THE ACQUISITION AND REDUCTION OF RESPONDING IN RATS TO AUDITORY STIMULI OF DIFFERENT INTENSITIES

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ABSTRACT

THE ACQUISITION AND REDUCTION OF RESPONDING IN RATS TO AUDITORY STIMULI OF DIFFERENT INTENSITIES

By

Earl Donald Walker

Auditory intensity discrimination training involving two intensities of a pure tone and a "zero" intensity condition produced by the absence of the tone was given to two groups of rats that differed with respect to whether responding to the more or the less intense value of the tone was reinforced, while the remaining tone intensity for each group and the zero intensity condition were nonreinforced. It was found that reinforced responding ultimately reached higher levels in the presence of the more intense stimulus, while the training to reduce nonreinforced responding proceeded more quickly for the less intense stimulus but did not progress at different rates for the two groups during the zero stimulus condition. The net effect was a large overall superiority in discrimination learning for the group with the more intense stimulus reinforced. The results by themselves and in combination with previous findings appear to offer more support for a generalization of inhibition interpretation than for a strict stimulus intensity dynamism position.

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A THESIS

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To Robert L. Raisler

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INTRODUCTION

It has generally been found that when reinforcement is given in the presence of a stimulus (S+) but not in its absence, responding is acquired more quickly for more intense values of S+ (Gray, 1965). It has not been determined, however, whether the inverse intensity relationship holds for a nonreinforced stimulus (S-) that is added to the presence vs absence discrimination problem, ie whether training to reduce responding to S- through nonreinforcement proceeds more quickly for less intense values of S-.

The present study employed a discrimination problem that included two intensities of a training stimulus as well as a "zero" intensity condition produced by the absence of training stimuli. Two groups of subjects differed with respect to whether the greater or the lesser intensity of the training stimulus was reinforced, while the remaining stimulus intensity for each group and the zero intensity condition were nonreinforced. This arrangement allowed observation of response reduction as well as acquisition in the presence of stimuli at different distances from the

nonreinforced zero intensity condition. If the above relationships hold in the present case it is predicted that the group with the more intense stimulus as S+ should learn the discrimination more quickly, both in terms of response acquisition to the stimulus of greater intensity and response reduction to the stimulus of lesser intensity.

METHOD

Subjects

The subjects were eight experimentally naive male albino rats of the Holzman strain 90-120 days old at the beginning of the experiment. One subject died of respiratory disease midway through the study and was not replaced. The subjects were housed in individual living cages with food (Wayne Mouse Breeder Blox) and water available on an ad lib basis throughout the period of experimentation. Deprivation schedules were not used because they were found to be unnecessary in similar previous research (Walker, 1970) where "sucrose" pellet reinforcements were given.

Apparatus

The apparatus included an experimental space (inside dimensions 9" x 12" x 9") painted flat black and equipped at one end with a bar centered three inches above the

hardware cloth floor. A depression of the bar (barpress) enabled (at the discression of the experimenter) a single 4mm x 3.3mm x 45mg. Noyes "sucrose" pellet (reinforcement) to be automatically delivered to a foodcup located directly below the bar. Sound stimuli were produced by a Hewlett-Packard specification #20-222 CD wide range oscillator and were switched on and off without audible "clicks" via photo-cell circuitry. Signals were amplified by a McIntosh MA 5100 amplifier and presented through a 4" speaker centered in the ceiling of the experimental space. Stimuli were presented and data were recorded with the aid of associated electronic programing equipment.

Procedure

The general procedure was very similar to that of previous research by the present author (Walker, 1970). The barpress response was conditioned by merely placing the subjects in the experimental space for daily 30 min. (maximum) sessions during which all barpresses were reinforced. The first stage of this training ended with the fiftieth barpress to occur in any two consecutive sessions. A uniformly high rate of responding was then conditioned by continuing the above training until 25 barpresses occured within a single 20 min. (maximum)

session. No sound stimuli were presented during original conditioning.

