AMOUNT AND DIRECTION OF CHANGE IN

BACKGROUND NOISE AS A CS

THE AMOUNT AND DIRECTION OF CHANGE OF BACKGROUND NOISE AS A CONDITIONED STIMULUS

By

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This thesis is concerned with intensity characteristics of conditioned stimuli in acquisition of a conditioned emotional response (CER) in rats. A comparison was made of CSs which differed (between groups) with respect to amount and direction of change in white noise from a constant background stimulation level. The measure of conditioning was the degree to which the CS disrupted ongoing, food-motivated, bar-pressing activity.

The major findings were (1) that rate of conditioning was a monotonic increasing function of amount of intensity change in either direction; and (2) an increase in noise intensity from background X to CS Y produced more rapid acquisition of the CER than did a decrease from background Y to CS X. (3) During pretests, a noise increase produced a small, but reliable, increase in rate of bar-pressing, while a noise decrease produced a slight suppression.

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CONTENTS

CHAPTER ONE

INTRODUCTION

The basic sequence of events in "Pavlovian" conditioning is: (a) the organism is presented with an *alteration* in the stimulus environment, a change which by itself does not elicit a specified response; (b) in close temporal relation to the first stimulus change, a second is presented which has an "unconditioned" effect on the organism; with the result that (c) after a number of such pairings the first stimulus alteration, or "*conditioned stimulus*" (CS), comes to evoke a "conditioned response". The present thesis is concerned with the intensity of the conditioned stimulus (CS), that is, with the degree to which the CS differs in intensity from the intertrial or background stimulation (S^-). The CS may, logically, be of either higher or lower intensity than S^-. Thus, it could consist of, e.g., a background auditory stimulus being increased or decreased to some different intensity (in the limiting cases a stimulus would be turned *on* or *off* for the CS period). Clearly, if one is to determine the relative efficacy of different CS intensities, one must consider not only the absolute intensity of the CS but also its intensity in relation to that of the background or intertrial level; it is obvious that no conditioning can occur to even a very intense stimulus unless it represents *some* change from the background stimulation level. The current confusion in the literature with respect to CS intensity effects seems to stem partly from the fact that most of the initial investigations employed only CSs consisting of an increase in intensity.

That is, the traditional procedure in effect regards the ambient background stimulation as being of zero intensity. The only CSs normally studied consist of the turning on of various stimuli (usually lights or sounds), differing in absolute intensity. Consequently, differences between CSs in absolute intensity are completely confounded with the amount of change from the constant background; furthermore, reductions of the intensity of background stimulation are not often studied as CSs. It is thus not surprising that a major theoretical formulation of CS intensity effects (Hull, 1949) recognized the significance of stimulus intensity, but completely ignored the questions of amount and direction of change from the background stimulation level. The resulting postulate of "stimulus intensity dynamism (V)" was:

> "Other things constant, the magnitude of the reaction potential (${}_{S}E_{R}$, i.e., V) has an increasing monotonic relationship to the intensity (i) of the stimulus in question, the increase taking place at a progressively slower rate according to the equation
>
> $${}_{S}E_{R} = V = A(1 - 10^{-b \log i})." \qquad \text{(p. 71)}$$

In unmodified form, the above statement would imply that in a situation in which the CS was of a lower intensity than the background or intertrial intensity, one should obtain best conditioning with the least amount of stimulus change; reduced to the absurd, no change at all should be better than any change in the negative direction!

Not only was Hull's dynamism concept limited in generality, but Perkins (1953) and Logan (1954) suggested, independently, that it was quite unnecessary in order to explain the data with which Hull had been confronted. Instead, they proposed to account for CS intensity effects by a process of differential conditioning. According to this view, there is nothing inherent in a stimulus of one intensity which would make it a more effective CS than a stimulus of another intensity, assuming that they both were above the absolute threshold. What is important is where on the intensity continuum they stand in relation to the S^- intensity. It is assumed that while the S is being conditioned to respond to the CS he is, at the same time, learning not to respond in the absence of the CS. Not only does the tendency to respond generalize to other intensities, but also the tendency NOT to respond generalizes to intensities other than that of the background; to the extent that the generalization gradient in the latter case extends to intensities to which the response is being conditioned, there will be less than the maximal response strength to the CS. It follows that if S_1 is a more intense stimulus than S_2 and S_2 is more intense than the background, S_1 will be a more effective CS since its response strength will be least depleted by generalized inhibition. This, of course, would be the case for the experiments on which Hull based his concept of stimulus intensity dynamism. On the other hand, the Perkins-Logan analysis also implies that if S_1 were more intense and S_2 less intense than the background, S_1 could be more, less, or equally effective as a CS, depending on the relative distances of S_1 and S_2 from the background intensity.

Two assumptions contained in the Perkins-Logan theory are:

1) That the generalization gradients around a given stimulus intensity will be symmetrical with respect to a j.n.d. scale of intensity, and

2) that there is greater generalization decrement with greater difference between a conditioned stimulus and a test stimulus.

It is possible that both the stimulus intensity dynamism and differential conditioning notions are correct. When one studies the effects of a series of CS intensities, each of which is greater than the background intensity level, both the intensity dynamism and differential conditioning views predict the same monotonic function relating response strength positively to CS intensity. However, the joint action of both principles could conceivably be manifested as a <u>non-monotonic</u> function (relating response strength to CS intensity) when the CSs consisted of <u>decreases</u> from a constant background level. One might expect response strength to increase with greater amounts of stimulus change until the generalized inhibition from the background (intertrial) intensity ceased to have any further effect. Thereafter, <u>without</u> an intensity dynamism mechanism, response strength should not change; <u>with</u> a dynamism, response strength should, at this point, become a <u>negative</u> function of amount of change (since the larger the change, the lower the absolute intensity of the CS). The possibility of obtaining such a non-monotonic function was, in fact, an impetus for the experiments reported in the body of this thesis.

Furthermore, it was conceivable that, as a consequence of a "dynamism" effect, an intensity increase would be more effective than a decrease <u>when the amounts of change from the background were, in some way equated</u>. The question arises as to how the stimulus change should be equated. The procedure adopted in this thesis was to match groups of subjects with respect to a given interval on the intensity continuum. For example, if one group had, as a CS, a decrease from a background noise level of 80 db to one of 60 db, another group had as its CS an increase from 60 to 80 db. It should be noted, however, that the effects of direction of stimulus change are, under this procedure, confounded with the effects of different absolute intensities. An alternative procedure might be to match a decrease from 80 to 60 db with an increase from 40 to 60 db; both the absolute intensity of the CS and the amount of change in decibels are the same for the two groups. The difficulty with this method is that, in the absence of relevant data, the decibel scale could well be quite different from a rat's "psychological" equal interval scale; amount of change would not be equated, therefore, in a psychologically meaningful sense.

The experiments described in this thesis were an attempt to clarify some of the relations between CS intensity and direction and amount of stimulus change in determining CR strength. We turn now to the history of the relevant research.

CHAPTER TWO

HISTORY

The experiments which have a bearing on the problem of CS intensity fall into two general categories. In the first, or "INCREASE" category, are those which, by themselves, could be used to support an unmodified intensity dynamism notion. In these "traditional" studies, the CSs are always of greater intensity than the background (which is normally an unspecified level of ambient stimulation). In the second, or "DECREASE" category, are experiments which show that intensity changes involving a decrease can function as CSs; these data indicate that the absolute intensity of the stimulus is not the only important factor.

The present thesis is concerned particularly with CS intensity in classical, or Pavlovian, conditioning, whereas Hull, Perkins, and Logan have used "stimulus intensity" in a more general sense to include "discriminative stimuli" (S^Ds) in instrumental learning. Consequently, the studies which will be discussed most extensively are those explicitly employing a classical conditioning procedure.

I. "<u>INCREASE" Category</u>.

> The effects of different intensities of conditioned stimuli when the stimuli are, in all cases, higher in intensity than the background, or S^{-}.

A relatively large number of experiments have been done which fall into this category. Some of these have dealt with humans but most have been on animals, and of the latter, over 160 have been contributed by the Russians (cf. Razran, 1957).

In 1930 Pavlov summarized work done in his laboratories in the following manner:

> ..."The stronger the conditioned stimulus, the greater the energy simultaneously entering the hemispheres, the stronger is the effect of the conditioned reflex, other things being equal, i.e., the more abundant the flow of saliva, which we consistently utilize in measuring the effect..........There is always, however, a limit beyond which a stronger stimulus not only does not increase but tends to decrease the effect." p. 210
>
> ..."A stimulus, the intensity of which is beyond that maximum, instantly elicits inhibition, thus distorting the usual rule of the relationship between the magnitude of the effect and the intensity of excitation;..." (p. 213)

A similar conclusion concerning the effects of CS intensity was reached by Razran (1957) in his review of a large quantity of Russian studies. Response strength was a monotonic increasing function of CS intensity, at least up to a point; with very high CS intensities, he reports that there is evidence for an inverted-U shaped function. Razran points out that these same high CS intensities nevertheless appear to be below intensities which would be painful. A further point discussed in the same article is that not only are there optimum CS intensities, but the optimum value is a function of the magnitude of the unconditioned response. Thus it is proposed that there are optimum CS-intensity UR-magnitude ratios. This idea seems related to observations made by Pavlov (e.g., 1927, p. 30) to the effect that if a stimulus is to be made into a CS, the initial (<u>un</u>conditioned) response to it must be "physiologically weaker and biologically of less importance" than the response to the UCS.

In an earlier review of Russian studies, Razran (1949) had reported a very different manifestation of the effects of stimulus intensity. When animals had been conditioned to a stimulus of high intensity and tested for generalization to less intense stimuli, a decreasing gradient was found. But when the original CS had been weak and the test stimuli strong, an increasing gradient resulted; that is, there was less response strength to the CS, itself, than to stimuli which had not been paired with the US, but which were now more intense than the CS. This discrepancy between Razran's 1949 and 1957 reviews was presumably attributable to the failure to take into consideration the effects of UR magnitude in the 1949 review.

Nevertheless, as has been pointed out by Kamin and Schaub (1963) and Kamin and Brimer (1963), there is some reason for considering the Russian data inconclusive. A major problem is that they are typically _within_-subject experiments, sometimes employing subjects which have been used in a number of previous experiments. Invariably (it would appear), the same dog is tested with different CS intensities. Consequently, the effects of CS intensity _per se_ are confounded with effects of generalization, discrimination, and other possible factors accruing from the repeated use of subjects in different experiments. For example, Kamin and Brimer (1963) have noted that the above mentioned curvilinear function described by Pavlov and Razran was based entirely on studies in which CS intensity was varied _within_ subjects, and thus could have been the consequence of "the combination of a monotonic effect of CS intensity, plus a relatively flat generalization gradient extending from the standard CS...." (p. 199). The "standard CS", in this case, is the intensity at which the _S_ was "originally" trained. In addition to the lack of sophistication in experimental design and statistics in the early Russian studies, there is some evidence

(Makarychev, A.I., 1951, and Søltysik and Zbrożyna, 1957) that the particular method of recording salivary responses may have produced, through tissue irritation and head movements, artifacts in the response measure. Further, the physical intensities of stimuli used in Pavlovian studies were not usually carefully controlled, consisting often of such variations as, e.g., "loud" and "soft" whistles. While the ordinal relationship may be clear, it is impossible to estimate the order of magnitude of these stimuli with any confidence.

American classical conditioning studies of CS intensity (in our INCREASE category) are at least 15 in number, all but three of which employ humans as subjects. The human experiments will be discussed first.

Three of these were conducted with conditioned stimuli in the neighborhood of the absolute threshold, and were concerned with the special question of whether conditioning could occur to psychophysically subliminal stimuli. Newhall and Sears (1933) employed the method of Constant Stimuli in conjunction with a conditioned finger retraction procedure to determine the visual intensity threshold. There was found to be a greater frequency of response to the higher intensities. It is difficult to interpret the result, however, since any differential effect of "intensity *per se*" is confounded with the expected increase in response probability which would occur as the stimulus acquires a greater probability of being "supraliminal". A study by Baker (1938) suggested that the pupillary response could be conditioned to stimuli which were, according to certain criteria, "subliminal" (that is, below an independently determined threshold". Subsequent attempts to replicate these results have met with little or no success (e.g., Wedell, _et al_, 1940 and Hilgard, _et al_, 1941). Wilcott (1953), in a within-_S_ experiment, found no differences in magnitude of conditioned galvanic skin response (GSR) with three (low) intensities of an auditory stimulus. The first was the lowest intensity that the _S_ "could consistently hear"; the other two were 10 and 20 decibels above threshold. Thus, the evidence concerning near-threshold CS intensities would appear to be quite inconclusive.

