

DISCUSSION

In the previous experiment we noted a slight tendency to adjust the variable a little too far from the standard for the ratio 3/4 and a little too near the standard for the ratio 1/4. This tendency has its analogue in an equally slight tendency to assign to the variable stimuli numerical estimates that are a little large at the low end and a little small at the high end. As is evident in Fig. 2, these two tendencies result in deviations in opposite directions from the average loudness function, and we have here a suggestive example of how the evidence from two procedures might be combined to cancel out systematic errors or biases in each of them.

The fact that in the experiment on magnitude estimation the standard intensity was about 10 db higher than it was in the experiment on adjustment may have contributed to the slightly flatter slope of the function determined by the numerical estimates. In a number of experiments we have found that these slopes become flatter as the level of the standard is increased, but an increase from 90 to 100 db usually makes only a small difference. We might also note in passing that, when *Os*' task is to give numerical estimates to loudnesses *greater* than the standard, the slope gets steeper instead of flatter as the level of the standard is increased (7).

Figure 2 suggests that the measurement of loudness is not hopeless—only difficult. If given a proper opportunity, people can make consistent quantitative statements about what they hear. It is true that such factors as context or adaptation level—the influence on one stimulus of others in the series—can be made to have potent effects, as Garner has demonstrated. But it is also true that we can minimize such factors in the experimental design. In our experiment there was no series of stimuli to provide a context, for each *O* heard only one comparison tone. Even under these stringent circumstances, the judgments were clearly consistent with the assumption that loudness is scalable, and that the

loudness heard by the typical *O* in a free situation is a power function of intensity.

SUMMARY

These experiments tested the ability of 65 *Os* to make consistent quantitative judgments of the relative loudness of tones on their first trials. They also explored some of the biasing factors that enter such experiments. The method of adjustment and the method of magnitude estimation were used.

CONCLUSIONS

1. In the method of adjustment it is advisable to use a "some potentiometer" on which the turn of the knob is approximately proportional to the loudness produced.
2. On his first trial an unpracticed *O* can adjust the intensity of a tone to produce an arbitrary loudness ratio relative to another tone. Each of three groups of *Os* adjusted the tone to a different loudness ratio in a consistent manner.
3. On their first trial, different groups of *Os* can consistently make direct numerical estimates of the relative loudnesses produced by different intensities.
4. The results for the method of adjustment corroborate those for the method of magnitude estimation, and both approximate the loudness scale derived from previous investigations.

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(Received January 3, 1955)

DISCRIMINABILITY AND STIMULUS GENERALIZATION¹

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Three different forms for the stimulus generalization gradient have been proposed: concavity (Hull, 6), convexity (Spence, 12) and linearity (Schlosberg and Solomon, 10). In the formulation of each of these proposals, however, there has been a tacit or explicit assumption of some relationship between discriminability, in the psychophysical sense, and the generalization decrement. This assumption is manifested in Hull's postulate that generalization gradients are decreasing exponential functions on a j.n.d. scale, and also in Schlosberg and Solomon's proposal that generalization gradients are straight lines on an equal-appearing interval scale. Spence's use of a logarithmic stimulus plot appears to stem from similar considerations.

This assumption does not only appear to be intuitively reasonable, but can also be shown to have a rational basis by comparing the dimensions of the difference threshold and the generalization decrement (from which the generalization gradient can be derived by integration). The difference limen (*DL*) is ordinarily defined by the slope of the psychophysical function. For

example,

$$DL = \frac{AS}{[p(R) = .75] - [p(R) = .50]} = \frac{AS}{\Delta p(R)}$$

On the other hand, the slope of the generalization gradient, i.e., the generalization decrement, is given by $\frac{\Delta p(R)}{\Delta S}$. This implies that the generalization decrement should be proportional to the reciprocal of the *DL*.

It is a way of saying that the organism generalizes to the extent that it cannot discriminate or that generalization is the inverse of discrimination. In essence, this proposal is a reformulation of Schlosberg and Solomon's hypothesis (10).