Discrimination training for each subject began on the day following the completion of original conditioning. A discrimination trial consisted of a nonreinforced silent interval or "zero" stimulus condition (ZSC) and a period during which a sound stimulus was presented. A ZSC did not end until a prescribed period of time had elapsed without a barpress. This period was either 10, 15, 20, 25, or 30 sec. for any given ZSC, depending on a prearranged sequence randomizing these values in blocks of five. Either a reinforced (S+) or a nonreinforced (S-) sound stimulus immediately followed each ZSC according to a prearranged semi-random sequence that, for blocks of fifty trials, paired each stimulus value with each ZSC value an equal number of times. The stimuli were, in addition, randomized in blocks of ten (containing two successive blocks of ZSC values), such that each value appeared exactly five times without occuring more than three times in succession. All S- presentations ended with the first barpress or with the passage of five seconds from the time of stimulus onset, wichever came first. The first barpress to occur during S+, regardless of latency, produced a single reinforcement

and ended the S+ condition. All stimulus presentations were immediately followed by a ZSC.

Performance was scored as correct or incorrect on the basis of the subject's behavior during the first five seconds following stimulus onset. A barpress during this interval was scored as correct if S+ was present and as incorrect if S- was present. Nonoccurance of response during the first five seconds of an S- trial was scored as correct. All S+ trials on which response latencies were greater than five seconds were counted as incorrect although the S+ condition remained in effect until a barpress finally occured. Response latencies to S+ and following the onset of the ZSC were recorded as totals for each session.

The training stimuli were 64 db (re: .0002 dynes/cm^2) and 72 db intensities of a 5000 Hz tone. Ambient noise level in the absence of the tone was approximately 40 db. All decibel values were determined and periodically checked using the A scale of a Bruel & Kjaer sound level meter. The subjects were randomly divided into two groups that differed with respect to whether S+ was the more intense (72+) or the less intense (64+) value of the tone. The groups were equal in size at the beginning of the study, but one of the 64+ subjects died midway through training

and was not replaced.

Training was given on a majority of days each week. Each subject received one 50-trial session per day until performance averaged 80% correct or better over five successive sessions or until a maximum of 100 sessions had been given.

RESULTS

The average time necessary for all subjects to complete original conditioning was 153 min.. There were no statistically significant differences between groups with respect to overall time or time to complete either stage of this training, although two of the 72+ subjects required some hand shaping (reinforcement of successive approximations) to meet the first stage criterion.

Acquisition of the intensity discrimination, however, was markedly different for the two groups. The 72+ subjects reached criterion in 46-64 sessions with a mean of 56.5, while none of the 64+ subjects were able to reach criterion within 100 sessions. Group discrimination performance in terms of percent response during the first 5 sec. of S+ and S- is presented for blocks of 5 sessions in Figures 1 and 2.

Figure 1 shows only the first 45 sessions, after which the 72+ subjects began reaching criterion. Figure 2 represents the entire course of training, showing group averages for the first, middle, last, and two intermediate blocks of sessions given each subject. In addition, the upper portion of Figure 2 shows the average number of responses per session during the ZSC over the same 5 equidistant blocks.

The probability of responding within the first 5 sec. after stimulus onset was virtually the same for either group in the presence of either stimulus at the beginning of training. The groups remained very similar in their acquisition of responding to S+ over the first 45 sessions. Analysis of variance for the S+ data did not show significant differences either between groups or for the groups-trials interaction, although the effect of trials was highly significant ($p < .001$, $F = 47.25$, $df = 8/40$). A similar analysis performed over the data represented in Figure 2 likewise did not show an overall significant difference between groups, but there was a significant simple main effect of groups for the last block of sessions ($p < .001$, $F = 23.42$, $df = 1/25$) as well as a significant interaction of groups and trials ($p < .005$, $F = 6.88$, $df = 4/20$) suggesting that S+ performance was different for the two groups when viewed over the entire course of training. A trend analysis subsequently showed

Figure 1. Percent response during the first 5 sec. after stimulus onset to 72 db and 64 db intensities of a 5000 Hz tone for one group of rats given discrimination training with the louder stimulus reinforced (72+) and another group trained with the softer stimulus reinforced (64+). Responding to the reinforced stimulus (S+) and the nonreinforced stimulus (S-) is represented by solid lines and broken lines, respectively.