The remaining evidence on CS intensity in humans is provided entirely by studies of either the conditioned galvanic skin response (GSR) or the conditioned eyeblink.

The GSR work in this area was begun by Hovland (1937 a, 1937 b). While both experiments were primarily concerned with stimulus generalization, the procedures involved an initial conditioning, for separate groups, to a high and a low intensity tone. At this stage, there was greater response to the strong than to the weak stimulus. This, of course, was a between-subject comparison. The second of the two experiments does not have further relevance, but in the first study each subject was then tested during extinction with four different CS intensities, separated by equal numbers of j.n.d.'s. The resulting generalization gradients were like those reported by Razran (1949; cf. above); response magnitude declined with stimuli less and less intense than the _high_ standard; but responses increased in magnitude to stimuli more intense than the _low_ standard. However, the experimenter was not concerned with the separate analyses of curves obtained from subjects trained with high and with low standards. Instead, an attempt was made to cancel out effects due to CS intensity _per se_ by combining the two generalization gradients, yielding a single curve relating response magnitude to stimuli which were different j.n.d. intervals from a standard. The pooled curve was, therefore, relatively flat.

A GSR experiment by Grant and Schneider (1949) has given some slight evidence (cf. below) of greater response magnitude to higher CS intensities. However, the design of the experiment has focused attention on a particularly troublesome problem with respect to CS intensity effects, which is, the distinction between effects of CS intensity on "conditioning" and on "performance". That is, an alternative to the hypothesis of different CS intensities producing different strengths of conditioning is the notion of the formation of a unitary "associative bond" with at least a certain minimal stimulus intensity; if greater observed response occurs with more intense stimuli, this is conceived to be a reflection, not of greater strength of associative bond(s), but of an increase in some motivational variable.[1] It may be noted that this problem is very similar to the question of "conditioning" vs. "pseudo-conditioning" or "sensitization"; but the latter distinction seems to be concerned with the presence or absence of any conditioning rather than with the presence of different amounts of conditioning. The procedure employed by Grant and Schneider (1949) was a 4 x 4 factorial design, with magnitude of the GSR in extinction as the response.

Initially there were four main groups of Ss, each group being trained on one of four CS intensities. For extinction, each group was

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[1] However, Hull's postulate of "stimulus intensity dynamism" applies, explicitly, both to an effect on performance and to an effect on the rate of "habit formation".

subdivided into four sub-groups; and each of these was extinguished with one of the four CS intensities. When the extinction scores were cast into a 4 x 4 table, each row contained scores for Ss which have had a particular CS intensity in acquisition; similarly, each column was restricted to one extinction intensity. Thus, differences between row means (which were not, in fact, significant) were supposed to reflect effects of different intensities on "conditioning", all extinction intensities being equally represented within each row. This follows, since row differences are attributable to a variable no longer operative at the time of testing. Differences in column means (which were nearly significant) should reflect the effects of different CS intensities on performance.[2] Unfortunately, there is at least one serious defect in the 4 x 4 design (cf. Schaub, 1962). Within, e.g., a single column it is true that all four acquisition intensities are equally represented. But it is not necessarily true that one would expect these four intensities to have equal effects on each column (leaving extinction intensity as the only important between-column variable). This can be seen by noting for each cell the absolute difference in intensity between the training and extinction intensities, and summing these differences for each column. Assuming that generalization decrement exists and that it is a monotonic, increasing function

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[2]In this experiment, the Ss were also given 5 "re-extinction" trials with the original intensity; under these conditions, response magnitude was a function of CS intensity, differences between means being significant at the .01 level. The interpretation of these results is complicated, however, by the prior interpolated "Extinction" trials with different intensities.

of amount of difference between training and test stimuli, it is clear that more decrement would occur in the end columns than in the middle columns, perhaps obscuring any monotonic effect of intensity on "performance". The same argument would hold for the row means and "conditioning" effects. While this imbalance does not occur in the case of a 2 x 2 factorial, there is a second criticism (Champion, 1962, p. 431-432) which has been made of all factorial designs used to separate "learning" from "performance". It is argued that one would expect differences between row means _even if there were no differences in amount learned_. The prediction is derived from the Perkins-Logan theory which attempts to account for all CS intensity effects on the basis of the interaction of opposing tendencies to respond and to inhibit response. The problem would still exist even if an _S_, trained to a weak stimulus, were to show an immediate increase in response strength upon presentation of a strong stimulus. According to the rationale for the factorial design, a sudden increase would reflect an effect of intensity on performance, i.e., a _motivational_ effect. Whereas, the Perkins-Logan theory could dispense with a motivational concept by, e.g., assuming that the generalization gradient for the S^+ was relatively flat and that the generalized inhibition from S^- was less for the strong test stimulus than for the original, and less intense, training stimulus. Thus differential conditioning might seem to provide the more parsimonious interpretation of "performance" as well as of "conditioning" effects. An alternative explanation would, of course, be required if empirical generalization gradients turned out to be inconsistent with the theoretical assumptions.

However, a "performance" or "motivational" factor derives some support in the case of galvanic skin responses, the magnitude of which, before either conditioning or adaptation trials, is a direct function of intensity of, e.g., an auditory stimulus (Hovland and Riesen, 1940). As exemplified by a study by Kimmel (1959), the GSR is quite easy to elicit and its susceptibility to "sensitization" makes it difficult to demonstrate good conditioning. Since a non-associative or performance factor is obviously present in the case of an UNconditioned response, it seems reasonable to suspect that a similar factor is operative in the case of the conditioned response. In the absence of a satisfactory way of separating the conditioning and performance factors, it would seem desirable to employ responses which occur infrequently and with small magnitude when the to-be-conditioned stimulus is presented <u>without</u> having been paired with a US.

Before leaving the GSR, there are two (related) studies which may be summarized as follows. The first, by Kimmel (1959) was designed to test Razran's (1957) statements concerning a possible non-monotonic relationship between conditioning and CS intensity. The three experimental groups had as CSs, 35, 75, and 115 decibel tones, respectively. The US, shock, was adjusted for each <u>S</u> to a level considered "annoying". Three other groups were run as controls for sensitization. Following preliminary presentations of shock and tones <u>alone</u>, there were 20 paired presentations of CS and US (or unpaired, in the case of the control groups). The basic response measure was a square root transformation of conductance changes during the five seconds following onset of the four second CS. However, in order to determine the amount of conditioning taking place, the difference was obtained between each response value in acquisition and the mean value for a number of pre-test CS presentations given to the same S. In this manner the "conditioned" effects were presumably separated from some (but not all) of the unconditioned effects; the control groups were a control for unconditioned "sensitization" effects. The results of this method of analysis suggested that conditioning had taken place only with the group receiving the lowest intensity and that merely "sensitization" had taken place with the group having the highest intensity (since both this group and its control had response magnitudes greater than the pretest level). The outcome was interpreted as supporting Razran's (1957) conclusions. As has been pointed out, however, by Kamin and Brimer (1963, p. 195), the measure of conditioning in this experiment "makes it extremely difficult for subjects trained with an intense CS to display 'conditioning', since the unadapted pretest response varies directly with CS intensity."

The results of the Kimmel (1959) experiment were extended by a study by Kimmel, Hill and Morrow (1962) which investigated seven CS intensities in the neighborhood of the 35 db tone found previously to produce "conditioning". The intention was to locate the peak of the inverted-U curve more precisely. There were a number of procedural changes from the first study, the most notable being the following:

1. Addition of a conditioned (avoidance) finger-withdrawal procedure, which was conducted simultaneously with the GSR procedure.

2. Elimination of 40% of all prospective Ss by reason of difficulties in following instructions for finger-withdrawal (which in itself was "an extremely difficult task").

3. Deletion of groups which might control for unconditioned effects of CS intensity on the GSR.

4. Use of the square root of conductance change as the measure of GSR conditioning, without subtracting from that value a pretest score.

5. Addition of a non-reinforced test trial between trial 8 and 9 of acquisition.

6. Division of each acquisition group into three extinction groups, each of which received one of three extinction intensities.

For the GSR, the only significant group differences occured in the two extinction trials; Ss that originally had been in the group receiving the next to the lowest of the seven acquisition intensities had the highest mean response magnitude. On the test trial (9) in acquisition, there was no significant intensity effect. The interpretation of these results is, at best, difficult. The two major problems (in addition to possible questions concerning the procedures) are those previously mentioned, namely, the significance of the extinction differences in view of the differential conditioning arguments discussed by Champion (1962; cf. above), and the question of the extent to which unconditioned CS intensity effects influence the GSR.

The remaining studies on human subjects involve the conditioned eyeblink.

Grant and Schneider (1948) used their factorial procedure (cf. pp. 11ff., above) to study eyelid conditioning as well as the GSR. However, even by their own interpretations, to which the previous criticisms would apply, there were no effects of different CS intensities on extinction responding. An examination of response frequencies for the cases in which the original acquisition intensity is tested does not reveal any systematic effect either.

Three other eyelid conditioning studies have investigated CS intensity effects in both acquisition and extinction. Carter (1941) used six intensities of a tone CS in a between-subject design. With

50 pairings of CS and US these groups did not differ significantly from each other, but did differ from a control group which received the US but not the CS. There was some suggestion, however, of greater response strength with the higher intensities. A study by Passey (1959) was intended to test the hypothesis of optimum ratios of CS intensity and UR magnitude (cf. Razran, 1957). A 3 x 3 factorial design was employed, with different intensities of a tone CS and an airpuff US.[3] In neither acquisition nor extinction was there an effect of varying the CS intensity, but strength of airpuff was important in acquisition. Somewhat more positive results were obtained by Walker (1960) using two intensities of a tone and two US (airpuff) intensities. In acquisition, strong stimuli were better than weak for both USs and CSs. On the basis of a Hullian idea concerning the relationship between habit, drive, and stimulus intensity dynamism, there had been expected to be a greater effect of CS intensity with the strongest airpuff. In this regard, the results were in the right direction, but the interaction was not significant. In extinction, there was no effect of either CS or US intensity if the criterion for a CR was the same as that employed in acquisition. If the criterion was made more liberal, in terms of the time interval following onset of the CS within which an eyeblink occurred, an effect of different US intensities was evident. An interesting aspect of this report is the apparent difficulty encountered in deciding what a "conditioned response" was to consist of. The major classification scheme eliminated from consideration all eyeblinks

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[3]It is assumed that intensity of US is highly correlated with UR magnitude and that the one term may, therefore, be substituted for the other.

occurring within 150 msec. after CS onset; responses between 150 and 300 msec. were called "voluntary", and the data for a subject were discarded if 50% or more of the responses were in this time interval. But for the subjects remaining, the voluntary responses were analyzed; in acquisition, "CRs" were responses between 300 and 565 msec. and were analyzed separately from the voluntary responses. "CRs" and "voluntary" responses apparently differ in "form" as well as latency. This kind of complication is characteristic of all eyeblink experiments.

There are three studies which seem to have encountered a minimum of technical and theoretical difficulties in providing a demonstration of CS intensity effects. All employ animals as subjects. The first, by Barnes (1956) was concerned with a conditioned leg movement in dogs. The CSs consisted of an 800 cps tone at either 60 or 80 decibels. US (shock) onset occurred 0.9 seconds after CS onset. Disregarding a second factor in the design, namely, the time between US termination and CS termination, there was a significantly greater mean number of conditioned responses to the 80 db tone than to the 60 db tone.

Two recent experiments on the Estes-Skinner (1941) "conditioned emotional response" (CER) have provided quite clear evidence for a monotonic function relating CS intensity and response strength. The measure of conditioning in this procedure is the degree to which a CS disrupts the ongoing bar-pressing behavior of a rat, reinforced by food pellets. In the first study, Kamin and Schaub (1963) compared, as CSs, three intensities of white noise in a delayed conditioning procedure. The three groups differed significantly from each other on the second acquisition day, more supression occurring with the more intense stimuli. Two additional groups were run on a trace conditioning procedure, using the highest and lowest of the previous three intensities as CSs. The CS in this case lasted two minutes instead of the usual three, and a minute of silence (the trace interval) occurred prior to the US. Only one S showed any sign of conditioning in the weak CS group, while the strong CS produced considerable suppression, particularly in the trace interval.

The above finding was confirmed in a second CER study, by Kamin and Brimer (1963). Both CS and US intensity were varied in a 3 x 3 factorial design employing nine independent groups of subjects in a delayed conditioning procedure. With the lowest shock intensity, there was no CS intensity effect since none of these three groups showed significant suppression. A similar lack of differentiation was produced by the highest shock intensity, strong suppression occurring for all three CS intensities. However, in the case of the medium US there was a significant difference between the least intense CS, which produced only slight suppression, and the other, more effective, intensities. This study, it should be noted, was designed particularly as a test of the conclusion reached by Razran on the basis of the Russian data, that is, that the function in question was non-monotonic (cf. p. 7ff. above). No evidence was obtained suggesting an optimum CS-US ratio.[4]

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[4]Subsequent studies by Kamin and his associates have further attested to the monotonicity of the function relating CS intensity to rate of acquisition of the CER over both a wide range of white noise intensities (35 to 81 db) and three intensities of light (Kamin, 1963).

