row means reflect the effects of CS intensity upon learning since CS intensity extinction levels are equated during extinction while acquisition CS intensity levels remain unequated during extinction. Significant row mean differences thus indicate that acquisition CS intensity level had an effect which continued to persist during extinction sessions. The column means, on the other hand, reflect CS intensity effects upon performance since acquisition but not extinction CS intensity levels are equated in each column. Significant differences among column means indicate therefore that the effect of CS intensity is upon performance since only the effects of a change in CS intensity during extinction is indicated in column means rather than an effect which has resulted from previous training.

Grant & Schneider (1948) were the first investigators to use a factorial procedure in order to determine whether CS intensity had an effect upon learning or upon performance. In their study, sixty-four human subjects were divided into four equal groups which received different CS intensities of a light ranging from 7 to 1,050 millilamberts during the conditioning of an eyelid response. All subjects received 25 paired trials of a light CS and a corneal air puff on each of two acquisition days and then were subdivided into 4 subgroups and given 15 extinction trials following the last acquisition trial on day 2. The principle finding of their study was that a variation in CS intensity did not have a statistically significant effect upon either strength of conditioning (e.g., learning) or upon response strength (e.g., performance).

In a second study which also used a factorial procedure, Grant & Schneider (1949) studied the effect of CS intensity upon the conditioning of the GSR. A 200 cps tone CS of either 76, 86, 96 or 106 db loudness was administered to four groups of subjects during reinforced tone-shock conditioning trials. Following conditioning trials the 4 major conditioning groups were then subdivided into four subgroups and administered extinction trials. Negative results were once again obtained in that variations in CS intensity had no significant effect upon either response strength or strength of conditioning.

Kessen (1953) used a 4x4 factorial design similar to that of Grant & Schneider in a study in which 32 rats learned to avoid shock by turning a wheel during the presentation of one of four CS intensities of a light CS--6, 15, 40 or 150 watts. The training procedure consisted of 42 trials in which a 15.0 sec. presentation of a light CS was followed immediately by a 90 v. electric grid shock. If the _S_ made a wheel turn during the first 5.8 sec. following the onset of the CS, no shock was administered. In extinction, _Ss_ received 30 trials of the 15 sec. CS alone and a trial was terminated if a response was not made during the CS presentation time. Kessen's results showed that performance measures during the 42 trial training phase had clearly demonstrated that CS intensity had an effect on response strength during acquisition. However, when the mean number of responses in the row and columns of the factorial design were analyzed for the extinction phase of the experiment no reliable differences were found in either case. Kessen concluded that CS intensity does have a significant effect upon response strength during training but that it does not influence behavior when extinction measures are used. Kessen hypothesized the omission of the UCS during extinction to be a possible reason for the negative findings obtained with extinction procedures.

In her dissertation, Walker (1960) attempted to provide a possible explanation for the conflict in studies which had and had not reported a CS intensity effect on response strength. A review of the literature by Walker demonstrated that a possible reason for the conflicting findings may have been that in those studies reporting a significant intensity effect measurements were obtained during acquisition when a UCS was present while in those studies reporting negative results measurements were taken during extinction sessions. To avoid this problem, Walker presented the UCS during extinction trials but with a CS-UCS interval which was known to produce extinction. Furthermore, Walker hypothesized an interaction between CS and UCS intensity based upon the theory that the relationship between CS intensity and CR strength was stronger the greater the intensity of UCS.

During acquisition, eight groups of 20 male Ss each received 80 paired CS-UCS trials in a single session with the stimulus conditions being: weak CS-weak UCS; strong CS-weak UCS; weak CS-strong UCS; strong CS-strong UCS and with two groups under each condition. The CS was a 1000 cps tone of either 30 or 80 db and the UCS was an air puff of either 0.5 lb./sq. in. or

5.0 lb/sq. in. In extinction there were 8 conditions; four groups received the same CS intensity that they had received during the acquisition trials while the remaining four groups were subdivided and received extinction CS intensities that were opposite to those that they had received during acquisition trials (e.g., weak acquisition CS-strong extinction CS or vice versa). Each group received 30 extinction trials with the UCS being the same in extinction as that which they had received during the acquisition trials, however, the CS-UCS interval was shifted from 500 to 2500 msec during extinction trials.