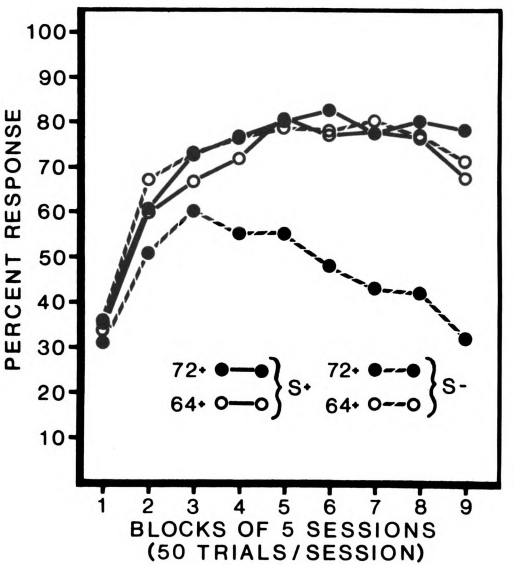
PERCENT RESPONSE
100
90
80
70
60
50
40
30
20
10
72+
64+
S+
72+
64+
S-
1
2
3
4
5
6
7
8
9
BLOCKS OF 5 SESSIONS
(50 TRIALS/SESSION)

Figure 1.

Figure 2. Lower portion: Percent response during the first 5 sec. after stimulus onset to 72 db and 64 db intensities of a 5000 Hz tone for one group of rats given discrimination training with the louder stimulus reinforced (72+) and another group trained with the softer stimulus reinforced (64+). Responding to the reinforced stimulus (S+) and the nonreinforced stimulus (S-) is represented by solid lines and broken lines, respectively. Data are represented for 5 equidistant blocks of 5 sessions, with the first, middle, last, and two intermediate blocks from the training of each subject averaged over groups. Upper portion: Average number of responses per session for the above groups during nonreinforced silent intervals that alternated with the presentation of S+ and S-. Data are for 5 blocks described above.