The contrast between the rather inconsistent results with humans and the relatively clear results with animals (in classical conditioning) may, as Kimble (1961, p. 120) has suggested, reflect greater mediational powers of humans, such that they are able to equate CSs of different intensities. Or the differences may be due to other factors, such as the differences between the responses selected for observation.

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So far we have considered, within the INCREASE category, only experiments which were explicitly concerned with classical conditioning. The stimuli commonly called "discriminative stimuli" (S^D) in the context of instrumental learning have also been varied in intensity, and the results of these studies may be relevant to our problem. However, in view of the difficulty in making meaningful comparisons of the classical and instrumental procedures in terms of CS (or S^D) presentation, and in terms of the measures of response, the latter studies will be summarized only briefly. Table 1 provides a very rough picture of eight experiments conducted with rats. In nearly all cases, the S^D is a visual stimulus which is varied in intensity (although it may be argued whether size of a stimulus patch constitutes an "intensity" variable). In six of the eight studies, there was evidence for greater response strength in the more intense stimulus condition. In contrast to the CSs of typical classical conditioning procedures, the S^Ds usually are not clearly localized in time and, in some instances, space. For example, Passey and Possenti (1956) gave rats 75 trials (5 per day) in which they could run down an alley for food. For one group, the intensity of diffused light from an overhead bulb was 4 foot-candles; for the other group the intensity was 128 foot-candles.

TABLE 1

Summaries of eight experiments with rats in which intensity of an S^D is varied in an instrumental situation. The symbol " $\rangle$ " should be read, "...produces greater response strength than..."

Experimenters	Learning Situation	Stimulus Varied	Result
Spence, 1937	Visual discrim. exper.	Size of S^D	Large $\rangle$ small
Brown, 1942	Harness pulling in runway	Light from a screen	Strong $\rangle$ weak
Hull, 1947	Alley	Intensity (color) of alley	White $\rangle$ black
Hays (cf. Hull, 1949)	Jump stand	Intensity (color) of stimulus card	White $\rangle$ black
Grice and Saltz, 1950	Panel pushing	Size of white circular panel	No differences between small and large size.
Fink and Patton, 1953	Drinking response	Int. of background auditory, visual, and cutaneous stimuli.	No intensity effect.
Passey and Possenti, 1956	Running response	Diffused light	Strong $\rangle$ weak
Heyman, 1957	Running response	Munsell stimulus papers.	Light $\rangle$ dark

The rats in the latter group tended to have shorter latencies and greater probabilities of response. Food was in no way contingent upon the light stimulus. Consequently, in this study (as in several of the others cited) there is no particular reason to suspect that learning (as opposed to some "motivational" factor) is being affected by stimulus intensity.

With regard to human instrumental studies, we can cite three on reaction times (Catell, 1886; Pieron, 1920; and Castenada, 1956), a key pressing experiment (Berlyne, 1950), and a lever pulling situation with children (Spiker, 1956), all of which demonstrate a differential effect of high and low stimulus intensities on their respective response measures. Again, there is no reason to suppose that this effect is on learning; the responses, which were not at all complex or difficult, were presumably "learned" via the experimental instructions.

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Two investigations of avoidance conditioning complete our review of evidence within the INCREASE category. The fact that the operations employed in classical and avoidance training are similar during at least the earliest trial(s) might lead one to expect the same kind of CS intensity effects in both types of situations.

Kessen (1953) performed two experiments, one involving acquisition alone and one involving both acquisition and extinction. In the first, six light intensities were used as CSs for each of ten rats, each S receiving 11 trials with every CS. An increase with intensity of the CS was demonstrated for three measures of the wheel-turning response: probability of response (frequency of CRs divided by number of trials), reciprocal of response latency, and rate of responding between trials. It was assumed that an effect of CS intensity on "habit strength" would have produced a function which first increased and then decreased in the within-subject experiment, since the intermediate intensities would have benefited most from stimulus generalization. Since the functions were monotonic, it was concluded that an effect on habit strength had not been demonstrated. A similar effect on response strength was obtained during acquisition of the second experiment, in which independent groups of Ss were used for each of four intensities. The acquisition and extinction phases together constituted a "learning vs. performance" 4 x 4 factorial design, in the manner of Grant and Schneider (1948, 1949). Although no reliable differences occurred in extinction, the design, as we have already seen, may not be a particularly meaningful one (cf. pp. 11ff., above).

Miller and Greene (1954) obtained somewhat corroborative results. Two groups of rats were initially trained to a criterion of five consecutive avoidances with 93 and 108 decibel CSs, respectively. While the high CS group learned more rapidly than the low CS group, the difference was just short of significance at the .05 level. Subgroups were then tested for generalization at 93, 99, and 108 db. The animals trained with the low CS generalized almost completely to the higher test stimuli, in terms of the number of trials to extinction. However, the gradient for the group trained with the high CS decreased sharply. The extinction data is much like that of earlier experiments with other procedures (e.g., Hovland, 1937(a); Brown, 1942; and Razran, 1949), and could be accounted for by either a dynamism or differential conditioning theory.

Summary of INCREASE category.

1. The large body of Russian evidence for an inverted-U shaped function relating CS intensity with response strength was criticized on two grounds. The first was methodological; the second was based on the findings of American animal studies, which seem to indicate a monotonic function.

2. The American human studies on classical conditioning are inconclusive. The GSR is sometimes a monotonic function of CS intensity, sometimes not; unconditioned aspects of this response seem to be a particular problem. Most reports of eyelid conditioning have found no significant effect of different CS intensities, and are beset with problems involving inclusion or exclusion of various "types" of response. Differences in the efficacy of different CS intensities does not, in general, seem to be related to whether acquisition or extinction measures were studied.

3. Studies of instrumental responding in rats and humans largely agree (11 out of 13) that there is greater response strength with higher S^D intensity. It has not been determined to what degree these effects might be due to some classical conditioning process within the instrumental procedure.

4. In instrumental avoidance conditioning, two experiments indicate a monotonic relationship between CS intensity and response strength.

II. "DECREASE" Category.

A most important aspect of all the above studies is the fact that intensity of the CS and the amount of change (increase) in intensity produced by the CS are confounded. A second category is therefore comprised of experiments which indicate that reductions of background stimulus intensity can function as CSs. The label, "DECREASE", is used for convenience although most of these studies involve both directions of change.

To quote a relatively early source:

> "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. Let us take the following example as an illustration. A metronome is sounding continuously in the experimental laboratory when the dog is brought in. The sound of the metronome is now cut out, and immediately an unconditioned stimulus, say food or a rejectable substance, is introduced. After several repetitions of this procedure it is found that the disappearance of the sound has become the stimulus to a new 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, 38-39)

Three more recent (human) classical conditioning experiments which are relevant to the problem are the following. Hansche and Grant (1960) used as the beginning of a CS-US interval in eyelid conditioning either the onset or the offset of a 1.5 second light. The CS-US interval was, for different subgroups, .15, .35, .55, or .75 seconds. An assumption was that .5 second is the optimum interval, and that with the above procedure either the onset or the offset,

<u>but not both</u>, was involved in the conditioning process. When "true" conditioned eyeblinks were distinguished from other varieties of eyeblink (e.g., "alpha responses" and "off-responses") it was found that optimal conditioning occurred with a 0.5 second CS-US interval whether the onset or offset of the light began the CS-US interval. Similarly, Logan and Wagner (1962) reported equivalent eyelid conditioning to both a light increase from two to four light bulbs and a decrease from four to two. An additional finding was that when each group was given a series of trials with the opposite CS condition, there was no apparent drop in performance! In neither of these two experiments was one direction of stimulus change more effective than the other.

In a human GSR experiment by Champion (1962), offset of a strong tone produced better conditioning than offset of a weak tone.

In instrumental conditioning, two rat experiments (Bragiel and Perkins, 1954, and Nygaard, 1958) have shown that black and white are equally effective as an S^D, and both are maximally effective when the background or the negative stimulus is maximally different on the black-white (intensity) continuum.

There are four avoidance conditioning studies, with rats, in which intensity changes in both directions were to some degree effective. The relative efficacy of the two directions is not clear.

The first of these, by Kish (1955), was a series of experiments in which rats were required to turn a wheel to avoid shock. The conditioned stimuli were either onset or cessation of either a light or a buzzer. Onset was consistently the more effective direction of change for both types of stimuli. However, studies by Myers (1959, 1960) have raised two problems concerning the Kish experiments. The first is that startle responses, as opposed to CRs, sometimes occur when a buzzer is used in conjunction with the wheel-turn response. Secondly, this same response can occur at a high rate outside the CS period as well as during it, and a rat might thereby be credited with a spuriously high number of avoidances. Myers favors subtracting from the number of responses in the CS the number in an equal intertrial period to get a measure of "discriminated avoidances". Also, Kish may have raised the probability of "CR"s by delaying trials until no intertrial response had occurred in ten seconds.

In one experiment by Myers (1960), onset of a tone was somewhat more effective than its termination, but the difference apparently was not significant. In the same study, onset of a buzzer produced much greater strength of (the wheel-turning) response than its termination, but this effect seems to have been attributable to the previously mentioned "startle" phenomenon.

Swartz (1958) found in one study that an increase in light intensity was a better CS than a decrease, but in another experiment (Swartz and Goodson, 1958) direction of change was not important.

Summary of DECREASE Category.

1. A decrease in the intensity of background stimulation can be used as a CS in classical and avoidance conditioning, and as an S^D in instrumental learning.

2. There is a single human GSR study suggesting greater response strength with greater amounts of change in the decrease direction.

3. It is not clear whether conditioning is a function of direction of change.

<u>General Conclusions</u>

With particular regard for the reasons for undertaking the experiment to be reported, the following summary statements may be made.

a) There is no question that either an increase or decrease in the intensity of a stimulus (including its onset or offset) will serve as a CS in classical conditioning with both humans and animals.

b) The function relating degree of intensity <u>augmentation</u> to amount of conditioning appears to be a monotonic increasing one for animals (at least for certain "defensive" conditioned responses), while the human data are not clear on this point.

c) However, the analogous function relating CR acquisition and degree of intensity <u>diminution</u> has not been adequately investigated.

d) Nor is there any clear data as to the relative efficacy of the two directions of intensity change.

In the experiment which follows, the Estes-Skinner (1941) CER procedure is employed in an approach particularly to the latter two problems. There are a number of advantages to this technique (over, e.g., eyeblink and GSR procedures), most notably its sensitivity to differences along many conditioning parameters. Also, the unconditioned effects of to-be-conditioned stimuli are very small, and the response employed (suppression of bar pressing) has a low probability of occurrency within an experimental session. Further aspects of the method are discussed by Kamin (1963).

CHAPTER THREE

METHOD

Subjects and Apparatus

The Ss were 80 experimentally naive male hooded rats from the McMaster colony, from three to five months of age. Ad lib weights ranged from 185 to 313 grams, and all Ss were reduced to approximately 75% of their ad lib weights by the first day of training. The Ss were randomly assigned to ten groups of eight Ss each.

The experimental spaces consisted of eight standard Grason-Stadler operant conditioning units ("Skinner Boxes") housed in wooden boxes with sand-filled walls. Food magazines and receptacles provided for the presentation of standard 45 mg. Laboratory Rat Food Tablets (P. J. Noyes Co.). Protruding from one wall of each unit was a metal lever ("bar"), and a speaker was attached to the rear of the same wall.

Unconditioned Stimulus. The UCS was electric shock. The floor of each unit was a grid of steel bars connected to a Grason-Stadler Model E1064GS Shock Generator set at "1.0 ma." for all experimental groups. The current actually delivered to the grid, with the rat in the circuit, is about .85 ma according to an estimate made by Annau (1960). The circuit was of the constant current type (high voltage, high resistance), which minimized the effect of changes in the rat's resistance on current flow. The shock presentation was of 0.5 second duration, and a grid scrambler prevented avoidance of the shock during that period as long as the animal was in contact with the grid, walls, or lever. The grids were cleaned at the end of each experimental day with a detergent solution followed by a water rinse.