The results showed that CS intensity did have an effect on response strength during training trials, but the predicted CS-UCS interaction was not significant. However, in partial support of her hypothesis, Walker did find that the difference between weak and strong CSs was significant under the strong UCS but not the weak UCS conditions during training. An additional finding of the study was that no CS intensity effect was observed in either the row or column means of the factorial design in extinction despite the use of the UCS during extinction sessions. Thus, no effect of CS intensity on learning or performance was found in her study and Walker concluded that extinction may not have provided a fair basis for evaluating CS intensity effects, presumably because of depressed response levels at the outset of extinction shown by the groups which had undergone CS intensity shifts during the course of the experiment.

Kamin & Schaub (1963) studied the effects of a white noise CS (40, 63, or 81 db) on the acquisition of a conditioned emotional response (CER) in rats and then omitted Ss in the medium intensity group and used a factorial design similar to the design used by Grant & Schneider (1949) in order to determine if the effects of CS intensity were on learning or on performance. An analysis of median suppression ratios obtained during acquisition showed that there was a direct monotonic effect of CS intensity on CR magnitude though all groups had achieved the same asymptote at the end of the training phase. In the analysis of extinction data the only significant effect found was an interaction between training CS and extinction CS.

Kamin's summation of the study was that no firm conclusion as to whether or not CS intensity affects learning or performance could be establised and that the significant interaction demonstrated only that a generalization decrement had occurred for those groups which had received different intensities of the CS during acquisition and extinction. However, one complication in interpreting the results of this study is that all groups had reached asymptotic performance levels prior to extinction, therefore, any decision concerning the learning-performance distinction would have been tenuous in any case since the effects of CS intensity on learning are assessed from differences in row means which indicate residual effects of different performance asymptotes which occur during training.

Finally, Woodard (1966) used a factorial design similar to that used in a study by Hillman, Hunter & Kimble (1953) in an attempt to separate effects of CS intensity on learning from those on performance with the use of only acquisition measures. In this study 127 fish were assigned to two major experimental groups and four pseudoconditioning control groups. Halfway through training, which consisted of five simple delay paired light CS-electric shock UCS trials, each of the two experimental groups were subdivided and one-half of each group was shifted to an opposite CS intensity condition for the remainder of the training trials. The control groups were trained under identical conditions to that of the experimental groups with the exception that they received unpaired CS-UCS trials during the experiment. The purpose for using the control groups was to assess the effects of shifts in CS intensity during the course of the experiment. After adjusting for the effects of CS intensity shifts by subtracting control group suppression measures from experimental group suppression measures, Woodard concluded that there was an effect of CS intensity on learning in that fish trained at a high CS intensity level performed at a higher level than fish trained at a low CS intensity level. However, there was inconclusive evidence as to whether or not CS intensity affected performance (other than shift effects) and that in any case the effect was substantially smaller than the effects of CS intensity on learning.

A source of possible confounding with the use of a factorial design and shifts in CS intensity occuring only during acquisition arises from the possibility that performance changes only gradually with changes in intensity values and that the groups which are switched take several trials to reach the performance levels of groups which are not switched. As Kimble (1961) points out, the answer to the question of whether or not a variable is observed to have an effect upon learning or upon performance is determined by which portion of the performance curve is analyzed. A measure obtained immediately following the shift will indicate an effect of the variable upon both learning and performance while an analysis of measures obtained following the shift will indicate an effect of the variable on performance only.

Finally, Woodard (1966) has reviewed several additional difficulties and possible sources of confounding which are necessarily included in any factorial design which attempts to counterbalance variable values during extinction procedures. Woodard, in agreement with Kamin, states that any such factorial design is inherently beset with possible confounding effects which may arise from within-S stimulus shifts. A brief summary of six possible effects of shifting variable values in a factorial design as summarized by Woodard are listed below:

1) a stimulus generalization decrement which would cause a performance decrement in groups shifted upward or downward.