The foregoing analysis may be subjected to empirical verification by investigating a continuum for which the discriminability function is known. For the present experiment, wave length of light was chosen as a dimension along which to test generalization because the *DL* for wave length ($\Delta\lambda$) is not constant over the spectrum. By an appropriate selection of *CS* values, therefore, it should be possible to produce a set of gradients whose slopes reflect the characteristics of the $\Delta\lambda$ function. Where $\Delta\lambda$ is small, the gradient should be sharp; where $\Delta\lambda$ is large, the gradient should be relatively flat; and if the *CS* is fixed at a value where $\Delta\lambda$ is either increasing or decreasing, the generalization gradient should show a corresponding asymmetry. This continuum is also interesting because of the

¹This study was supported by the Duke University Research Council and by grants M-631C and M-629C from the National Institute of Mental Health, United States Public Health Service. The research program of which this is a part is currently supported by grant MH-1002 from the National Institute of Mental Health, United States Public Health Service. The authors are indebted to Harley M. Hanson, Werner K. Hong, and Mrs. Deborah H. Nickerson for their assistance in this research.

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qualitative changes which occur within it and which would lead to the expectation, on the basis of subjective experience, that generalization would occur extensively within a hue but would decrease abruptly as the transitions between spectral hues are approached.

The technique of the present study, which utilizes the aperiodically reinforced key-pecking response, permits an examination of the generalization gradients for individual Ss. Moreover, this technique makes it possible to investigate the generalization gradients at different levels of response strength during the course of extinction, as well as variations in the generalization gradient attributable to individual differences in response strength. The obtaining of generalization gradients for individual Ss in this experiment of an outcome of the fact that aperiodic reinforcement greatly increases resistance to extinction, such that the introduction of a test stimulus for a brief interval during experimental extinction reduces the response strength by a small fraction of its total extent, e.g., in a 30-sec. test, 50 responses may be subtracted from a "reserve" of several thousand.

METHOD

Subjects.—The Ss were 24 experimentally naive pigeons maintained by restricted feeding to 80% of their body weight under ad libitum feeding.

Apparatus.—A modified version of the Skinner automatic key-pecking apparatus was used. The S's compartment consisted of a plywood box 14 in. high, 12 in. wide, and 12 in. long and was situated in an air-conditioned, darkened, soundproof chamber. The roof of S's box was clear Lucite and the floor was a perforated metal grating covered with a sheet of translucent plastic. The upper half of one of the walls was made of aluminum with a $\frac{7}{8}$ -in. round aperture at the center 6.5 in. above the floor of the box. The S's key, a rectangle of translucent plastic (Insurak) lightly sprung against the wall of the box, was exposed through this opening and controlled counting and reinforcing circuits.

The magazine was situated directly below the key and consisted of a metal door hinged at the top. This door was actuated by a cam on a constant-speed motor which completed a cycle in 5 sec. When a reinforcement was presented, the cam allowed the door to open abruptly, exposing the food and switching on a 7.5-w. lamp behind the food tray. The door remained open for 3.5 sec. and then closed gradually, turning off the light as it shut.

The external side of the key was illuminated by a 6-v., 18-amp. ribbon filament lamp whose beam was directed through a tunable wave-length filter and whose filament image was cast slightly out of focus on the key. The filter was a Cambridge Thermionic Corp. Monochromator (Model B). This instrument utilizes the differential rotation of quartz crystals for various wave lengths to produce dispersion of the spectrum. Its transmission spectrum at a given setting consists of a centroid of high relative intensity flanked symmetrically by a series of periodically spaced bands of lower intensity. Although the instrument may not be considered a true monochromator, it produces a stimulus patch of high apparent purity for the human observer. The band width of the centroid increases linearly from 14 to 24 $M\mu$ over the range of settings from 450 to 640 $M\mu$. The percentage transmission of incident light is approximately flat over this range, varying between 2 and 4%. No attempt was made to produce an equal energy spectrum or alternatively to equate the spectrum lights in terms of the visibility function.

Procedure.—The procedure used in the present study derives from the work of Skinner (11) and Ferster (3), and is similar to that used by Brush, Bush, Jenkins, Johns, and Whiting (2). When the Ss were reduced to 80% of their ad lib. weight, they were trained to eat from the food magazine and were conditioned by the method of successive approximation to peck at the key. The 24 Ss were divided into groups of 6, and each group was trained on a given CS. The CS wave lengths were 530, 550, 580, and 600 $M\mu$. Fifty consecutive reinforcements were given on each of two days. Following this, additional sessions of aperiodic reinforcement were administered, using a mean inter-reinforcement interval of approximately 1 min. During APR, 60-sec. stimulus-on intervals were alternated with 10-sec. stimulus-off intervals, and 30 stimulus-on intervals constituted each daily training session. During the stimulus-on interval a shutter in the light path of the monochromator was opened and the key was illuminated with colored light. At the same time, the interior of S's box was illuminated by a 2.5-w. lamp reflected through the translucent plastic floor, resulting in an illuminance of <1.00 ft.-candle on the vertical walls. In the stimulus-off condition, similar to