Conditioned Stimulus. The CS was white noise, of varying intensities for different groups. The two speakers for a given pair of experimental units were connected (in parallel) to a Grason-Stadler 901A Noise Generator. Adjustment to the desired white noise levels was accomplished by means of variable resistors both within the experimental units and in the control room. Exhaust fans which normally operated in each unit produced a mean sound level of about 62 decibels. However, all references to the white noise level are based on determinations made with all the exhaust fans off, since only in this manner could sensitive and reliable readings be obtained for the lowest white noise levels. A General Radio Sound Survey Meter, Model #1555-A (range, 40-136 db; re 0.0002 μ bar), was used for this purpose. Rechecks of the noise level in each unit were made at the end of each experimental day, and a half-hour generator warm-up period occurred before the start of the first session of each day. The six white noise levels employed were; 0, 45, 50, 60, 70, and 80 decibels. Sound and shock generators, operant conditioning units (Grason-Stadler) for the automatic programming of experimental procedure, and digital, print-out, and cumulative recorders were all housed in a room adjacent to the one containing the Skinner boxes. The programming and recording of all phases of the experiment were automated, using standard operant conditioning relay and timer circuits.

Experimental Design

The experiment as a whole can be viewed as a 2 x 5 factorial design,[5] as shown in Table 2. The conditioned stimuli for the ten

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[5] Groups 1 - 4 and half of each of Groups 5 - 10 were run in three consecutive 14 day periods.

TABLE 2

Experimental Design

Amount of stimulus change in decibels	White Noise Sound Level(db) during:	DECREASE Inter-trial		DECREASE CS		INCREASE Inter-trial		INCREASE CS
10	Group 1	80	to	70	Group 6	70	to	80
20	Group 2	80	to	60	Group 7	60	to	80
30	Group 3	80	to	50	Group 8	50	to	80
35	Group 4	80	to	45	Group 9	45	to	80
80	Group 5	80	to	0	Group 10	0	to	80

groups differed with respect to direction of stimulus change and to amount of change. Thus, groups 1 - 5 all had an 80 db background (white) noise level and the CSs consisted of a reduction of the intensity, by different amounts, for a period of three minutes. For Groups 6 - 10, the CSs were varying amounts of increase in background noise intensity for three minutes. There was a matching of amount of stimulus change between the increase and decrease conditions such that, e.g., both the 80-to-70 group and the 70-to-80 group had intensity changes of 10 db, etc.

Procedure

In general, the procedure consisted of: preliminary training in which the *S*s learned to bar press for food pellets; pretesting of the auditory stimulus which was to be the conditioned stimulus; and CER acquisition, in which CS-US sequences were superimposed on the operant behavior.

Preliminary training. The acquisition of the bar press response involved, on the first day of preliminary training, an initial presentation of 40 "free" food pellets on a one minute variable interval schedule. This "magazine training" was immediately followed by a period in which the *S* could obtain food only via bar presses.[6] The *S* was removed from the Skinner box after 80 responses on a continuous reinforcement schedule. From the second day through the remainder of the experiment, the animals were reinforced on a 2.5 minute variable

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[6]In any case in which the *S* did not press the bar on his own within an hour, a small amount of wet mash was placed on the bar to facilitate shaping of the bar press response.

interval schedule, and the daily session for each S was two hours in duration. White noise at one of six intensities (including zero) was continuously present in each Skinner box on all experimental days after the second day of preliminary training. This basic background noise level was always the same for an individual S, but was varied between groups (cf. Table 2.).

Pretest. On Day 6, the Ss were administered four pretest trials. Each trial consisted of a three minute period during which the white noise level was switched to an intensity different from the normal background level. These changed noise intensities, which during conditioning were to be the CSs, were presented 19, 55, 95, and 115 minutes after the beginning of the session.

CER Acquisition. Conditioning of the CER was begun on Day 7, and continued for a total of eight days. The procedure was the same as in Pretest, except that a .5 second shock was delivered simultaneously with the termination of each three-minute CS. There were, therefore, four CS-UCS sequences during each two-hour, CER acquisition day. These sequences were superimposed on the bar-pressing behavior, programmed independently of it.

Measures. The "suppression ratio" adopted by Kamin (1961) was used as the index of amount of CER conditioning. The ratio is $\frac{B}{A + B}$, where "B" is the number of bar presses made during the three-minute CS, and "A" is the number made during the three minutes immediately preceding the CS. A ratio of 0.50 would mean that the same number of responses was made in the CS period as in the Pre-CS period. Complete suppression of bar pressing during the CS would give a ratio of 0.00. And 1.00 represents the theoretically possible case in which there were no responses in the Pre-CS period, but at least one during the CS. Thus, the suppression ratio should begin at about .50 and tend toward .00 as conditioning proceeds.

The recording methods permit the use of ratios based on individual trials or on the daily session (four trials) as a whole. (The responses for the respective periods are summed in the latter case).

With regard to the (rare) occasions in which there are no responses in either the Pre-CS or CS periods, the usual procedure has been to assign to that trial the mean of the ratios for the trials occurring before and after the one in question.[7]

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[7]There were four cases in which estimates of this type were made. In four other cases the baselines remained at zero for too long a period to permit estimation of the ratios. Replacement Ss were run later in the experiment. These cases did not occur predominantly in any one experimental group.

CHAPTER FOUR

RESULTS

CER Acquisition

The major points of interest in the data are the differences in rate of acquisition of the CER as functions of (a) differences in amount of stimulus change and (b) different directions of stimulus change.

In Figure 1 are presented the CER acquisition curves for each of the five groups in the DECREASE condition (for which the CS was a decrease in white noise intensity). The daily ratios of the eight Ss in a group were computed individually for each day, pooling the data for the four daily trials. The means of these daily ratios constitute the data points in Figure 1. Each curve is labeled with the number of decibels by which the intensity was decreased. While all five groups show some conditioning, the effect of amount of intensity change is obvious. The least conditioning occurs with a 10 decibel change; suppression then increases as a function of amount of change until, with 35 and 80 db changes, an asymptote appears to be reached.

Figure 2 portrays the analogous data for the five INCREASE groups. Here also, the least suppression occurs with the least stimulus change which, in this case, is a 10 db increase in intensity. However, the remaining four groups appear quite similar to each other; they all acquire the CER very rapidly.

The effect of direction of stimulus change may be seen more clearly in Figure 3, in which is plotted the mean "overall ratio"

Figure 1. DECREASE condition. Mean suppression ratio for each of the five groups on Pretest day, and on 8 CER days. Curves are labeled with amount of intensity change in decibels.

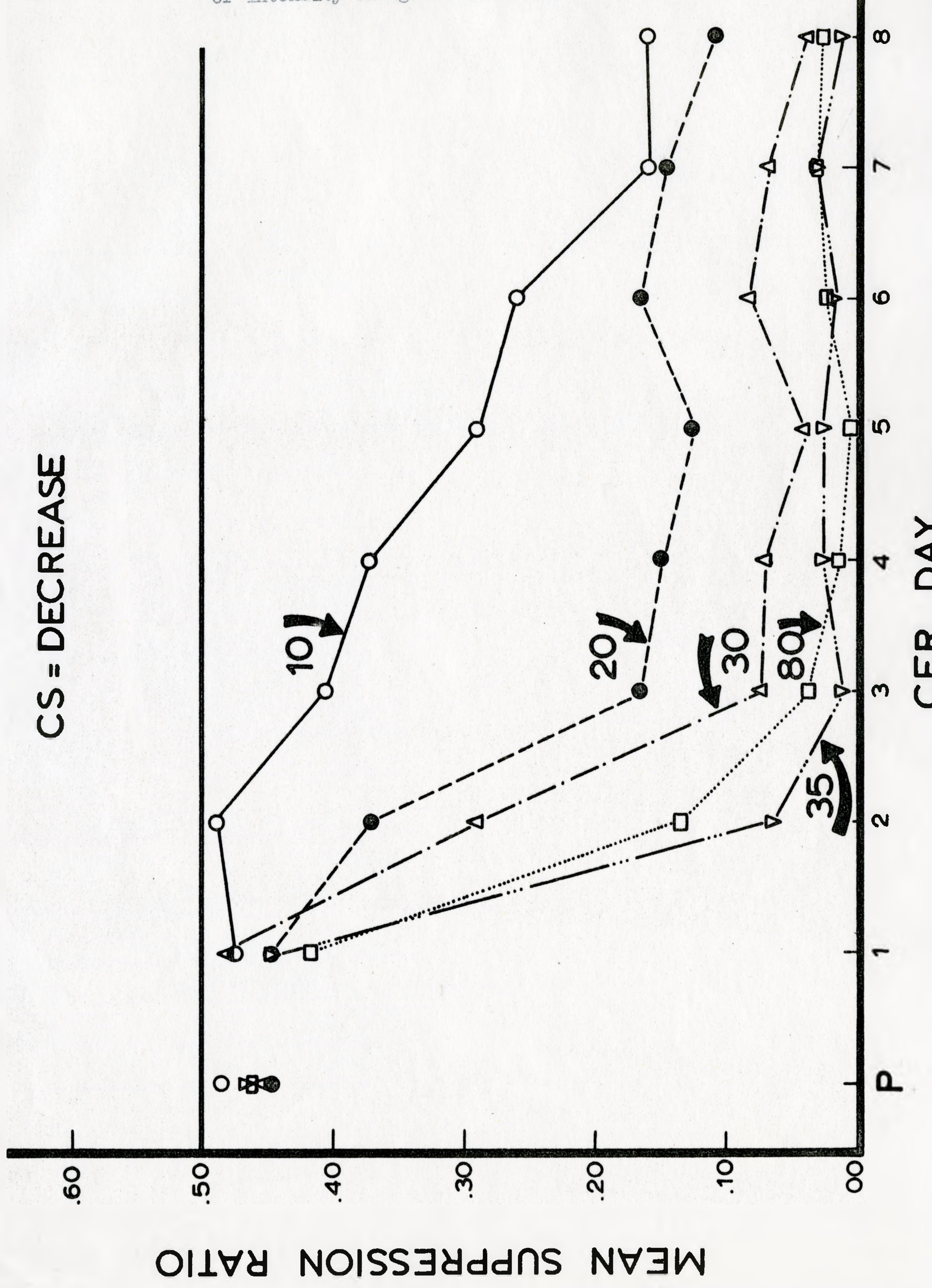


Figure 2. INCREASE CONDITION. Mean suppression ratio for each of the five groups on Pretest day, and on 8 CER days. Curves are labeled with amount of intensity change in decibels.