2) a contrast effect, which would cause a relatively large transient performance increment in a group shifted upward and a smaller transient performance decrement in a group shifted downward.

3) a CSUR effect which would cause a long lasting performance increment for a group shifted upward and a corresponding decrement for a group shifted downward, both with respect to pre-shift performance.

4) an OR (i.e., orienting response) effect which would cause a transient performance increment (or decrement, depending upon the CR) in groups shifted upward or downward.

5) a nonassociative effect exclusive of other shift effects, which would cause a group shifted upward to shift its performance level immediately to a group trained entirely at a high level and a group shifted downward to shift its performance level in the opposite manner.

6) An associative effect, which would cause performance to increase at a higher rate over trials in a group shifted upward and performance to increase at a lower rate over trials in a group shifted downwards.

In summary, the theoretical literature with respect to CS intensity effects is as controversial as the empirical literature. Hull and Perkins and Logan predicted a positive monotonic relationship between CS intensity and response strength while Pavlov and more recently Razran (1957) predicted an inverted u relationship between CS intensity and response strength. Studies which have been cited as having supported the theories have been criticized on several grounds. First, empirical support for the theories is somewhat limited by the findings that within-S designs produce substantially greater intensity effects than between-S designs. Secondly, support for the effect has not been duplicated in the few studies which have used extinction measures, a finding which contradicts the expected correlation between acquisition and extinction measures. Finally, the counterbalanced factorial procedure, though directed at providing a distinction between learning and performance is complicated by within-S shifts in intensity values which occur between acquisition and extinction sessions.

The Present Experiment

The CER technique

In 1941 Estes and Skinner introduced the conditioned emotional response (CER) procedure as a technique which could be used to investigate quantitative properties of "anxiety." The technique has proven to be a sensitive methodology demonstrating relationships that were typically difficult to observe with traditional classical and instrumental procedures. Essentially, the CER procedure consists of training a subject to perform an operant (i.e., bar press for food) until a stable baseline rate is established. Once a stable rate has been established superimposed paired stimulus presentations of a "neutral" CS and an aversive UCS (i.e., electric shock) are administered. Suppression of the operant rate during the presence of the CS is considered to be an index of conditioned "anxiety" or "fear." The Estes-Skinner technique has been used to study the effects of several independent variables upon the conditioning process (i.e., CS intensity, CS duration, UCS intensity, and CS-UCS intervals) and with a wide variety of subjects (i.e., rats, pigeons, cats, dogs, monkeys and humans). Kamin (1963, 1965) has recently adapted the technique to investigate several parameters of classical conditioning. His data were concise and void of the usual variability in response measures obtained in traditional classical conditioning procedures.

One complication of applying the Estes-Skinner procedure to a research problem is the time required to establish a stable operant rate (i.e., lever pressing) prior to superimposing paired CS-US trials. Leaf and Muller (1965) have substituted operant drinking for lever pressing and reduced the tedium of shaping an operant response. Briefly the procedure consists of a conditioning session and a test session. During the conditioning session subjects are administered various CS-US contingencies followed by a period of water deprivation. The test session consists of providing the deprived subjects with access to a drinking tube and superimposed CS alone trials. Suppression of licking is analogous to suppression of lever pressing during the presence of the CS.

The Leaf and Muller modified technique provides a means of studying CER suppression when the details of the reinforcement schedule are not of any special interest. Furthermore, the licking suppression procedure provides an even more stable operant baseline (Corbit & Luschei, 1969) than that obtained with lever pressing schedules.

<u>Associative vs. nonassociative effects</u>.

Contiguity between CS and US has traditionally been considered a critical variable in the establishment of conditioned reflexes. Rescorla (1967) has pointed out that a requirement vital to the definition of conditioning is that the presentation of an unconditioned stimulus be contingent upon the occurrence of a conditioned stimulus. According to Rescorla, changes in behavior not dependent upon this contingency are not considered to be examples of "true" conditioning (i.e., associative effects). In order to identify such effects (i.e., nonassociative) control groups have been used.