TABLE 1
GENERALIZATION TEST STIMULI IN $M\mu$

Group	GENERALIZATION TEST STIMULI IN $M\mu$													
	-70	-60	-50	-40	-30	-20	-10	CS	+10	+20	+30	+40	+50	+60
530		470		490		500	510	520	530	540	550	560	570	590
550		490		510		520	530	540	550	560	570	580	590	610
580		520		540		550	560	570	580	590	600	610	620	640
600		550		560		570	580	590	600	610	620	630	640	

the "blackout" situation used by Ferster (4), both the key and box illumination were terminated. The blackout condition was introduced to facilitate the changing of the key color during the stimulus generalization tests.

Generalization testing was carried out under extinction and was preceded by six 30-sec. intervals of responding to the CS during which three reinforcements were administered. The wave lengths used in the generalization tests are given in Table 1. The 11 different stimuli were randomized within a series and 12 different random series were presented to each S resulting in a schedule of 132 stimulus presentations. Twelve different schedules were constructed for Ss given the 550 and 580 $M\mu$ CS's and the same 12 schedules were subsequently used for Ss given the 530 and 600 $M\mu$ CS's. Each stimulus presentation was 30 sec. and was followed by a 10-sec. stimulus-off interval.

Following generalization testing, three additional APR sessions were given using the original CS. After this a second generalization test identical to the first was administered. During both testings, the number of key pecks for each 30-sec. test stimulus presentation was recorded.

RESULTS

Characteristics of the generalization gradient.—The mean generalization gradients obtained in the first test are shown in the upper portion of Fig. 1. For each CS group (530, 550, 580, and 600 $M\mu$), the gradient was obtained by plotting the mean total number of responses for each test stimulus against wave length in arithmetic units.

It will be seen that the various generalization gradients have highly comparable forms. On either side of the CS, the rate of responding declines first in a nearly linear fashion, and as the rate approaches zero, the curves become negatively accelerated. The differences among the curves for

various CS's appear to be principally in terms of vertical displacement, i.e., total level of responding. The slopes of the generalization gradients, on the other hand, are very similar over the major portions of the curves and do not appear to conform to the expectation of marked changes corresponding to the transitions between spectral hues. The most conspicuous illustration of this point is the left half of the curve for 600 $M\mu$ which passes from orange through yellow to green. It

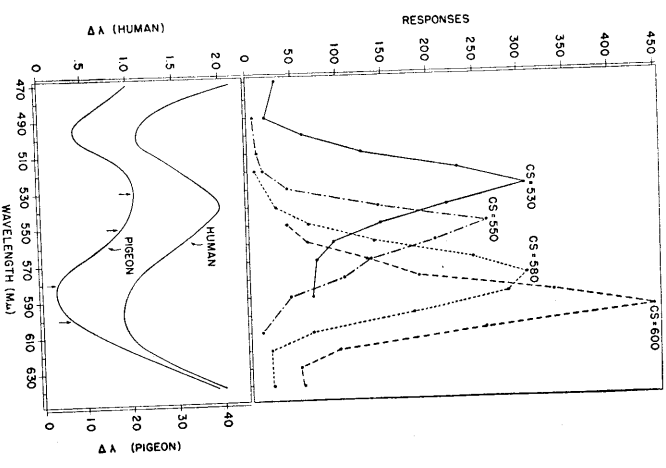


Fig. 1. Upper: Mean generalization gradients, first test. Lower: Hue discrimination as a function of wave length for pigeons (adapted from [15]), and humans (adapted from [1]).

exhibits approximately the same changes in slope as the other curves which do not pass through as many hues.

The similarity among the slopes of the curves is further substantiated by tests of trend (Type I analysis of variance [7]) for the right and left halves of the gradients separately. For the left half of all gradients, over the stimulus range from the CS to $-40 M\mu$, the interaction between wavelength of test stimuli and CS groups was not significant ($F = 1.02; 12, 80 df$), indicating that the hypothesis of parallel slope cannot be rejected over this range. For the right side of these gradients, over the stimulus range from the CS to $+40 M\mu$, the interaction was significant beyond the .1% level ($F = 3.84; 12, 80 df$). A further analysis of the differences in slope between pairs of gradients on the right side revealed that the interaction previously obtained resulted from a slope difference between the 600 and 580 $M\mu$ CS groups ($F = 5.10; 4, 40 df; P < .005$). The other slope differences on the right side were not statistically significant.