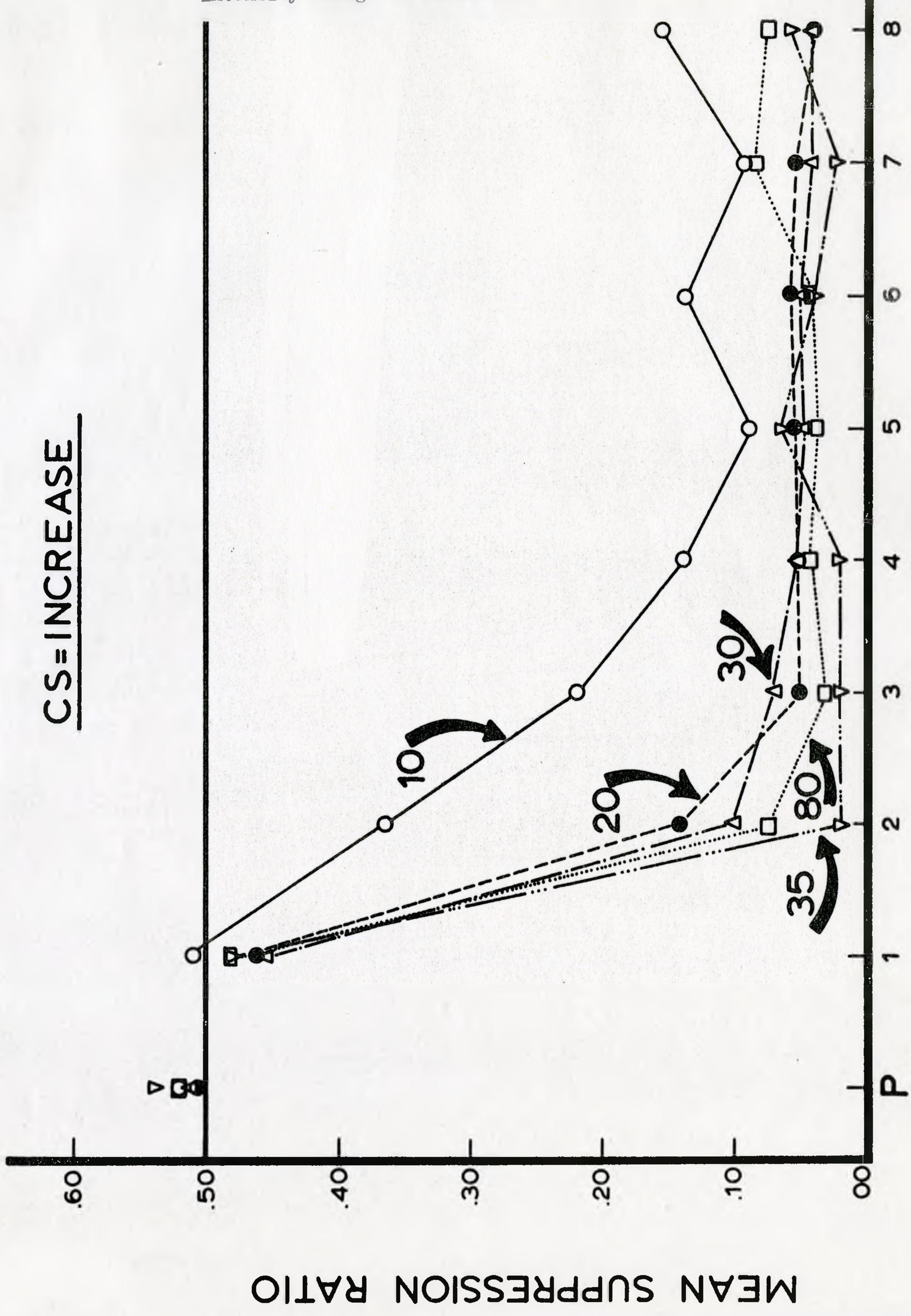
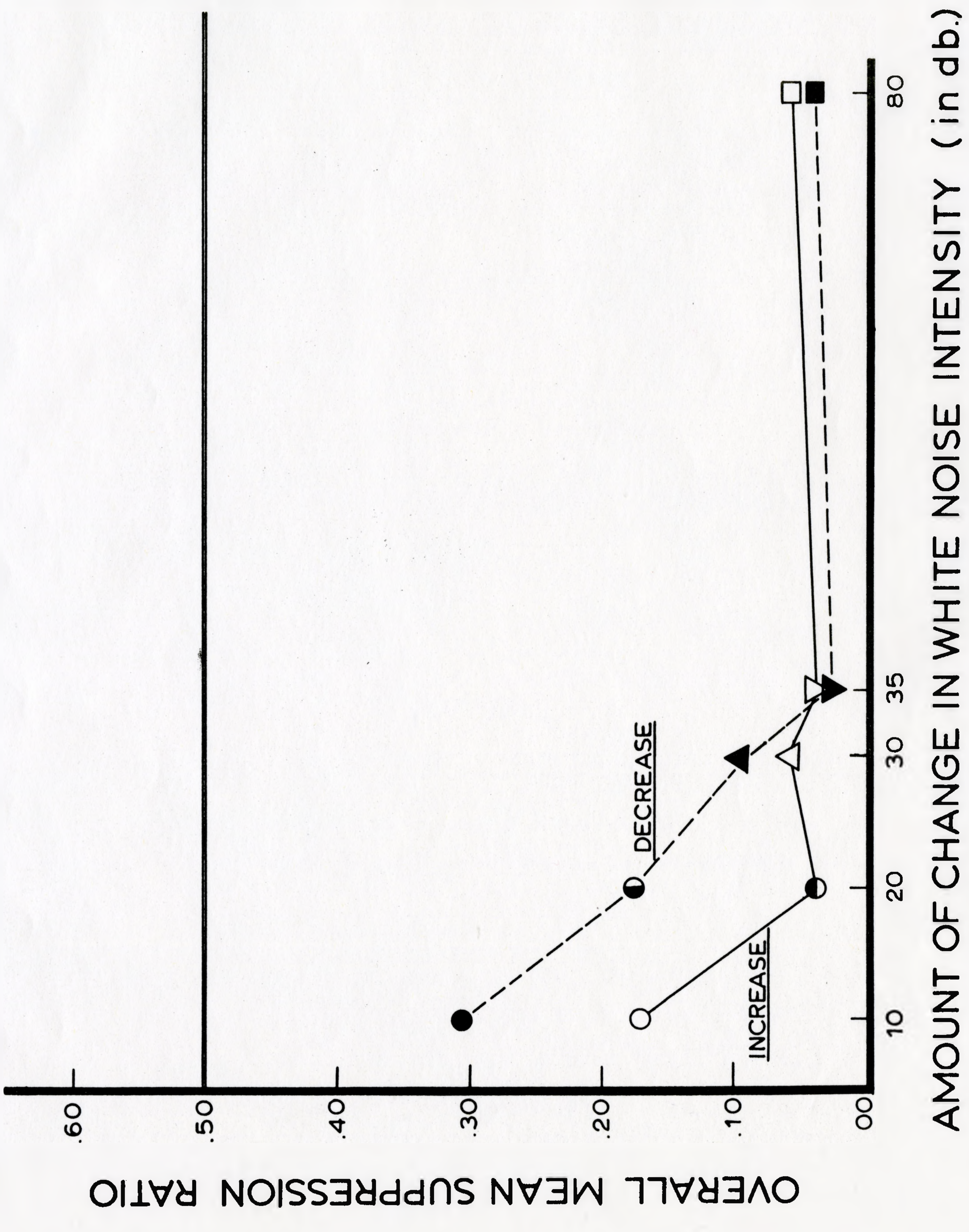


Figure 3. Mean overall suppression ratios, over CER days 2-8, for the five INCREASE and the five DECREASE groups. Each data point is the mean for one group.



for each group, averaged over CER days 2 through 8.[8] For both the DECREASE and INCREASE procedures, suppression appears to be a monotonic function of amount of stimulus change. When the intensity change is relatively small, an increase is more effective than a decrease; but when the intensity change is large, both procedures appear to produce asymptotic suppression. These conclusions are supported by statistical analysis. The overall mean ratios were submitted to a 2 x 5 analysis of variance (see Table 3a for summary). There were significant main effects of direction of change ($p < .005$) and of amount of change ($p < .001$), as well as a significant interaction ($p < .01$). A multiple comparison of the group means (Tukey <u>a</u> procedure as described by Winer, 1962) indicated that the following differences between groups were significant at better than the .05 level (see Table 3b for a summary of all differences between groups):

1) Within the DECREASE condition, the 80-70 group showed less suppression than the other four groups; the 80-60 group suppressed less than the 80-45 and 80-0 groups.

2) Within the INCREASE condition, the 70-80 group suppressed less than the 60-80 and the 45-80 groups.

3) With respect to the two directions of intensity change, the INCREASE procedure was more effective than the DECREASE when the stimulus was altered by 10 db or 20 db, but there was no significant difference when the change was of greater amounts.

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[8] The ratio for Day 1 was omitted from the overall ratio (following Kamin, 1961) since "conditioning" can not possibly occur until the first US is presented at the <u>end</u> of trial 1, and since suppression characteristically does not appear until Day 2. The "overall ratio" is simply the mean of an animal's ratios for each of Days 2 through 8.

TABLE 3a

Summary of analysis of variance of mean overall suppression ratios

(CER days 2-8)

SOURCE	d.f.	SS	MS	F
Direction of Change (A)	1	63788.5	63788.5	10.56**
Amount of Change (B)	4	434991.0	108747.7	18.01***
A x B	4	91164.0	22791.0	3.77*
Within (error)	70	422779.9	6039.7	

* $p < .01$

** $p < .005$

*** $p < .001$

TABLE 3b

Summary of Multiple Comparisons of Ten Groups for CER Acquisition

Critical differences between group totals:

$q_{.99}(10,70)\ \sqrt{nMS_{error}}$ = 1199 ** $p < .01$

$q_{.95}(10,70)\ \sqrt{nMS_{error}}$ = 1023 * $p < .05$

	DECR. 80 to70	80 to60	80 to50	80 to45	80 to0	INCR. 70 to80	60 to80	50 to80	45 to80	0 to80
DECR. 80-70		*1038	**1695	**2224	**2127	*1070	**2148	**1977	**2155	**1993
80-60			657	*1186	*1089	32	*1110	939	*1117	995
80-50				529	432	625	453	282	460	298
80-45					97	*1154	76	247	69	231
80-0						*1057	21	150	28	134
INCR. 70-80							*1078	907	*1085	923
60-80								171	7	155
50-80									178	16
45-80										162
0-80										

Pretest

We consider now the effects of CS-presentation on the Pretest day.

In Figures 4 (a) and (b) are shown, separately, the mean suppression ratios for the INCREASE and DECREASE groups when they were tested with their "to-be-conditioned" stimuli for four consecutive trials. Mean suppression (or "facilitation" if the ratio is greater than .50) is plotted as a function of Pretest trial. The effects which are discernable in these graphs are relatively small, but nevertheless quite consistent. On Trial 1, both directions of intensity change tend to produce a modest decrement in response rate. On the remaining trials, the Ss presented with an intensity decrease continue to show a response decrement. However, the curves for the five INCREASE groups move upward to values which are almost all greater than .50. An analysis of variance of Pretest ratios (Lindquist, 1953, Type III), summarized in Table 4, indicates a significant main effect of direction of intensity change ($p < .001$) and a significant interaction between Trials and Direction of change ($p < .05$). Amount of stimulus change was not a significant factor with respect to Pretest ratios. Thus, the analysis confirmed that INCREASE Ss had higher Pretest ratios than the DECREASE Ss, and that this difference occurred primarily during the later Pretest trials.

The question now arises as to whether the ratios slightly above and below .50 represent genuine facilitation and disruption of bar pressing when the CS is presented. There is no guarantee, of course, that "dummy ratios" slightly above or below .50 would not have occurred had the CS not been introduced. That is, over a two hour experimental

Figure 4 (a & b). Mean Pretest ratios for each trial for each of the five DECREASE groups (a) and the five INCREASE groups (b). Note that the ordinate has been expanded over that of previous graphs. Curves are labeled with amount of intensity change in decibels.

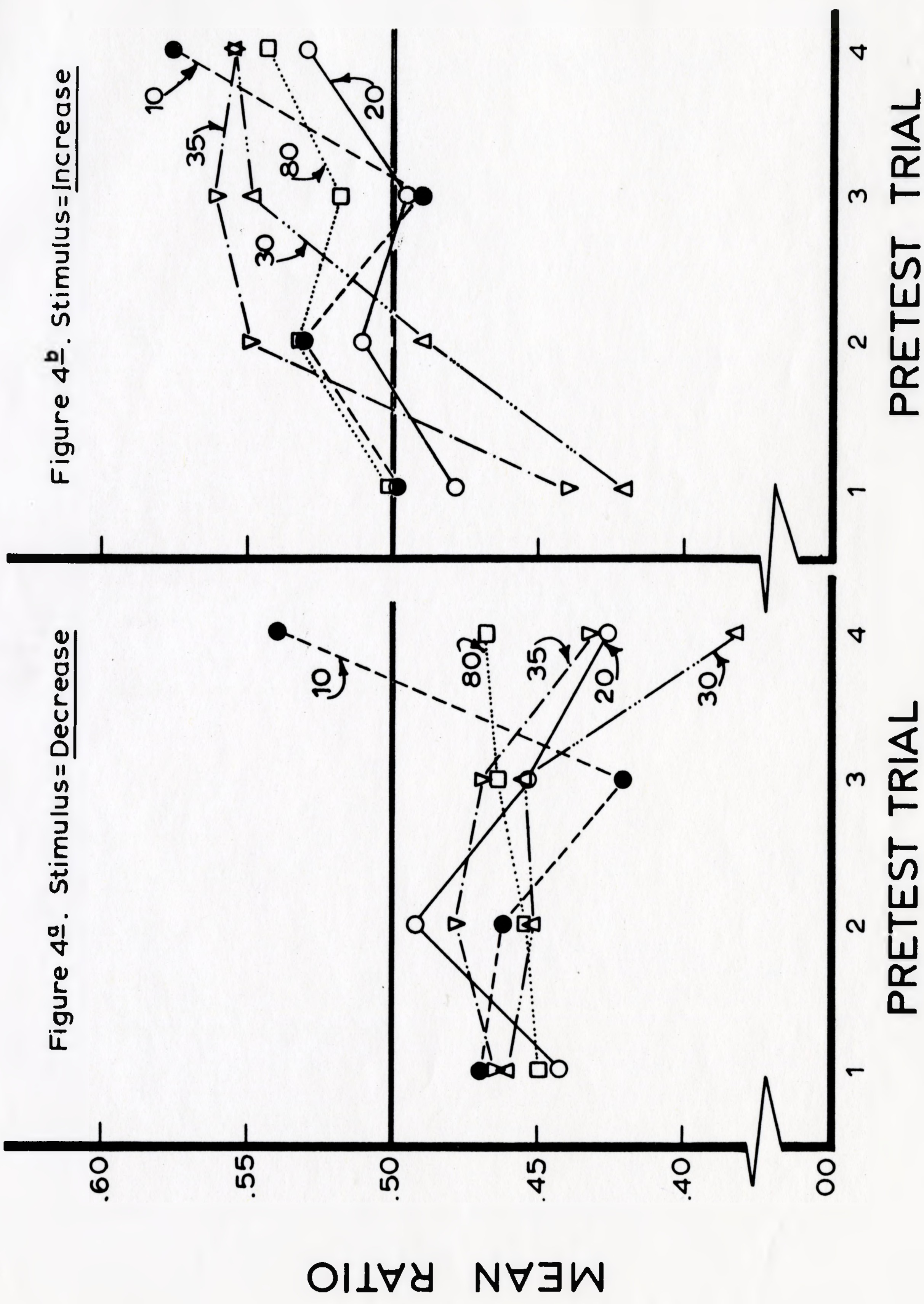

TABLE 4

Summary of analysis of variance of Pretest suppression ratios.