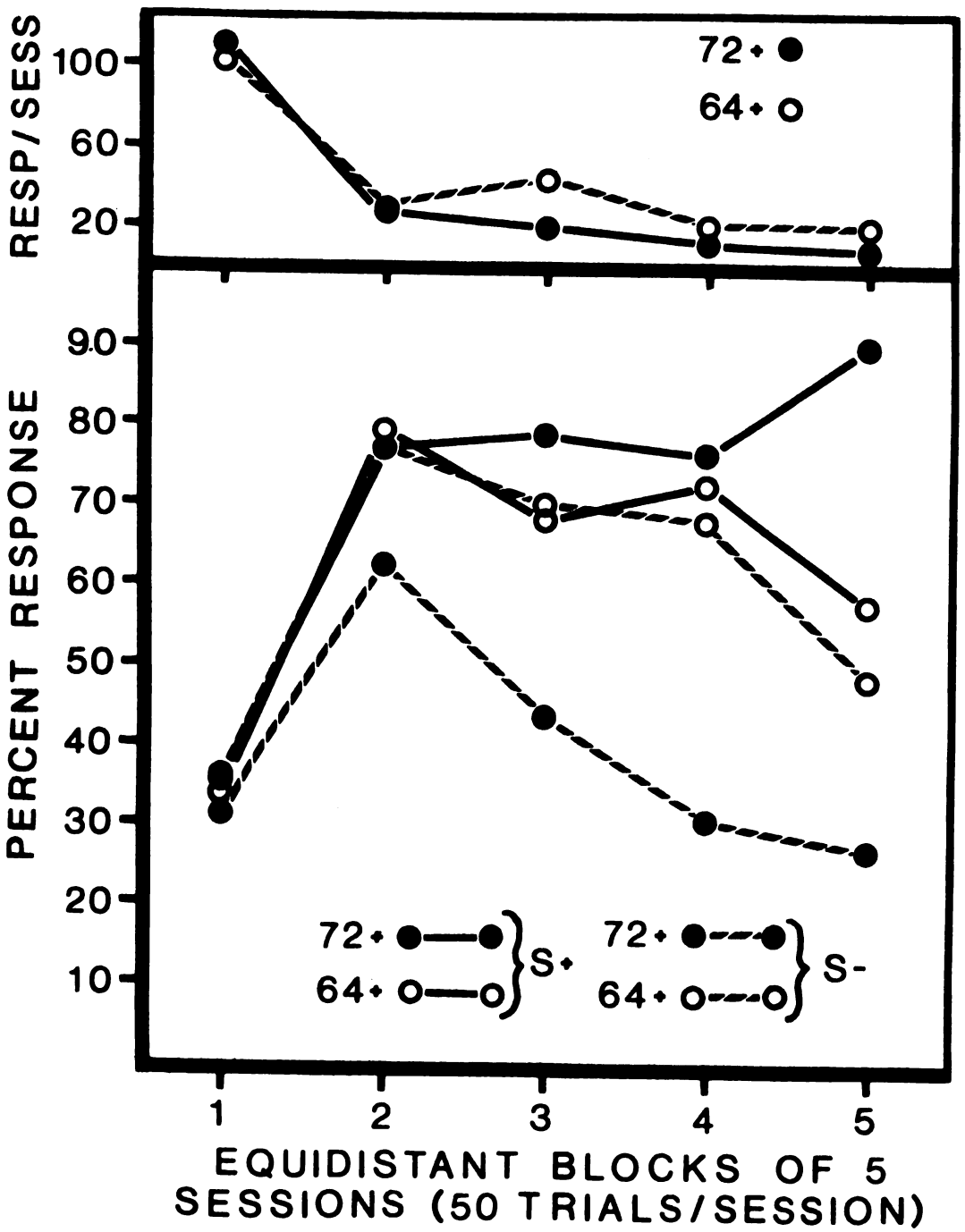
RESP/SESS
100
60
20
72+
64+
PERCENT RESPONSE
90
80
70
60
50
40
30
20
10
72+
64+
S+
72+
64+
S-
1
2
3
4
5
EQUIDISTANT BLOCKS OF 5 SESSIONS (50 TRIALS/SESSION)

Figure 2.

significant differences between groups both for the linear and the quadratic components ($p < .05$, $F = 9.22$, $df = 1/5$, and $p < .05$, $F = 6.82$, $df = 1/5$, respectively). These differences in combination with the fact that group performances were virtually identical over the first two blocks of sessions suggest a significant reduction in percent response to S+ (within 5 sec.) for the 64+ group over the latter portion of training.

The tendency to respond to S-, however, remained relatively high for the 64+ group throughout training. Analysis of variance showed significant differences in S- performance between groups over the first 45 sessions ($p < .05$, $F = 7.80$, $df = 1/5$) and over the entire course of training ($p < .01$, $F = 17.78$, $df = 1/5$). The groups-trials interaction was significant in both cases ($p < .001$, $F = 5.13$, $df = 8/40$, and $p < .005$, $F = 5.87$, $df = 4/20$, respectively), and the linear and quadratic components for the S- functions in Figure 2 were also significantly different ($p < .025$, $F = 10.93$, $df = 1/5$, and $p < .025$, $F = 11.39$, $df = 1/5$, respectively). All of the above contribute to the general finding that S- training proceeded more quickly for the 72+ group.

In contrast to the S- condition, response reduction

during the ZSC was virtually identical for the two groups (Figure 2, upper portion). The between-groups differences and the groups-trials interactions were not statistically significant either for the first nine blocks of sessions or for the five blocks representing the entire course of training. The effect of trials was highly significant in both cases, however, ($p < .001$, $F = 46.28$, df = 8/40, and $p < .001$, $F = 57.25$, df = 4/20, respectively), indicating that marked response reduction took place for both groups during the ZSC training.

