AUDITORY INTENSITY GENERALIZATION AFTER CER DIFFERENTIATION TRAINING

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Abstract. Auditory intensity generalization was tested in 32 rats trained in CER (conditioned emotional response) differentiation between the 50- and 70-dB white noise intensities. All generalization gradients showed regular monotonicity across the noise intensity dimension independently on experience with the CS+ value prior to the differentiation training. Two kinds of peak shift were obtained. Stimuli further away from the CS- value and more intense than the CS+ inhibited the on-going food motivated behavior more strongly than the CS+ itself. Stimuli further away from the CS- value and more intense than the CS- enhanced the on-going behavior more than the CS-.

A method of statistical analysis indicated that individual gradients and group data corresponded to the same generalization functions.

INTRODUCTION

Displacement of the peak of the generalization gradient around CS+ in a direction opposite to that of CS- after successive differentiation training has been observed in many studies. The peak shift is produced

1 According to terminology used so far in this Laboratory, successive differentiation training requires presentation of two conditioned stimuli, separately on individual trials in either random succession or predetermined order. The conditioned stimulus associated with presentation of the unconditioned stimulus (US), independent of whether the “reinforcing” agent is attractive or aversive, under probability P greater than zero (0 < P ≤ 1), is called positive or CS+. The other stimulus, associated with presentation of the US under probability P = 0, is termed negative or CS-.
only when CS$^+$ and CS$^-$ trials are interspersed during training and not after separate, chronic extinction of the stimulus value that differs from CS$^+$ (e.g., 15). Similarly, the peak shift is not obtained after simultaneous differentiation training (e.g., 14). The peak shift of the generalization gradient is observed only in situations that involve errors of commission by subjects during training (e.g., 24). Since observation that a subject may have learned differentiation by response emission to CS$^+$ and non-performance of the same response to CS$^-$ does not in itself provide evidence of inhibitory control (17), it is inferred that only learning with errors leads to dual stimulus control of behavior (2, 3). Thus the peak shift of the generalization gradient may be considered as an effect from the interaction of excitatory tendencies conditioned to CS$^+$ and inhibitory tendencies conditioned to CS$^-$. This is in accordance with the summation hypothesis stated long ago by Spence (23). Variables influencing the course of the differentiation learning may have an influence on the magnitude of this interaction, and the amount of the peak shift of the generalization gradient serves as an important depending variable (15).

All of the above considerations required us to prolong study, the first part of which has been published recently (16). That experiment investigated the effects of intensity relations between CS$^+$ and CS$^-$ and previous experience with CS$^+$ on the course of the differentiation learning in rats, employing a conditioned emotional response (CER) technique. Both major variables influenced the course and the rate of differentiation learning. Animals that had a CER initially established to CS$^+$ followed by introduction of CS$^-$ reached the stage of training in which there was no overlap in CER ratios between CS$^+$ and CS$^-$ trials significantly earlier than subjects that had both CSI simultaneously introduced in differentiation training. Under all training conditions differentiation of the more intense CS$^+$ and less intense CS$^-$ was easier than differentiation of the less intense CS$^+$ and more intense CS$^-$. Further, intensity relations between stimuli exerted a strong effect in all experimental groups at each stage of differentiation learning including the criterion sessions.

The notion that differential responding on both CS$^+$ and CS$^-$ trials does not testify to inhibitory control exerted by CS$^-$ (17) is especially critical in a CER situation. In this technique, developed by Estes and Skinner (7), preliminary training requires shaping of the bar-press response for intermittent food reinforcement. When CER acquisition starts, the compound consisting of the experimental situation and CS$^+$ is followed by unavoidable electric shock (evoking a fear response interfering with bar-pressing for food), whereas the experimental situation alone is not related to shock and as before is associated with food re-
inforcement. Thus, CER acquisition involves the discrimination of two drives and bound with them two separate response patterns, one related to the entire experimental context, and a second related to CS+. The correct response to CS−, a sporadic stimulus never paired with the painful US, consists in undisturbed bar-pressing behavior for food, similar to that emitted to the experimental situation alone. It has been shown in experiments employing white noise of different intensities as conditioned stimuli that the amount of generalization of the fear response from CS+ to CS−, measured by suppression of the bar-pressing on CS− trials, depends on intensity relations between CS+, CS− and the background noise level. When onset of the CS− was a change of the background noise intensity in the direction opposite to that provided by CS+ onset, no generalization of fear to the CS− was observed (26). In this situation rats discriminated two intensity values of the white noise from the very beginning of differentiation training, and no extinction of the fear response generalized to CS− was possible. When both CS+ and CS− were above the ambient noise level, the bar-press rate on CS− trials resembled the level observed during intertrial intervals only after some training (16, 25). On the basis of the course of differentiation learning, it is very difficult to judge whether recovery of the regular bar-press rate is due to inhibition of the fear response generalized to the CS− value or because subjects learn to neglect all stimuli except the CS+ value as far as fear and pain are concerned. When the first contingency is in operation, double stimulus control must be established during CER differentiation learning. The second contingency involves only sharpening of the excitatory generalization gradient around the CS+ value as a result of CER differentiation. The aim of this study was to test the shape of generalization gradients after several CER differentiation training procedures.