Evidence for differences in vertical displacement of the gradients was also furnished by the Type I analysis of variance used to test slope. The F obtained for the mean differences in rate of responding for the left sides of the gradient is 5.55 (3, 20 df) which is significant beyond the 1% level. The corresponding F for the right sides is 2.80 (3, 20 df) which is significant between the 5 and 10% levels. The mean differences on the right side are presumably reduced by the interaction involving the 600 and 580 $M\mu$ CS groups.

The lower portion of Fig. 1 presents the spectral difference threshold ($\Delta\lambda = f(\lambda)$) for both pigeons (5) and humans (1) adjusted to the same approximate ordinates. The functions

for the two species appear to be highly similar with minima and maxima at approximately the same wavelengths. Three characteristics of the $\Delta\lambda$ function might be reflected in the generalization gradients. The first is the absolute value of $\Delta\lambda$ which determines the j nd interval between any two values on the continuum, and hence might be related to the slope of the gradient. The other two characteristics are the first and second derivatives of $\Delta\lambda$ with respect to λ , which might be related to rate of change of curvature. For the purpose of the present analysis, we shall be concerned mainly with the absolute value of $\Delta\lambda$.

In terms of the discriminability function for the pigeon, the generalization gradients for CS values of 530 and 580 $M\mu$ should be relatively symmetrical. For values near the CS, however, the gradient for 580 $M\mu$ should be steeper than for any other CS. The gradients centered at 550 and 600 $M\mu$ should be asymmetrical, with 550 $M\mu$ being steeper in the direction of increasing wave length, and vice versa in the case of 600 $M\mu$.

In general, these expectations are not borne out. Figure 1 and the preceding statistical analyses of slope differences suggest that for the most part the gradients are of uniform slope. The major exceptions to uniformity of slope are the relative steepness of the 600 $M\mu$ gradient and the flatness of the 580 $M\mu$ gradient, both of which features are in the direction contrary to the hypothesis based on the $\Delta\lambda$ function.

The bidirectional symmetry of the gradients was examined by means of separate analyses of variance ($A \times B \times S$ [7]) for each CS group. In effect, one side of the gradient was superimposed on the other and a test of trend difference was obtained from the $A \times B$ (Right-Left Sides

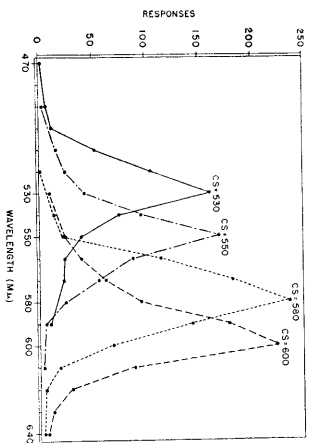


Fig. 2. Mean generalization gradients, second test.

\times Test Stimuli) interaction. The

values entering into this analysis were obtained by subtracting response rate for each test stimulus from the response rate at the CS. The hypothesis of symmetry could not be rejected for the 530 and 580 gradients, since the interaction F in each case was less than 1.00. This appears to conform to the $\Delta\lambda$ hypothesis. On the other hand, however, significant asymmetries contrary to the direction indicated by the $\Delta\lambda$ function are revealed in the analyses of variance for the 550 and 600 $M\mu$ groups. The interaction F for the 550 $M\mu$ gradient is 8.39, which is significant beyond the .1% level for 4, 20 df ; the F for the 600

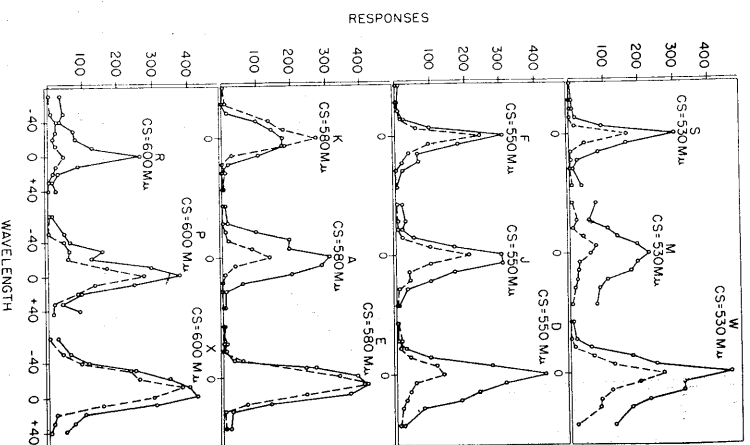


Fig. 4. Individual generalization gradients for 12 Ss representing various CS groups and levels of response strength. Solid lines designate the first test, broken lines the second test.

level for 4, 20 df ; the F for the 600 $M\mu$ gradient is 5.85, which is significant beyond the 1% level for 3, 15 df .