Changes in ZSC performance are also illustrated in Figure 3, which shows response speed (mean reciprocal response latency) after the onset of the ZSC (broken lines) and the S+ (solid lines) for the same five blocks of sessions as in Figure 2. In keeping with the results for number of ZSC responses, response speed to ZSC onset decreased significantly over trials ($p < .001$, $F = 20.27$, df = 4/20) while the between-groups differences and the groups-trials interaction were not statistically significant.

The changes in S+ speeds shown in Figure 3 are consistant with the results for S+ presented above. As with percent response, the groups began at virtually the same

Figure 3. Response speed (mean reciprocal response latency) after the onset of a reinforced stimulus (S+), represented by the solid lines, and a nonreinforced zero intensity condition (ZSC), represented by the broken lines, for two groups of rats, one with a 72 db 5000 Hz tone as S+ (72+), and the other with the 64 db intensity of that same tone as S+ (64+). Five equidistant blocks of 5 sessions are presented with the first, middle, last, and two intermediate blocks from the training of each subject averaged over groups.

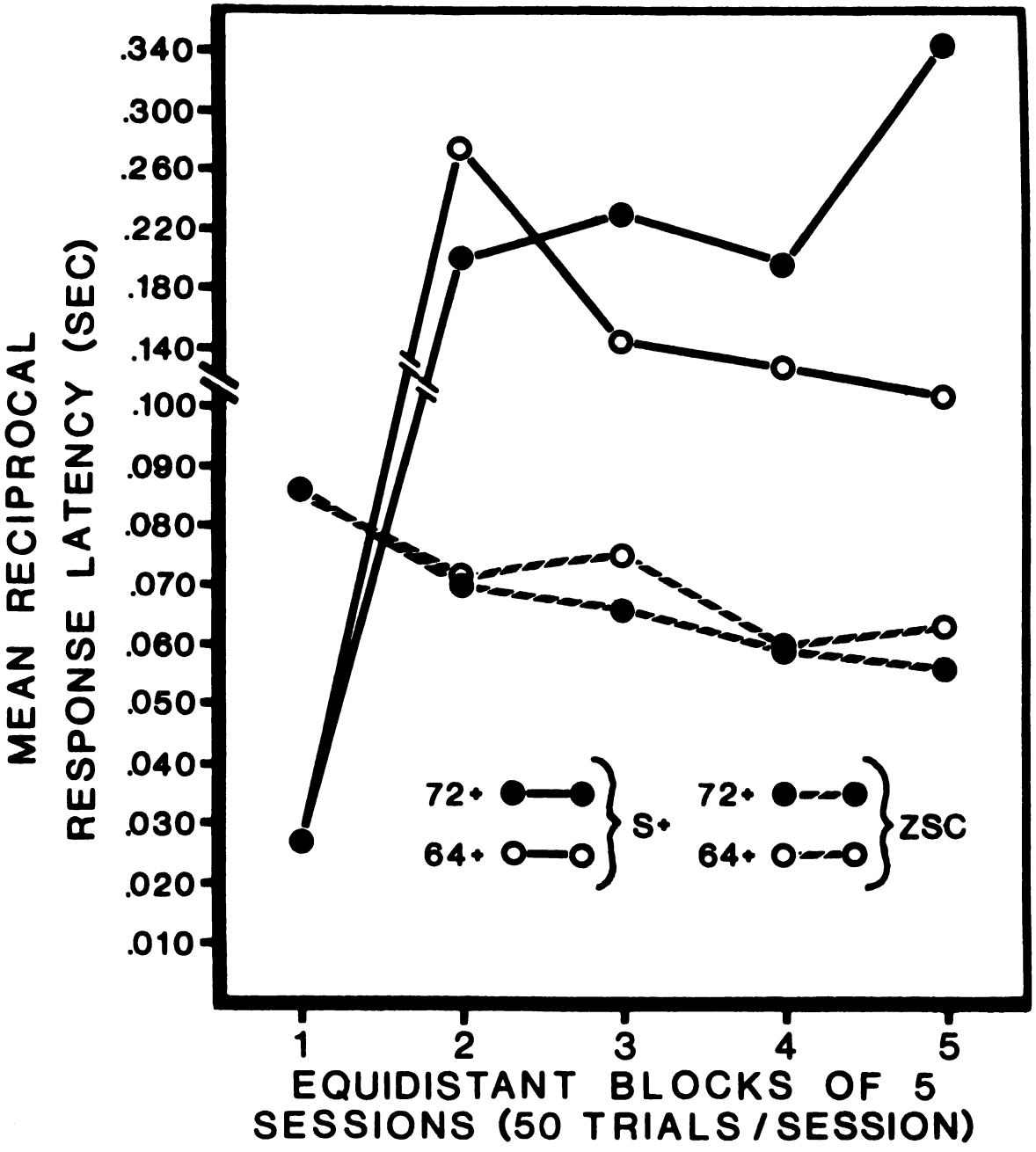
MEAN RECIPROCAL RESPONSE LATENCY (SEC)
.340
.300
.260
.220
.180
.140
.100
.090
.080
.070
.060
.050
.040
.030
.020
.010
72+
64+
S+
72+
64+
ZSC
1
2
3
4
5
EQUIDISTANT BLOCKS OF 5 SESSIONS (50 TRIALS/SESSION)