SOURCE	d.f.	SS	MS	F
Between Subjects:				
Amount of change (B)	4	338.9	84.7	—
Direction of change (C)	1	2808.4	2808.4	22.70**
B x C	4	42.8	10.7	—
Error (b)	70	8656.7	123.7	
Within Subjects:				
Trials (A)	3	681.6	227.2	
A x B	12	1136.5	94.7	—
A x C	3	874.8	291.6	2.83*
A x B x C	12	815.5	68.0	—
Error (w)	210	21672.1	103.2	

** p .001

* p .05

session there might have been a gradual change in response rate anyway, as the result, e.g., of food satiation, reinforcement contingencies, etc. Further analysis of these ratios consisted, therefore, of the following comparison. For each S, a single suppression ratio was calculated from the pooled response frequencies of the last two trials of Pretest day. A second ratio was calculated for the last two "dummy" trials[9] of the previous day of preliminary training, and the S was assigned either a plus or a minus depending on whether the Pretest ratio was greater or less than the comparable dummy ratio of the preceding day. The binomial test revealed a significant ($p = .007$) "facilitation" effect for the INCREASE Ss. A similar analysis of the five groups in the DECREASE condition confirmed that in this case the Pretest ratios were lower ($p = .02$) than the same Ss' dummy ratios for the day before. Thus, while the initial Pretest CS presentation appears to disrupt bar-pressing for both INCREASE and DECREASE Ss, the later CS presentations continue to disrupt bar-pressing for the DECREASE Ss, but actually facilitate bar-pressing for INCREASE Ss. These effects are quantitatively small, but significant. Further, it should be noted that whereas during Pretest the INCREASE condition produced higher ratios than did the DECREASE condition, exactly the reverse was true during CER training.

Baseline Response Rates

In the remainder of this section, an examination will be made

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[9] "Dummy" trials occurred during preliminary training at the same times within a session as did regular trials during CER training, but they consisted only of recording responses without presenting the S with a stimulus.

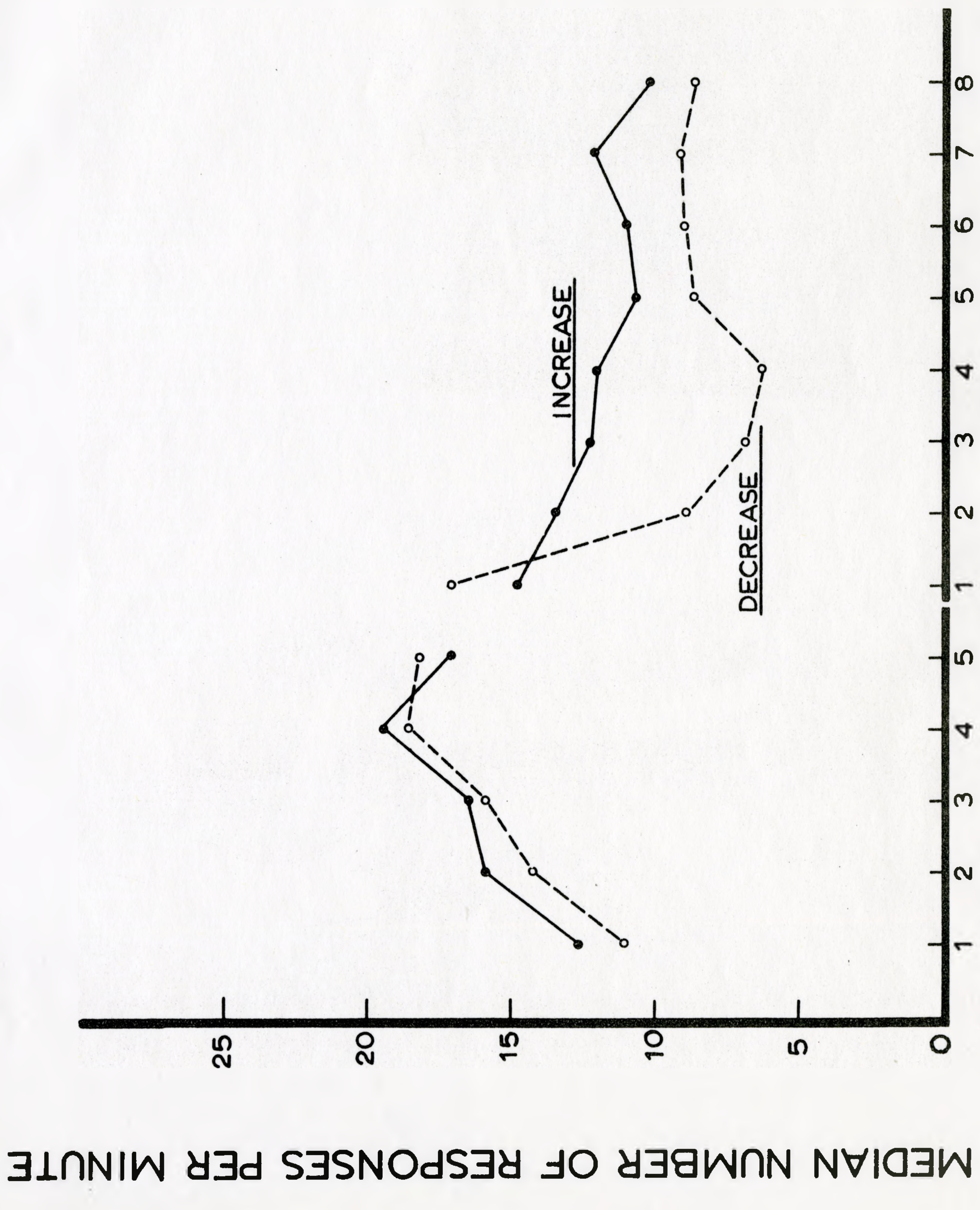
of possible differences between groups in the baseline rate of bar-pressing. As will be seen, this aspect of the data can be a source of difficulties, since baseline rates are relatively variable and appear to be highly sensitive to small, uncontrolled variations in day-to-day temperature, S's body weight, etc. It should also be pointed out that while significant differences in baseline rates were found in the present study, they do not seem to be related to our findings with respect to CER acquisition. This conclusion is made primarily on the basis of data (Theodor, 1963) which was collected after the present experiment, and which will be taken up in the Discussion section.

The frequencies of responding within the Pre-CS periods (or "dummy" Pre-CS periods in the case of the Pretraining days) were used as an index of baseline bar-pressing rates.

A general indication of the changes in baseline responding is provided by Figure 5 in which the median baseline response rate (responses per minute) for the INCREASE (pooled) and DECREASE (pooled) subjects are presented for each day of the experiment. The predominant tendency is for response rate to increase during Pretraining to a maximum on the fourth and fifth Pretraining days, to decrease during the first few days of CER acquisition, and finally to increase somewhat over the remaining CER days. This general pattern has been obtained in earlier CER studies (e.g., Annau and Kamin, 1961). However, it also appears that the median for the DECREASE Ss is below that for the INCREASE Ss, particularly during CER training.

The difference between INCREASE and DECREASE Ss during Pretraining was not significant. There was a significant effect,

Figure 5. Median baseline response rates for $\underline{S}$s in the DECREASE and INCREASE conditions for each day of the experiment.



however, over CER days 2-8. For the latter seven days, the response frequency scores were transformed[10] and an overall mean then calculated for each S. A 2 x 5 analysis of variance of these means (summarized in Table 5) indicated a significant ($p < .01$) difference between the INCREASE and DECREASE Ss. There was no significant effect of the Amount-of-change variable, nor was there a significant interaction between the two factors. These relationships are evident in Figure 6, which shows the overall mean of the (transformed) response scores for each of the ten groups; each data point is the mean of eight S means. Four of the five DECREASE means are below the means for the corresponding INCREASE condition. However, a multiple comparison of these means (Tukey a procedure, Winer, 1962) disclosed only one significant difference within the set of ten means: that between the 60-80 INCREASE and 80-45 DECREASE groups ($p < .01$).

Within this experiment, the only further evidence which might have a bearing on the baseline differences is the fact that the DECREASE Ss (most of which were run before the INCREASE Ss) were prone to be a few grams above their respective "75%" (of ad libitum) weights. For example, on CER day 4 the tendency to be slightly over-weight rather than slightly under-weight was significant ($p = .0026$, binomial test). The INCREASE Ss, however, were almost evenly distributed above and below 75% weight.

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10 $X' = \sqrt{X} + \sqrt{X + 1}$ where X = original number of responses and X' = transformed score.

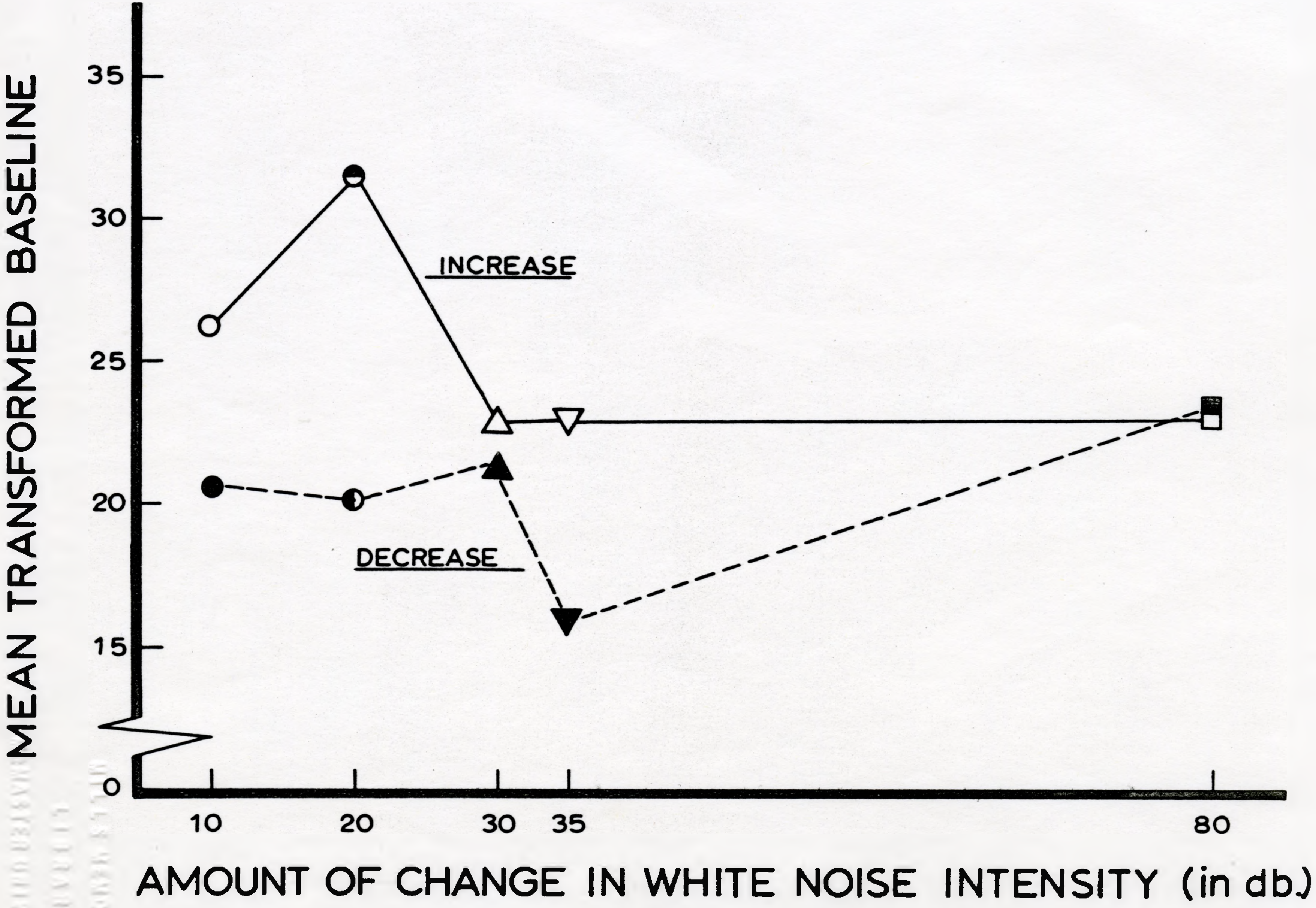

Figure 6. Overall means (CER days 2-8) of transformed baseline response frequencies. Each data point is the mean for one of the ten groups. INCREASE groups are on solid line; DECREASE on dotted line.