The present experimenter was designed to test the effects of CS intensity upon associative (i.e., stimulus contigent) and nonassociative processes (i.e., noncontingent stimulus presentation) with the licking suppression technique. An application of the Leaf and Muller technique to a design including experimental and pseudoconditioning groups provides a basis for separating associative and nonassociative effects without within-S shifts in intensity values during extinction. The purpose of the present experiment is twofold (a) to test for an effect of CS intensity during extinction of licking suppression and (b) to distinguish between associative and nonassociative effects. Acquisition and extinction effects will be based upon comparisons of experimental (paired CS-US trials) and control group (random, unpaired CS and US presentations) suppression ratios during the first trial of extinction and repeated extinction trials respectively.

Experiment 1

Method

Subjects. Three days prior to the beginning of the experiment each of 24, 90-100 day old, male Holtzman rats will be handled for approximately 10 min. each day.

Apparatus. The apparatus will consist of a conditioning and a testing chamber. The conditioning chamber, a BRS Foringer Skinner box (Model RC-004) with levers and food cup removed, will be housed in a BRS Foringer ventilated sound attenuating test cubicle (Model RCH-001). The Skinner box will be continuously illuminated by two 4.75 w. bulbs located on the back panel of the box 9 in. above a stainless steel grid floor. White noise CSs (58 or 82 db) will be produced by means of a Grason-Stadler noise generator (Model 901B) while the US, a scrambled electric shock of (1 ma., 1 sec. duration) will be provided by a Grason-Stadler shock generator (Model E6070B).

The Ss will be tested in a galvanized steel box measuring 24 x 18 x 18 cm. which will have a wire mesh front, a plexiglas cover, and a brass rod grid floor. The test box will be housed in a ventilated sound resistant shell and continuously illuminated by two 4.75 w. bulbs. The end of a drinking tube (3mm orifice) which will make available a 20% by weight sucrose solution will be positioned 6 cm. above the grid floor adjacent to the wire mesh so that the S can contact the solution only with its tongue. Each tongue contact with the drinking tube will close the electric circuit of a drinkometer and be recorded on a cumulative digital print-out counter (Grason-Stadler, Model 1238) and on an event marker (Ralph Gerbrands, Model P2C). The ambient noise level in both the conditioning and test chambers will be equated. The CS intensity levels measured with the fans disconnected in either box should have values of 58 and 82 db for the weak and strong CSs respectively. The weak CS will be tested to see that it is clearly audible through the background noise of the exhaust fans.

The conditioning and test chambers will be located in a separate room from that of the automatic programming and recording equipment and stimuli for all phases of the experiment will be programmed with commercially available relay, timing and counting equipment.

Procedure. The Ss will be randomly assigned to four groups of six Ss each. The factors in the experimental design will be (a) the presentation of a 58 db vs. an 82 db white noise CS during extinction trials and (b)

CS-US acquisition contingency (i.e., paired vs. random CS-US acquisition trials).

<u>CER training</u>. The CER training phase will begin immediately following the last handling session and will consist of 10 simple delay paired CS-US trials with a variable intertrial interval average of two minutes for the two experimental groups E-1 (58 db white noise CS) and E-2 (82 db white noise CS). The two control groups C-1 (58 db white noise CS) and C-2 (82 db white noise CS) will be administered the CS and US in a random order with a 1 min. average interstimulus interval during the CER acquisition session.

<u>CER extinction</u>. Immediately following CER acquisition trials, all <u>S</u>s will be water deprived for 24 hrs. and will receive their water rations in two sessions 24 hrs apart in the test chamber. Each session will last 600 sec. following the twentieth lick from the drinking tube. The first extinction session will begin 24 hrs. following the last lick training session. Four presentations of the same CS received during CER acquisition trials will be administered to each <u>S</u> during each of the eight extinction sessions. The US will never be presented in the test chamber. The first CS presentation will begin immediately following the 100th lick response. Each subsequent CS presentation will occur following a 60 sec. interval from the previous CS-alone presentation. Four daily CS alone extinction trials will be administered during each of eight, 10-min. extinction sessions.