MATERIAL AND METHODS

The subjects were 32 male hooded rats, approximately 3.5-4 mo old at the time of stimulus generalization testing. The apparatus consisted in four modified operant chambers with electrifiable grid floors. Each chamber contained a single bar on one of the walls, a food-tray beneath the food bar, and was located in separate, acoustically shielded enclosure. The CS+, CS− and test stimuli were different intensities of the white noise ranging from 50 dB to 80 dB (SPL) in gradations of 5 dB steps with durations of 3 min. The auditory stimuli were delivered to the experimental chamber from a Grasson–Stadler Noise Generator (Model 901 A) via a permanent magnet speaker, 8 cm in diam, placed
below the floor of the box. A Brüel & Kjær Pulse Precision Sound Level Meter (Type 2209) indicated that these values were fairly constant with maximal variation not exceeding 0.5 dB. The US was scrambled electric shock of 1 mA intensity and 0.5 s duration provided by a shock generator.

Prior to any training the rats were reduced to 75% of ad lib. body weight and maintained at that weight on a 24 h feeding rhythm during the entire experiment. Each experimental session lasted 2 h and took place at the same time each day. The bar-press responses were reinforced according to a 2.5 min VI schedule. The food reinforcement schedule and occurrence of the CSi were independently programmed throughout the entire experiment.

The rats were randomly divided into six groups. In Groups 1a and 1b, both CS+ and CS− were presented from the first session of the differentiation training. The same procedure was used in Groups 2a and 2b except for additional “habituation pretraining” consisting of five sessions each with four presentations of the white noise intensity that subsequently served as CS+ during differentiation training. In Groups 3a and 3b CER pretraining was given during five sessions. On each session, CS+ was presented four times for 3 min periods, the last 0.5 s of which coincided with 1 mA shock.

Differentiation training was the same in all Groups a and in all Groups b. For Groups a CS+ was 70 dB white noise and CS− was 50 dB white noise, whereas for Groups b these relations were reversed. Each CS was presented four times during the 2 h session, and stimuli onsets were at 18.5, 29.0, 43.0, 53.5, 61.0, 74.5, 92.0, and 106.0 min from the beginning of the session. The order of CS+ and CS− trials was changed each day in predetermined arrangements in which the same intensity was never given more than twice in a row.

The main measure of subjects’ behavior during CSi presentations consisted of “suppression ratios” described by Annau and Kamin (1). The ratio is determined by $B/(A + B)$, where $B$ represents number of bar-presses emitted during the 3 min CS action and $A$ is the number of responses during the 3-min immediately preceding CS onset. The criterion of differentiation was three consecutive days without overlapping in suppression ratios between CS+ and CS− trials for each session.

For 24 of the rats intensity generalization tests were given on the day after the differentiation criterion was attained, whereas the eight remaining subjects received overtraining lasting from 2 to 15 sessions before testing. The numbers of subjects in each group and numbers of overtrained animals are given in Table I. The test consisted in presentation of seven noise intensities: 50-, 55-, 60-, 65-, 70-, 75-, and 80-dB white
noise during a single session. The $CS^+$ value, 70 dB in Groups a and 50 dB in Groups b, was presented twice during the test session with shock in a similar manner as during the regular differentiation sessions. However, the other white noise intensities were not associated with the US. The order of noise intensity presentations was random for each subject and partially contrabalanced between subjects of each experimental group. Only the response measure of the first presentation of the $CS^+$ value was used for construction of the generalization gradients. The onset of the test stimuli was programmed at the same intervals used during differentiation training sessions. The 2.5 min food-reinforcement schedule remained continuously operable during the test session as in differentiation training.