TABLE 5

Summary of analysis of variance of transformed Baseline response rate scores, CER days 2 - 8.

SOURCE	d.f.	SS	MS	F
Direction of Change (A)	1	489.1	489.1	7.53*
Amount of Change (B)	4	358.4	89.6	1.38
A x B	4	354.0	88.5	1.36
Error (w)	70	4546.9	65.0	

* $p < .01$

CHAPTER FIVE

DISCUSSION

There are two major findings in the present experiment. The first is that the rate of acquisition of the CER is clearly a monotonic function of the amount by which the CS differs in intensity from the background level of stimulation. The fact that this was true for the DECREASE, as well as the INCREASE, procedure suggests that it may not be necessary to postulate any "intensity dynamism" effect to account for the gradients revealed by previous "traditional" studies of CS intensity. The traditional studies confound intensity and amount of change; but the same type of orderly gradient has now been produced when amount of change was varied appropriately while absolute intensity of the CS was varied in the inverse direction to that employed in traditional studies.

With regard to the five DECREASE groups, it will be recalled (cf. p. 4) that the combined action of the hypothesized principles of "intensity dynamism" and "differential conditioning" might have produced a <u>non-monotonic</u> function. That is, with lower and lower CS intensities, generalized inhibition of the "fear" response from the 80 db background might detract less and less from the response strength, and response strength would increase. Below the intensities at which the generalized inhibition was operative, a dynamism factor might lead to worse conditioning with lower CS intensities (i.e., with <u>greater</u> amounts of change from the background intensity). However, the data of the present experiment provide no evidence of such a reversal. With large amounts of intensity change, rate of conditioning increases to an asymptote but does not thereafter decrease. If the data for the DECREASE procedure and for the INCREASE procedure are considered independently, the Perkins-Logan differential conditioning hypothesis would seem to provide an adequate explanation.

However, the specter of "intensity dynamism" reappears when the INCREASE and DECREASE procedures are compared at fixed amounts of stimulus change. The second major finding of the experiment is that, as long as amount of intensity change is not too great, the INCREASE Ss show the more rapid learning; this result at least suggests the possibility that the absolute intensity of the CS may be an important variable even when, in at least one sense, the amount of change from the background stimulation has been controlled. We should point out that the difference in CER acquisition between the INCREASE and DECREASE conditions cannot be attributed to the differences in baseline rates with which, in this experiment, they were associated. Recent experimentation has confirmed the significantly greater efficacy of the INCREASE procedure in a comparison of a 70-50 db group with a 50-70 db group (Theodor, 1963). In this case the INCREASE group had the lower baseline rate. Hence, it seems clear that in the present study the association between baselines and the effects of direction of change was coincidental, and that the baseline differences should be interpreted in terms of uncontrolled variations in temperature, body weights, etc.

While the direction-of-change effect is thus a reliable phenomenon, it is not unambiguously interpretable. As was indicated in the introduction (p. 2), "traditional" studies of CS intensity confounded amount of intensity change with absolute intensity of the CS; but with the present approach, it is direction of change that is confounded with intensity. The structure of the present experiment was such that in all five INCREASE groups the intensity of the CS was 80 db. Perhaps, if a comparison were made between an increase and a decrease, by "equal" amounts, to a single CS value, there would be no difference in conditioning. But for this to be accomplished, it would be necessary to have an adequate equal interval scale for the rat. The CSs for such an experiment are diagramed in Figure 7 as A and C. This kind of scale would also be necessary for determining whether "percentage change" (or some similar measure of the relative values of CS and background intensity) were a relevant variable. E.g., comparisons might be made between A and D and between B and D of Figure 7.

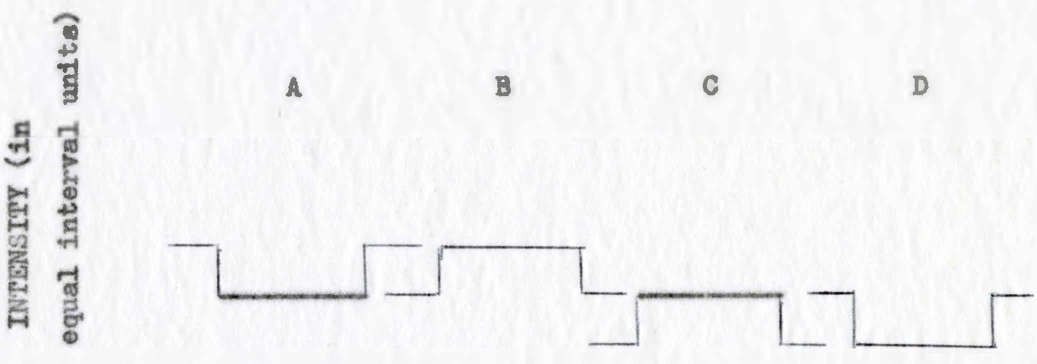

Figure 7. Schematic diagram of four possible CSs. The amount of change in intensity is the same for all four, according to a rat "equal interval scale".

Within the present experiment, there is one remaining piece of evidence bearing on the direction-of-intensity-change question.

This consists of the unconditioned effects of the CSs prior to their pairing with shock. If the change in white noise intensity is a decrease, the predominant tendency during all pretest trials is for the rat to suppress to a small but reliable extent. This is not too surprising, since one would expect any suprathreshold, novel stimulus to have a "distracting" effect. Under the INCREASE condition, a similar suppression occurs on the first pretest trial. Less explicable, however, is the fact that these Ss show an increase in bar pressing during subsequent pretest trials. Two aspects of these phenomena seem noteworthy. First, the amount of stimulus change had no significant effect; only the direction. Second, the effects on pretest ratios do not in any simple way predict the effects on CER acquisition ratios. The effects (on bar pressing) of the INCREASE and DECREASE conditions, relative to each other, are reversed from one stage to the next.

The Pretest results have been repeatedly replicated in this laboratory, but we have no adequate explanation of the finding. One might conceivably interpret the increased bar pressing during pretest presentation of a noise increase as a result of an "energizing" effect of increased stimulation on performance. The noise increase might be acting as a "drive source" in the sense discussed by Brown (1961, Chapter 2). That is, the effect of intensity change would not be specific to the bar press response but, instead, would influence whatever response tendency is dominant at the moment. Thus the bar press response is facilitated during pretest. We should now have to assume that, during acquisition, fear is for some reason more energized than is bar pressing, and that fear, of course, interferes with bar pressing. However, there is no independent evidence to support this speculation. The differential effects of increased and decreased stimulation on pretest performance are, in any event, real phenomena; and it is possible that an improved understanding of them would shed light on the effects of such stimulation on CER acquisition.

Another interpretation of the difference in efficacy of the INCREASE and DECREASE procedures in CER acquisition is concerned with the previous conditioning experience of the Ss. An analysis of the extra-experimental-space life of the rat might reveal, for example, that unconditioned stimuli are most often paired with CSs which fall into our INCREASE category. That is, "important events," such as presentation of food, cats, dogs, caretakers, etc., might tend to occur in conjunction with an ONset of an auditory stimulus followed by its OFFset (......), rather than with an OFFset followed by an ONset (......). Certainly it is not the case that, e.g., cat sounds are normally present when the cat is away and that they disappear when the cat arrives! If it were, in fact, true that INCREASE stimuli were predominant in a rat's life, there would presumably be positive transfer to new conditioning situations in which the CSs were of the INCREASE variety. This type of interpretation, of course, does not depend on the postulation of an "energizing" effect of INCREASE stimuli.

SUMMARY

This thesis has been concerned with intensity characteristics of conditioned stimuli in acquisition of a conditioned emotional response (CER) in rats. A comparison was made of CSs which differed (between groups of 8 rats each) with respect to amount and direction of change in white noise from a constant background stimulation level. The measure of conditioning was the degree to which the CS disrupted ongoing, food-motivated, bar-pressing activity.

The major conclusions were as follows.

1) Rate of conditioning was found to be a montonic increasing function of amount of intensity change in either direction. This finding supports a "differential conditioning" theory as opposed to an unmodified (Hullian) "intensity dynamism" theory.

2) An increase in noise intensity from background X to CS Y produced more rapid acquisition of the CER than did a decrease from background Y to CS X. This effect of "direction of change" suggests the existence of a factor in addition to a differential conditioning process. What exactly this factor is, is not clear since a number of variables are confounded: e.g., "direction of change", absolute intensity of the CS, and "percentage change" (or other expressions of the relative intensities of the CS and the background).

3) Finally, during pretests of the to-be-conditioned stimuli, it was found that a noise increase produced a slight suppression followed by a small, but reliable, increase in rate of bar-pressing; whereas, a noise decrease produced only a slight suppression. The suppression seems attributable to a "distraction" effect common to any

novel stimulus; the facilitation might encourage speculation about an "energizing" effect related to CS intensity.

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APPENDIX A

RAW DATA: SUPPRESSION RATIOS

For each trial of Pretest day, for Pretest day as a whole, and for each CER day.

SUPPRESSION RATIOS

		Pretest (PT) trial				PT				CER DAY				
	S	1	2	3	4	Day	1	2	3	4	5	6	7	8
INCREASE 70-80	1	.53	.51	.52	.62	.54	.55	.42	.45	.57	.33	.47	.29	.40
	2	.41	.41	.48	.51	.45	.49	.44	.19	.01	.00	.04	.03	.02
	3	.54	.48	.49	.60	.52	.52	.47	.10	.06	.00	.02	.09	.05
	4	.51	.51	.52	.57	.53	.52	.45	.29	.10	.05	.22	.07	.10
	5	.46	.48	.52	.47	.49	.52	.07	.03	.00	.01	.11	.03	.13
	6	.60	.70	.19	.76	.54	.46	.32	.36	.24	.14	.11	.16	.25
	7	.48	.55	.51	.49	.51	.48	.26	.08	.02	.01[E]	.00	.00	.00
	8	.46	.60	.69	.59	.59	.54	.49	.28	.11	.17	.13	.08	.30
INCREASE 60-80	1	.46	.28	.46	.52	.48	.29	.00	.00	.00	.00	.05	.01	.00
	2	.58	.58	.51	.39	.51	.39	.01	.00	.00	.00	.00	.06	.03
	3	.35	.55	.54	.62	.51	.54	.16	.03	.03	.03	.00	.04	.00
	4	.53	.70	.57	.80	.62	.54	.24	.12	.26	.38	.33	.26	.17
	5	.47	.57	.52	.51	.52	.50	.04	.01	.01	.00	.00	.01	.01
	6	.41	.44	.44	.46	.44	.45	.43	.23	.10	.01	.06	.05	.05
	7	.53	.48	.47	.45	.48	.50	.02	.02	.01	.01	.02	.01	.06
	8	.49	.49	.46	.49	.48	.49	.23	.00	.01	.01	.01	.00	.01
INCREASE 50-80	1	.49	.48	.53	.53	.51	.50	.19	.00	.03	.02	.09	.05	.03
	2	.46	.46	.70	.63	.57	.61	.02	.00	.00	.00	.06	.05	.02
	3	.47	.53	.60	.57	.54	.51	.05	.00	.00	.00	.00	.01	.04
	4	.40	.48	.54	.49	.48	.39	.21	.52	.31	.30	.14	.18	.09
	5	.26	.44	.45	.52	.43	.39	.01	.00	.01	.00	.03	.01	.00
	6	.28	.47	.47	.56	.47	.44	.00	.00	.00	.00	.00	.01	.01
	7	.59	.53	.52	.60	.56	.54	.31	.04	.07	.07	.09	.03	.14
	8	.42	.52	.57	.55	.52	.25	.01	.00	.00	.00	.00	.00	.00