Figure 3.

point and did not differ statistically overall, while there was a significant simple main effect of groups for the last block of sessions ($p < .005$, $F = 12.93$, df = 1/25) and a significant groups-trials interaction ($p < .005$, $F = 5.49$, df = 4/20) as well as a highly significant effect of trials ($p < .001$, $F = 12.80$, df = 4/20). The linear (but not the quadratic) component was also significantly different for the two functions ($p < .025$, $F = 10.29$, df = 1/5), supporting the apparent downward trend that can again be seen in the 64+ data.

In summary, the prediction that the 72+ group would learn the discrimination more quickly because of the dual presence of a more intense stimulus for S+ and a less intense stimulus for S- was fully confirmed. Both the probability and the speed of S+ responding were ultimately higher for the 72+ group, while the probability of responding to S- was consistantly lower for this group after the first block of sessions. Furthermore, the fact that the magnitude and speed of ZSC responding were nearly identical for the two groups suggests that the S+ and S- differences observed were specific to the manipulation of stimulus intensity and did not represent a generalized deterioration in the performance of the 64+ group, whose complete failure to achieve the discrimination had not been expected.

DISCUSSION

Hull (1949) reviewed work by several investigators showing that asymptotic levels of conditioned responding increased with increased intensities of the training stimulus. To account for these findings Hull postulated a general principle which he called stimulus intensity dynamism (SID) denoting a positive correlation between the intensity of a conditioned stimulus and the magnitude of the resulting response. Perkins (1953) and Logan (1954) independantly challenged Hull's formulation on grounds that it was not necessary to postulate a distinct mechanism for the SID effect. They argued that if the experimental situation includes a zero intensity or relatively low intensity condition during which responding is not reinforced (which has usually been the case in experiments where SID has been observed), then generalization of inhibition from the zero intensity condition could produce the SID effect by more greatly affecting stimuli of lower intensities.