**Measures of behavior and method of the statistical analysis of the generalization gradients**

The numbers of bar-press responses emitted during the 3 min periods preceding, and during the 3 min action of each test intensity were collected for each rat. The number of responses emitted to a given intensity of white noise provided a first measure of stimulus control in the generalization test. However, within a given session, this measure is highly sensitive to fluctuations in the base-line rate of responding, which may be either systematic or sporadic. This problem is typically used as a justification for the use of ratio measures of suppression (5). Thus the $B/(A+B)$ suppression ratio for each test intensity was calculated. However, previous data (25) have indicated a further problem, since both the absolute values and the magnitude of individual variability in suppression ratios depend on the intensity relationship between $CS^+$ and $CS^-$. To minimize effects of different training conditions and of differences in absolute values of suppression ratios on shape of generalization gradients for each subject, the ratios were transformed to ranks. Specifically, the rank 1 was assigned to the smallest value of the $B/(A+B)$ ratio (i.e., the greatest suppression of
the on-going bar-pressing behavior) and the rank 7 was assigned to the
greatest value of the $B/(A + B)$ ratio. Tied ratio values were assigned the
average of the tied ranks. Accordingly, generalization gradients expressed
in ranks of suppression ratios represent the relative strength of the clas-
sically conditioned defensive response to the test stimuli, measured on an
ordinal scale.

The major problem in this study was to examine the shape of gene-
ralization gradients obtained in subjects trained under various conditions
of differentiation the two intensities of white noise. Several hypothetical
gradients of the response strength expressed in ranks are shown on Fig. 1.

Fig. 1. Arrangements of ranks corresponding to shapes of several hypothetical ge-
neralization gradients after differentiation of 50- and 70-dB white noise in-
tensities.
In the left column are shown gradients for the Groups a trained with the 70 dB CS⁺ and 50 dB CS⁻, and hypothetical gradients for the Groups b trained with the 50 dB CS⁺ and 70 dB CS⁻ are presented in the right column. Set 1 represents the monotonic function of response strength in regard to the test intensities. For the Groups a this shape of the generalization gradient denotes a considerable peak shift of the CER away from the CS⁻ value. For the Groups b the gradient hypothesized in Set 1 indicates that stimuli further away from CS⁺ evoke a mode of behavior even more incompatible with that conditioned to the CS⁺ than did the CS⁻ value itself. Conversely, Set 6 represents symmetrical generalization gradients around the CS⁺ or CS⁻ values. Thus, for the Groups a Set 6 denotes a gradient of excitation not disturbed by influences from the CS⁻, whereas a pure gradient of inhibition of the acquired defensive reaction is indicated for the Groups b. Sets 2–5 represent different degrees of asymmetry of generalization gradients around the 70 dB value. Considering all of the sets together one may deduce a decreasing effect of the 50 dB CS⁻ on the generalization gradient around the 70 dB CS⁺ from Sets 1–6 for the Groups a. Similarly, the progression in Sets 1–6 indicates a decreasing effect of the 50 dB CS⁺ on the generalization gradients around the 70 dB CS⁻ for the Groups b.

The statistical analysis of the data consisted in individual comparisons of the empirical gradients with the sets of ranks presented in Fig. 1. The method employed was derived from the nonparametric technique described by Fergusson (8). This method makes use of the statistic $S$, introduced by Kendall in the definition of rank correlation (18). In our case the statistic $S$ is descriptive of disarray in the empirical set of ranks compared to the hypothetical set of ranks. For each individual rat, magnitudes of the CER ratios transformed into ranks were compared with each of the six sets of hypothetical rank values. Referring to Table 5 of Fergusson’s guide (8, p. 27) it is possible to evaluate statistical significance of the monotonicity in empirical gradients for each subject independently. However, the group data were of main interest. Thus, for each group we obtained a composite score expressed in $z$ values that assessed the extent of similarity among individual generalization gradients with hypothesized monotonic, asymmetrical and symmetrical arrangements.