	S	Pretest (PT) trial 1	2	3	4	PT Day	CER DAY 1	2	3	4	5	6	7	8
INCREASE 45-80	1	.44	.55	.45	.49	.49	.48	.01	.00	.02	.01	.01	.00	.01
	2	.64	.58	.52	.43	.54	.46	.08	.12	.08	.33	.20	.03	.15
	3	.43	.58	.60	.55	.55	.48	.00	.01	.00	.00	.01	.07	.03
	4	.44	.71	.74	.71	.65	.39	.00	.00	.04	.02	.00	.00	.00
	5	.35	.50	.63	.55	.53	.46	.00	.00	.00	.00	.00	.00	.00
	6	.54	.52	.47	.53	.51	.59	.03	.00	.02	.03	.08	.03	.05
	7	.25	.42	.53	.59	.50	.44	.01	.01	.00	.00	.00	.01	.09
	8	.43	.53	.56	.58	.53	.53	.05	.04	.00	.10	.05	.05	.12
INCREASE 0-80	1	.79	.52	.54	.42	.54	.52	.03	.02	.00	.01	.00	.02	.00
	2	.46	.55	.48	.54	.51	.42	.01	.01	.01	.01	.02	.01	.01
	3	.59	.54	.55	.54	.55	.49	.09	.04	.15	.09	.04	.13	.09
	4	.45	.47	.54	.78	.56	.57	.26	.12	.10	.06	.12	.22	.30
	5	.47	.57	.53	.47	.50	.44	.05	.03	.02	.06	.03	.06	.03
	6	.50	.59	.40	.56	.52	.42	.14	.01	.04	.06	.05	.24	.16
	7	.29	.52	.60	.58	.52	.58	.00	.00	.01	.00	.04	.00	.00
	8	.46	.48	.50	.46	.47	.38	.01	.03	.02	.02	.04	.01	.01

	S	Pretest (PT) trial 1	2	3	4	PT Day	CER DAY 1	2	3	4	5	6	7	8
DECREASE 80-70	1	.51	.48	.46	.49	.49	.47	.44	.39	.33	.19	.10	.09	.07
	2	.58	.52	.40	.58	.52	.39	.39	.24	.32	.24	.11	.14	.14
	3	.55	.48	.47	.40	.46	.48	.51	.50	.66	.42	.40	.17	.25
	4	.52	.46	.53	.49	.50	.52	.45	.29	.04	.10	.05	.03	.06
	5	.46	.50	.51	.53	.50	.52	.50	.47	.42	.43	.26	.15	.10
	6	.31	.52	.55	.57	.51	.49	.54	.57	.57	.42	.55	.24	.13
	7	.48	.58	.00	.67	.50	.51	.52	.49	.44	.36	.48	.40	.41
	8	.34	.16	.45	.59	.41	.42	.56	.30	.20	.15	.13	.05	.12
DECREASE 80-60	1	.46	.47	.47	.40	.44	.47	.45	.12	.32	.20	.15	.05	.00
	2	.46	.45	.51	.43	.46	.49	.36	.12	.00	.01	.00	.01	.00
	3	.35	.50	.16	.25	.31	.31	.26	.00	.00	.09	.02	.13	.09
	4	.47	.48	.52	.53	.50	.51	.53	.14	.08	.34	.27	.30	.12
	5	.51	.45	.49	.38	.46	.41	.30	.17	.03	.06	.06	.02	.02
	6	.44	.49	.48	.45	.46	.51	.49	.34	.39	.13	.55	.47	.36
	7	.49	.55	.50	.47	.50	.47	.50	.26	.07	.04	.05	.14	.12
	8	.36	.55	.50	.50	.45	.41	.08	.17	.29	.13	.23	.05	.15
DECREASE 80-50	1	.48	.44	.49	.42	.45	.46	.45	.03	.05	.10	.27	.20	.08
	2	.56	.42	.40	.38	.43	.48	.48	.07	.17	.00	.01	.02	.00
	3	.45	.49	.38	.41	.44	.41	.02	.00	.01	.00	.00	.00	.00
	4	.45	.38	.54	.49	.48	.48	.49	.36	.14	.01	.10	.12	.07
	5	.56	.43	.49	.00	.48	.51	.20	.00	.00	.12	.07	.06	.09
	6	.36	.55	.53	.52	.52	.56	.26	.00	.09	.00	.09	.08	.00
	7	.44	.44	.46	.45	.45	.44	.10	.05	.05	.02	.02	.03	.01
	8	.38	.47	.35	.39	.40	.50	.33	.07	.05	.06	.09	.02	.02
DECREASE 80-45	1	.33	.49	.47	.00	.37	.24	.00	.00	.00	.00	.00	.00	.00
	2	.42	.45	.38	.51	.44	.50	.05	.03	.06	.04	.00	.01	.00
	3	.42	.48	.47	.45	.46	.44	.01	.01	.02	.01	.04	.10	.03
	4	.73	.53	.50	.49	.54	.46	.31	.00	.01	.05	.11	.14	.07
	5	.42	.38	.47	.54	.46	.40	.00	.00	.00	.00	.00	.00	.00
	6	.49	.43	.64	.43	.49	.50	.12	.06[E]	.04[E]	.02[E]	.00	.00	.00
	7	.36	.45	.53	.12	.40	.47	.00	.00	.04	.02	.00	.00	.00
	8	.55	.61	.29	.92	.57	.57	.02	.00	.03	.07	.00	.00	.00

	S	Pretest (PT) trial 1	2	3	4	PT Day	CER DAY 1	2	3	4	5	6	7	8
DECREASE 80-0	1	.38	.56	.43	.52	.47	.43	.10	.01	.01	.00	.09	.01	.02
	2	.44	.37	.39	.29	.37	.34	.00	.00	.00	.00	.00	.01	.00
	3	.45	.48	.43	.50	.47	.31	.16E	.00	.00	.01	.00	.01	.00
	4	.50	.45	.53	.46	.48	.47	.32	.02	.02	.01	.00	.15	.19
	5	.46	.34	.45	.50	.44	.45	.33	.25	.09	.02	.05	.07	.00
	6	.35	.41	.41	.57	.45	.41	.03	.02E	.00	.00	.00	.00	.03
	7	.45	.54	.51	.51	.51	.48	.13	.01	.00	.00	.03	.00	.00
	8	.57	.48	.56	.39	.50	.45	.01	.00	.00	.00	.00	.00	.00

APPENDIX B

RAW DATA: BASELINE RESPONSE FREQUENCIES

For each of the five Pretraining days, including Pretest day, and for each CER day. Each number is the sum of the responses in the four Pre-CS (or "dummy" Pre-CS periods) of a session.

BASELINE RESPONSE FREQUENCIES

		Pretraining Day					CER DAY							
	S	1	2	3	4	5(PT)	1	2	3	4	5	6	7	8
INCREASE 70-80	1	114	154	183	233	143	118	128	100	68	91	53	83	58
	2	252	258	358	569	508	470	444	409	395	302	441	607	644
	3	121	107	155	174	160	154	127	94	144	126	124	182	106
	4	227	337	295	302	253	244	264	235	189	258	146	226	234
	5	298	458	364	368	475	459	317	188	301	350	437	392	366
	6	182	202	289	278	200	221	326	353	280	315	269	229	280
	7	203	136	174	197	175	113	74	12	40	0	40	51	63
	8	85	105	109	96	102	89	66	58	41	49	55	54	62
INCREASE 60-80	1	234	285	422	471	435	361	576	281	434	517	358	385	368
	2	144	130	179	123	75	92	81	54	68	75	74	84	100
	3	153	211	199	169	127	148	123	96	147	122	103	152	101
	4	172	142	167	175	114	141	101	72	82	77	126	187	138
	5	307	475	472	597	618	538	478	687	549	681	779	725	710
	6	201	308	362	318	374	421	330	342	208	228	229	210	243
	7	154	194	285	433	452	431	353	386	442	469	403	396	525
	8	163	310	457	497	539	528	274	97	99	128	103	277	433
INCREASE 50-80	1	104	147	202	252	254	247	207	223	272	252	138	248	184
	2	206	324	409	368	211	152	238	228	273	300	271	333	273
	3	87	54	49	125	47	66	52	20	52	46	42	68	47
	4	160	231	189	196	240	164	100	29	60	42	48	46	21
	5	100	120	96	120	120	60	96	64	86	117	71	160	186
	6	138	305	339	433	483	318	298	196	150	166	141	145	143
	7	151	155	190	124	273	230	203	198	158	182	227	140	126
	8	181	160	142	150	132	126	66	73	80	89	91	90	100

	S	Pretraining Day 1	2	3	4	5(PT)	CER DAY 1	2	3	4	5	6	7	8
INCREASE 45-80	1	145	344	332	287	294	251	215	216	343	232	192	243	188
	2	149	317	291	237	171	179	89	52	60	51	45	112	47
	3	73	174	204	175	137	183	186	172	213	295	298	286	249
	4	98	72	42	39	65	86	22	63	53	56	66	73	52
	5	98	156	86	107	136	134	92	66	73	84	107	68	82
	6	139	208	171	132	220	109	163	153	156	226	165	114	91
	7	131	151	168	232	252	207	189	142	162	118	125	146	63
	8	184	187	232	246	153	174	230	204	122	128	142	102	146
INCREASE 0-80	1	174	157	160	137	118	81	35	65	79	83	87	103	114
	2	139	186	196	254	190	161	165	149	153	134	164	166	172
	3	147	162	166	186	160	190	104	49	105	118	120	146	118
	4	187	246	274	297	310	275	159	170	152	128	85	128	86
	5	151	275	172	157	156	177	143	107	93	107	83	61	68
	6	182	235	281	266	271	308	117	147	104	377	231	76	86
	7	135	209	304	242	241	84	69	173	119	170	175	91	107
	8	107	178	198	44	266	256	325	166	227	362	208	173	286

		Pretraining Day					CER DAY							
	S	1	2	3	4	5(PT)	1	2	3	4	5	6	7	8
DECREASE 80-70	1	117	185	193	256	259	292	205	117	96	130	92	94	163
	2	100	187	179	187	123	254	78	35	50	64	47	84	57
	3	128	222	316	327	350	326	100	16	3	4	6	5	9
	4	268	415	316	337	371	287	190	145	135	225	226	263	316
	5	198	304	365	347	408	399	353	260	213	233	230	221	252
	6	86	85	75	76	117	121	52	6	15	51	18	16	34
	7	176	346	129	255	52	166	178	108	80	136	172	171	172
	8	118	266	209	195	166	138	155	62	59	137	221	296	244
DECREASE 80-60	1	177	229	136	121	193	303	139	113	104	105	129	103	147
	2	134	194	205	110	167	109	96	45	57	82	100	110	103
	3	210	168	171	136	85	134	53	48	53	74	56	65	105
	4	150	353	490	480	501	252	150	18	33	41	38	40	66
	5	133	147	221	307	357	387	159	138	94	279	232	244	189
	6	111	134	182	280	283	205	194	121	40	13	45	61	82
	7	190	255	250	218	233	281	263	287	252	297	329	344	351
	8	81	33	36	20	27	39	23	14	25	40	47	53	71
DECREASE 80-50	1	120	157	104	121	132	120	101	78	76	104	107	106	100
	2	111	157	162	242	249	223	46	40	19	60	132	165	90
	3	130	245	341	306	299	278	40	77	84	68	103	112	178
	4	161	158	191	244	279	256	220	218	153	146	161	127	162
	5	177	191	121	126	87	130	245	207	118	174	159	153	98
	6	199	103	69	61	74	80	64	37	32	50	48	70	43
	7	99	120	253	279	271	270	121	84	123	151	183	176	162
	8	132	201	215	250	280	246	207	196	214	135	177	183	181
DECREASE 80-45	1	95	113	121	66	61	50	85	89	55	66	67	49	59
	2	150	145	160	223	188	180	137	60	47	70	64	67	77
	3	72	154	184	260	412	287	80	104	94	152	168	155	128
	4	138	132	201	180	114	141	36	43	76	140	165	122	150
	5	90	150	169	211	235	260	38	0	10	40	61	52	77
	6	106	118	181	208	174	146	7	0	0	0	27	8	15
	7	58	63	77	129	184	133	56	49	68	82	84	142	142
	8	107	92	115	116	71	66	57	58	71	78	103	80	93

	S	Pretraining Day 1	2	3	4	5(PT)	CER DAY 1	2	3	4	5	6	7	8
DECREASE 80-0	1	174	408	433	510	452	441	480	420	313	274	275	438	458
	2	224	253	258	322	202	122	99	24	54	106	79	101	93
	3	134	183	182	242	203	97	0	110	97	111	111	122	68
	4	158	272	249	287	225	163	155	155	176	117	135	141	144
	5	98	136	219	126	244	218	190	161	207	225	190	242	220
	6	148	166	190	220	228	167	37	0	8	28	24	43	57
	7	148	176	199	224	212	206	171	91	90	97	109	77	71
	8	244	260	382	404	424	357	116	179	245	366	274	285	304