The results for response acquisition in the present study do not agree with previous findings of SID or with either of the above theoretical interpretations in that asymptotic levels of performance as shown over the first 45 sessions were virtually the same regardless of whether

S+ was 72 or 64 db. On the other hand, the fact that final levels of S+ performance were higher for the 72+ group (Figure 2) replicates previous findings and agrees with both theoretical interpretations. The difficulty is in determining at what point asymptotic levels of performance were actually reached. The significant downward trend shown in the 64+ data over the last 3/5 of training suggests that there was an erosion of S+ performance helping to produce the final differences observed. Although Hull's position predicts lower asymptotic levels of S+ performance for the 64+ group, it does not predict a reduction of response strength over trials. Such a reduction has not, to the writer's knowledge, ever been previously observed, but it can be predicted from the Perkins-Logan position by assuming that the generalized inhibitory strength of the ZSC continued to increase over trials after S+ responding had reached maximal strength. This assumption cannot be directly supported by the present data since no gradients of inhibition were measured, but the data for number of ZSC responses and ZSC response speed indicate that response reduction during the ZSC continued over the entire course of training, while S+ responding clearly reached maximal levels for the 64+ group over the first 45 sessions. In addition, the fact

that the subjects in the present study were never food deprived, but worked solely for the incentive value of the "sucrose" pellets, may have made S+ responding more easily affected by subtile influences from the ZSC. All known previous studies in the present area have encouraged strong S+ responding through the use of deprivation schedules or aversive stimuli. At any rate, the downward trend in S+ performance observed for the 64+ group can be handled by the Perkins-Logan hypothesis far more easily than by a strict Hullian interpretation, although the lack of differences that may be seen in maximum levels of performance remains unexplained from either standpoint.

In general, the present data partially replicate previous findings that higher levels of responding are produced as the intensity of the training stimulus is increased. The major purpose of the present study, however, was to determine whether training to reduce responding may proceed more quickly as the intensity of the training stimulus is decreased. The present data are very clear on this point. The 72+ group consistently maintained lower levels of S- responding than the 64+ group after the first block of sessions. The significant between-groups differences and groups-trials interactions obtained for S-

performance reinforce the conclusion that training proceeded more quickly when S- was 64 db rather than 72 db, while the lack of such significance for the ZSC data suggests that the groups reduced responding equally well when the stimulus conditions were the same.

The S- results can be interpreted in terms of either the Hullian or the Perkins-Logan hypothesis, but the latter position is strengthened at the expense of the former to the extent that the ZSC training was important for the observed differences. Generalization of inhibition from the ZSC, once again, needs finally to be established by generalization tests, but the importance of the ZSC training is suggested by a comparison of the present results with those of a previous study by Harris and Denny (1968). These workers trained rats on a brightness discrimination for food reward in a barpress apparatus. The brighter of two white light stimuli was reinforced for half of the subjects and was nonreinforced for the other half, in a design similar to that of the present study. However, the zero intensity condition (training lights out) was not introduced until after the discrimination had been learned to criterion. Extinction was massed during a single presentation of the zero intensity condition, and additional

extinction took place immediately afterwards in the presence of the individual training stimuli. Although resistance to extinction of the positive stimulus was found to be greater for the group that had the brighter stimulus previously reinforced, no statistically significant differences were found in resistance to extinction for the previously nonreinforced stimuli. These results suggest that a single exposure to the nonreinforced zero intensity condition may not be sufficient to produce differential S- performance, whereas S- differences were reliably observed in the present study, which incorporated the ZSC throughout discrimination training. The comparison between these two studies is admittedly loose since the stimulus modality, levels of deprivation, and measures of response strength (as well as other possible factors) also differed in addition to the amount and positioning of ZSC training. However, these studies do suggest that investigations directly manipulating ZSC training might be helpful in determining the role that generalized inhibition may have in the SID effect and in the reduction of responding to nonreinforced stimuli when a ZSC is part of conditioning.

In summary, the present study has replicated the general finding that conditioned responding is stronger

with more intense training stimuli, in that response strength for a less intense stimulus was observed to decrease over trials after reaching maximum levels. It was also observed that training to reduce non-reinforced responding proceeded more rapidly for the less intense of two training stimuli, both of the above findings occuring in the context of a discrimination problem that included a nonreinforced "zero" intensity condition. The present results by themselves and in combination with previous findings (Harris and Denny, 1968) appear to offer more support for the generalization of inhibition hypothesis of Perkins (1953) and Logan (1954) than for Hull's (1949) stimulus intensity dynamism position.

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