RESULTS

Level of responding prior to the generalization test

Daily suppression ratios for the last 3 days before generalization testing were computed for each rat by summing responses emitted during
Mean daily suppression ratios during the last 3 days before the generalization test

<table>
<thead>
<tr>
<th>Group</th>
<th>Positive trials</th>
<th>Negative trials</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Day 1</td>
<td>Day 2</td>
</tr>
<tr>
<td>1a</td>
<td>0.126</td>
<td>0.134</td>
</tr>
<tr>
<td>1b</td>
<td>0.277</td>
<td>0.232</td>
</tr>
<tr>
<td>2a</td>
<td>0.042</td>
<td>0.057</td>
</tr>
<tr>
<td>2b</td>
<td>0.140</td>
<td>0.121</td>
</tr>
<tr>
<td>3a</td>
<td>0.088</td>
<td>0.092</td>
</tr>
<tr>
<td>3b</td>
<td>0.154</td>
<td>0.174</td>
</tr>
</tbody>
</table>

Source of variation | df | Values of $F$ statistics
--- | --- | ---
Procedure B | 2, 26 | 3.83* | 0.57
Stimuli C | 1, 26 | 6.82** | 13.74***
BC | 2, 26 | 0.58 | 0.55
Days A | 2, 52 | 0.30 | 0.40
AB | 4, 52 | 0.46 | 0.27
AC | 2, 52 | 0.45 | 1.90
ABC | 4, 52 | 0.39 | 1.25

* $P < 0.05$; ** $P < 0.025$; *** $P < 0.005$.

the appropriate intervals on each of the four positive and four negative trials. The results of the analyses presented in Table II indicate that even at this stage of differentiation training the stimuli arrangement exerted a significant effect on CER ratios on both positive and negative trials (mixed design, type III, 19). The 70 dB CS+ suppressed the on-going bar-pressing behavior more than the 50 dB CS+. The mean suppression values were smaller than 0.5 for the 50 dB CS− and greater than 0.5 for the 70 dB CS−. The training procedure affected CER ratios on positive trials only, with less suppression in Groups 1a and 1b that had both CS+ and CS− introduced from the very beginning of training. Prior to the generalization test, animals reached asymptotic performance and the effects of days were not significant on either positive or negative trials.

Responding during the generalization test

Group generalization gradients are presented in Fig. 2–4. For construction of the curves the following measures were used respectively: (i) median numbers of bar-presses emitted during the 3 min action of each test intensity, (ii) median suppression ratios and (iii) mean ranks of suppression ratios. Inspection of the graphs shows that generalization gradients obtained for all Groups a are similar, independent of the
Fig. 2. Generalization gradients based on the median numbers of bar-presses emitted during the 3 min action of each test intensity. Horizontal lines denote level of performance during pre-stimulus 3 min periods (medians from individual means for all eight A periods). Groups without pretraining (Groups 1a and 1b) are shown in solid lines, groups with habituation pretraining (Groups 2a and 2b) are shown in dashed lines and groups with CER pretraining (Groups 3a and 3b) are shown in broken lines with dots.

Fig. 3. Generalization gradients based on CER ratios. The 0.5 value of the ratio corresponding to no change of the on-going bar-pressing behavior during presentation of test stimuli is marked by horizontal line. Denotations of groups as in Fig. 2.
measure used. Gradients for all Groups b are also alike. The arrange-
ment of stimuli used in differentiation training exerted a strong effect
on the slope of gradients, since the 70 dB CS+ suppressed on-going bar-
press behavior more strongly than the 50 dB CS+, whereas responding to
the 50 dB CS- and 70 dB CS- was similar and did not differ from the
rate of bar-presses prior to test stimuli presentations. In effect, within
each training procedure the differences in CER ratios between the 70 db
CS+ and 50 dB CS- were greater than between the 50 dB CS+ and 70 dB
CS-. These relations are reminiscent of those observed at the end of
differentiation training shown in Table II.

Responding to the 75 dB and 80 dB intensities, which were outside
of the conditioned stimuli range, are of special interest. For the
Groups b numbers of bar-presses emitted to the 70 dB CS-, 75 dB and
80 dB test stimuli were compared with the mean numbers of responses
during the 3 min periods preceding test stimuli presentations. As shown
in Table III, the analysis of variance revealed an overall effect from the
stimuli, whereas procedure effect and the interaction were not significant
(mixed design type I, 19). Further a Duncan test showed that respond-
ing to the 80 dB and 75 dB stimuli each differed from the base-line rate
(\( P < 0.01 \)), whereas responding to the 70 dB CS- did not differ from
base-line (6). An analogous analysis for the Groups a was based on the
CER ratios during the first and the second presentations of the 70 dB
CS+, and during 75 dB and 80 dB stimuli. The analysis indicated a signi-
ificant overall effect from stimuli, while the effects of procedure and the
interaction were not significant (Table IV; the same method). The Dun-
Mean numbers of responses emitted in Groups b during the 3 min periods preceding test stimuli presentations (base-rate) and during the action of 70-, 75- and 80-dB white noise.