Experiment 2

A second experiment will be conducted in accordance with the Perkins-Logan hypothesis if differences are observed during extinction in Experiment 1. Two additional paired CS-US groups will be administered the <u>offset</u>

rather than the onset of a white noise (58 db or 82 db) as a CS during the conditioning and testing sessions in this experiment.

Method

Subjects. The Ss will be 12 rats, identical in detail to those used in Experiment 1.

Apparatus. The apparatus to be used in this experiment will be identical to that to be used in the first experiment.

Procedure. The procedures in this experiment will be similar to those administered in the previous experiment with the exception that (a) during the conditioning session one group of Ss will receive paired CS-US trials with the offset of a continuous 58 db white noise background as a CS while a second group will receive the same treatment except that the offset of a continuous 82 db white noise background will serve as a CS and (b) during testing the two groups will receive the offset of the same continuous background noise intensity that they had been administered during the conditioning session. All other procedures will be identical to those received by the paired CS-US groups in the first experiment.

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Appendix II

Mean Group Suppression Ratios on First Trial of Extinction

	E-1 (58 db)	E-2 (82 db)
	.05	.02
	.40	.19
	.46	.02
	.09	.22
	.41	.02
	.12	.06
$\bar{X}$ =	.26	.06

	C-1 (58 db)	C-2 (82 db)
	.50	.26
	.54	.41
	.48	.25
	.43	.27
	.43	.46
	.48	.30
$\bar{X}$ =	.48	.33

Appendix III

Summary of 2 x 2 Analysis of Variance on First-trial

Extinction Suppression Ratios

Source	SS	df	MS	*F*
Total	7,324	23	--	--
A (CS intensity)	1,520	1	1,520	11.51**
B (Acquisition contingency)	3,151	1	3,151	23.87**
A x B	4	1	4	.03
Error	2,649	20	--	--

** $p < .005$

Appendix IV

Suppression Ratio Across Days for Groups in Experiment 1

	Days							
Group	1	2	3	4	5	6	7	8
E-1(58 db)	.03	.03	.45	.40	.35	.51	.48	.49
	.25	.18	.09	.46	.41	.47	.40	.49
	.29	.40	.44	.36	.43	.50	.51	.42
	.04	.18	.31	.42	.50	.42	.50	.49
	.19	.27	.49	.43	.50	.50	.49	.53
	.16	.32	.49	.49	.35	.43	.45	.46
E-2(82 db)	.02	.03	.35	.25	.39	.40	.40	.49
	.08	.13	.03	.09	.36	.31	.25	.30
	.02	.03	.02	.23	.24	.26	.55	.49
	.07	.10	.28	.37	.44	.43	.30	.48
	.07	.13	.44	.22	.29	.21	.47	.48
	.07	.11	.04	.13	.31	.24	.29	.27
C-1(58 db)	.39	.48	.49	.50	.48	.48	.46	.50
	.44	.49	.50	.49	.47	.42	.50	.50
	.46	.43	.32	.44	.49	.35	.44	.49
	.42	.46	.51	.47	.49	.51	.42	.47
	.48	.44	.47	.43	.35	.46	.29	.42
	.41	.53	.53	.35	.37	.51	.43	.49
C-2(82 db)	.10	.36	.36	.49	.50	.49	.42	.49
	.35	.40	.46	.46	.38	.33	.48	.50
	.26	.38	.39	.41	.54	.51	.47	.44
	.08	.30	.47	.46	.40	.36	.29	.43
	.43	.39	.35	.45	.42	.49	.48	.44
	.29	.49	.48	.37	.50	.36	.34	.44