<table>
<thead>
<tr>
<th>Group</th>
<th>Base-rate</th>
<th>Test stimuli</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>70 dB</td>
</tr>
<tr>
<td>1b</td>
<td>21.8</td>
<td>22.4</td>
</tr>
<tr>
<td>2b</td>
<td>27.2</td>
<td>33.0</td>
</tr>
<tr>
<td>3b</td>
<td>19.5</td>
<td>22.8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>df</th>
<th>Values of F statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Procedure B</td>
<td>2, 13</td>
<td>0.20</td>
</tr>
<tr>
<td>Stimuli A</td>
<td>3, 39</td>
<td>4.93*</td>
</tr>
<tr>
<td>AB</td>
<td>6, 39</td>
<td>0.80</td>
</tr>
</tbody>
</table>

* $P < 0.01$

can test revealed that suppression ratios to 80 dB and 75 dB stimuli each differed from the ratio to the second presentation of the 70 dB CS+ ($P < 0.05$), while suppression ratios to the two presentations of the CS+ did not differ.

Table V presents the results of comparisons of the ranked suppression ratio values with the hypothetical generalization gradients shown in

**Table IV**

Mean suppression ratios in Groups a during two presentations (1 and 2) of the 70 dB stimulus and during the action of 75 dB and 80 dB white noise.

<table>
<thead>
<tr>
<th>Group</th>
<th>Test stimuli</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>70 dB (1)</td>
</tr>
<tr>
<td>1a</td>
<td>0.180</td>
</tr>
<tr>
<td>2a</td>
<td>0.072</td>
</tr>
<tr>
<td>3a</td>
<td>0.226</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>df</th>
<th>Values of F statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Procedure B</td>
<td>2, 13</td>
<td>1.73</td>
</tr>
<tr>
<td>Stimuli A</td>
<td>3, 39</td>
<td>3.52*</td>
</tr>
<tr>
<td>AB</td>
<td>6, 39</td>
<td>0.21</td>
</tr>
</tbody>
</table>

* $P < 0.025$
Table V
Comparisons (z scores) of individual gradient slopes with hypothesized rank values for monotonic, asymmetrical and symmetrical functions during the generalization tests

<table>
<thead>
<tr>
<th>Ranks assigned to white noise intensities</th>
<th>Group 1a</th>
<th>Group 2a</th>
<th>Group 3a</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 55 60 65 70 75 80</td>
<td>4.11</td>
<td>4.85</td>
<td>4.88</td>
</tr>
<tr>
<td>7 6 5 4 3 2 1</td>
<td>3.91</td>
<td>4.84</td>
<td>5.00</td>
</tr>
<tr>
<td>7 6 5 4 2.5 1 2.5</td>
<td>3.41</td>
<td>4.70</td>
<td>4.80</td>
</tr>
<tr>
<td>7 6 5 3.5 1.5 1.5 3.5</td>
<td>2.95</td>
<td>4.69</td>
<td>4.01</td>
</tr>
<tr>
<td>7 6 5 3.5 1.5 3.5 1.5</td>
<td>3.70</td>
<td>4.96</td>
<td>3.87</td>
</tr>
<tr>
<td>7 6 4.5 2.5 1 2.5 4.5</td>
<td>2.57</td>
<td>4.32</td>
<td>2.81</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Group 1b</th>
<th>Group 2b</th>
<th>Group 3b</th>
</tr>
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<tbody>
<tr>
<td>1 2 3 4 5 6 7</td>
<td>3.49</td>
<td>4.11</td>
<td>4.86</td>
</tr>
<tr>
<td>1 2 3 4 5 6.5 6.5</td>
<td>3.46</td>
<td>3.95</td>
<td>4.92</td>
</tr>
<tr>
<td>1 2 3 4 5.5 7 5.5</td>
<td>3.33</td>
<td>3.54</td>
<td>4.67</td>
</tr>
<tr>
<td>1 2 3 4.5 6.5 6.5 4.5</td>
<td>3.02</td>
<td>2.96</td>
<td>3.84</td>
</tr>
<tr>
<td>1 2 3 4.5 6.5 4.5 6.5</td>
<td>3.02</td>
<td>3.79</td>
<td>3.84</td>
</tr>
<tr>
<td>1 2 3.5 5.5 7 5.5 3.5</td>
<td>2.20</td>
<td>2.14</td>
<td>2.46</td>
</tr>
</tbody>
</table>

Fig. 1. All z scores obtained levels beyond the 0.05 criterion of significance. However, the empirical gradients yielded the greatest correspondence to the monotonic function (Set 1) and to the Set 2 which departs only slightly from monotonicity. This finding is in agreement with the results of the analyses presented in Tables III and IV. The monotonic character of the empirical generalization gradients was further supported by the observation that 20 individual gradients (two to four from each group) reached a 0.05 (or better) level of significance as shown by the directional monotonic trend test for correlated data (8).

Discussion

These data clearly indicate that after CER differentiation of two intensities of white noise, the obtained generalization gradients were not symmetrical around either the CS+ or CS− values of the noise intensity dimension. For groups that acquired the discrimination between the 50 dB CS− and 70 dB CS+, suppression of the on-going bar-pressing behavior to the 75 dB and 80 dB test stimuli was greater than to the CS+ value. This finding reflects a peak shift of the CER away from the CS− value. In those groups trained to discriminate between the 50 dB CS+ and the 70 dB CS− the observed generalization gradients indicated that the 75 dB and 80 dB test stimuli increased the response rate over the baseline level. It may be argued that stimuli further away from the CS+
evoked a mode of behavior even more incompatible with the CER than the CS− itself.

Both the statistical analyses as well as shapes of generalization gradients showed that experience with the CS+ presented either without US (Groups 2) or with the nociceptive US (Groups 3) prior to differentiation training did not affect generalization functions. This finding was rather surprising, since Hoffman (12) showed that pigeons trained in CER yielded gradients of different shapes depending on whether they have been conditioned to the CS+ prior to auditory frequency differentiation training or not. In present experiment the only variable strongly influencing the shape of generalization gradients was the arrangement of discriminated stimuli on the white noise intensity scale. All generalization gradients obtained in this study were of monotonic character and differed from typical generalization gradients which have the form of bitonic sloping gradients of decreasing response strength away from the reinforced stimulus. The monotonic change of the response strength within the range of CS+ and CS− values have been also previously reported for CER ratios (22). However, in this study the monotonicity exceeded toward higher intensities of the white noise. More data are necessary to evaluate the nature of the observed peak shifts (away from the CS− value and away from the CS+ value), since in both cases they may have been confounded with the increase of noise intensity. The enhancement of the rate of on-going bar-press behavior to stimuli further away from the CS+ value is the most intriguing finding of this study. Similar "supernormal suppressions ratios" (4) have been observed in numerous studies especially to the CS− values at the end of differentiation training (16, 22, 25, 26). Ray and Stein (22) hypothesized that facilitation of food-motivated behavior during CS− presentations in CER experiments may be related to the phenomenon of slight supression of responding during periods between stimulus presentations, since these periods occasionally terminated with the onset of the CS+, while terminations of the CS− never lead into a CS+ but started a relative "safe" interstimulus periods. Enhancement of food motivated behavior to stimuli remote from the CS+ value was observed during later phases of generalization testing after CER conditioning to the single tonal frequency in experiments performed on pigeons (9–11, 13). Hoffman (10) proposed another mechanisms to explain this energizing effect on the rate of the on-going food motivated behavior from stimuli remote from the CS+ value. However, these explanations are more suitable to his and his co-workers data in which enhancement of responding was observed only after prolonged extinction of the CER response to all stimuli including the CS+ value.
In this study the CS\(^+\) evoked a strong CER response and only one generalization test was conducted. The enhancement of bar-press rate to the 75 dB and 80 dB intensities in animals trained to discriminate between 50 dB CS\(^+\) and 70 dB CS\(^-\) may be considered as a spreading of inhibition from the CS\(^-\) value and described as a peak shift away from the CS\(^+\) value. The method of statistical analysis of individual data employed in this study confirmed that the peak shift away from the CS\(^+\) reached significance equally often as the peak shift away from the CS\(^-\) value (in the first case, 9 rats out of 16 reached the \(P < 0.05\) level; in the second case, 11 rats out of 16).

It has to be pointed out that the method of statistical analysis derived from the nonparametric technique described by Fergusson (8) and employed in this study makes it possible to discard objections to generalization studies raised by Loucks (20) and Razran (21), relating to possible artefacts caused by averaging of the data obtained on individual subjects. The method of analysis presently described permits evaluation of statistical significance of the shape of generalization functions obtained on individual subjects during presentation of a single set of test stimuli; i.e., not biased by the averaging of data and under minimal extinction influence on measured response strength.

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