Appendix V

Means and Standard Deviations for Groups Across Days in Experiment 1

Group		Days 1	2	3	4
E-1(58db)	M	16.0	23.0	37.8	42.7
	SD	10.7	12.9	15.6	4.5
E-2(82db)	M	5.5	8.8	19.3	21.5
	SD	2.7	4.7	18.7	9.8
C-1(58db)	M	43.3	47.2	47.0	44.7
	SD	3.3	3.7	7.6	5.5
C-2(82db)	M	25.2	38.6	41.8	44.0
	SD	13.9	6.2	5.8	4.3

Group		Days 5	6	7	8
E-1(58db)	M	42.3	47.7	47.2	48.0
	SD	6.7	3.9	4.1	3.7
E-2(82db)	M	33.8	30.8	37.7	41.8
	SD	7.3	8.9	11.8	10.4
C-1(58db)	M	44.2	45.5	42.3	47.8
	SD	6.4	6.2	7.1	3.1
C-2(82db)	M	45.7	42.3	41.3	45.6
	SD	6.5	8.1	8.1	3.0

Appendix VI

Summary of Analysis of Variance on Group Suppression

ratios during extinction sessions

Source	SS	df	MS	*F*
Between subjects	13,278	23	--	--
A (CS intensity	3,790	1	3,790	32.34**
B (Acquisition contingency)	6,291	1	6,291	53.69**
A x B	854	1	854	7.29*
Subject w. groups error between	2,343	20	--	
Within subjects	24,246	168	--	--
C (Extinction session)	9,926	7	1,418	22.90**
A x C	682	7	97	1.57
B x C	4,249	7	607	9.80**
A x B x C	722	7	103	1.66
C x subjects w. groups	8,667	140	--	--

** $p < .005$

* $p < .025$

Appendix VII

Mean Suppression Ratios Across Days for Groups in Experiment 2

Group		1	2	3	4	5	6	7	8
E-1 (58db)		.14	.40	.47	.46	.43	.46	.43	.43
		.23	.23	.41	.36	.44	.52	.48	.48
		.36	.47	.50	.47	.49	.49	.50	.49
		.31	.47	.46	.46	.48	.46	.49	.50
		.32	.50	.48	.29	.49	.48	.48	.45
		.31	.37	.33	.48	.47	.47	.48	.50
	$\bar{X}$ =	.28	.41	.44	.42	.47	.88	.48	.48
E-2 (82db)		.15	.12	.41	.47	.49	.50	.49	.50
		.15	.07	.05	.03	.26	.46	.42	.51
		.15	.04	.03	.21	.35	.36	.50	.39
		.02	.06	.03	.11	.26	.17	.32	.31
		.01	.03	.02	.06	.28	.44	.40	.28
		.09	.11	.04	.18	.29	.21	.47	.49
	$\bar{X}$ =	.10	.07	.10	.18	.32	.39	.43	.41

Appendix VIII

Summary of Analysis of Variance on Suppression Ratios

to CS Offset during Extinction Sessions

Source	SS	df	MS	*F*
Between subjects	10,742	11	--	--
A (CS intensity)	7,848	11	7,848	27.15 **
Subj. w. groups	2,894	10	289	
Within subjects	15,208	84	--	
B (Extinction session)	9,176	7	1,311	28.50 **
A x B	2,793	7	399	8.67 **
B x subj. w. groups	3,239	70	46	
Total	25,950			

** $p < .005$

APPENDIX IX

ABSTRACT

CS INTENSITY AND EXTINCTION OF THE CER IN RATS

Twenty-four albino rats were divided into four groups with CS intensity (58 db and 82 db white noise) and conditioning contingency (simple delay or random unpaired) varied in two levels. Two additional groups received paired trials of two levels of CS offset (58 db or 82 db) according to the Perkins-Logan model. Following ten acquisition trials, eight 4 trial per day extinction sessions were conducted in a separate chamber with conditioned suppression of licking responses measured. Analysis of the first trial of extinction (acquisition test trial) and repeated measures of extinction indicated a correspondence between the effect of CS intensity on acquisition and extinction. The results were interpreted as having supported the hypothesis that CS intensity, whether onset or offset, effects nonassociative properties of conditioning.