The results of the second generalization test, shown in Fig. 2, are highly similar to those obtained in the first test. In general, all gradients are reduced in height and the differences in vertical displacement and slope are attenuated. Neither the F for vertical displacement nor the F for slope difference is significant ($P \leq .20$). The hypothesis of symmetry can be rejected only for the 600 $M\mu$ gradient, since $F = 3.44$ (3, 15 df ; $.025 < P < .05$). The relationships among the

³The number of df s is reduced for the 600 $M\mu$ group because only four points to the right of the CS were available for analysis.

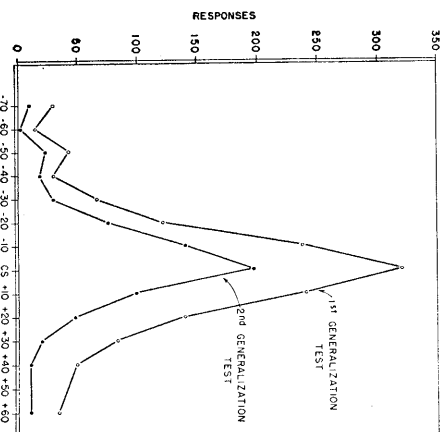


Fig. 3. Mean generalization gradients, first and second test, for all CS groups combined.

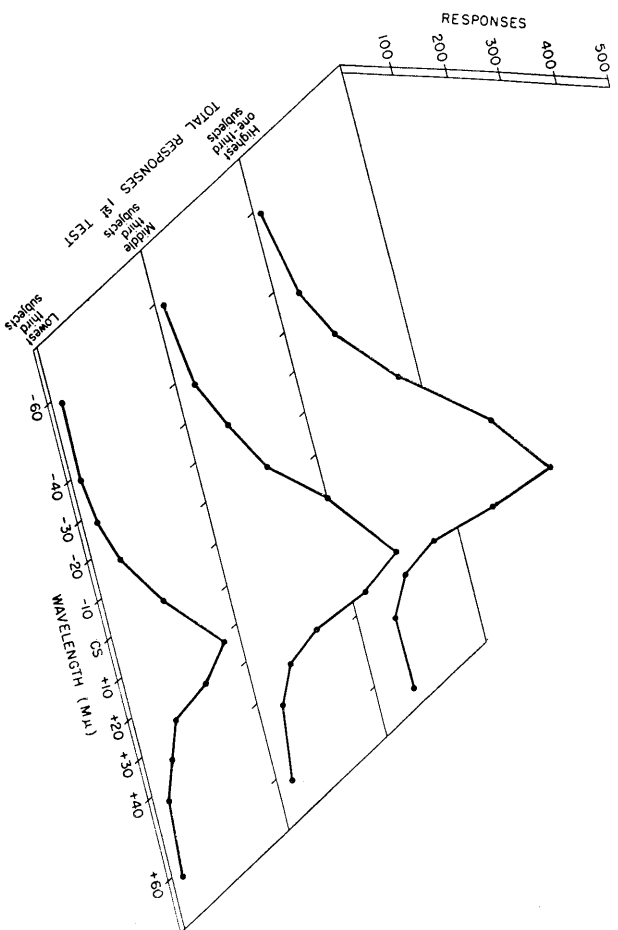


Fig. 5. Mean generalization gradients for groups of eight Ss differing in total number of responses, first test.

gradients for the second generalization test are such that the curves can be nearly superimposed by translating them along the wave-length axis to a common CS point.

The relationships between the mean generalization gradient for all groups in the first test and the mean for all groups in the second test are shown in Fig. 3.

Individual generalization gradients.

—Twelve pairs of individual generalization gradients for the first and second tests are shown in Fig. 4. These gradients are arranged in order of ascending response rate, and for each CS group the Ss presented are the lowest, the highest, and the S nearest the group median. Perhaps the most salient aspect of these curves is the orderliness and reproducibility of the generalization process within the individual S. Although these gradients are summed over the individual's schedule of 132 stimulus presentations, it is interesting that a similar bidirec-

tional gradient may be obtained from any one series of 11 stimulus presentations. A second interesting feature of these curves is the extent to which each S produces a gradient in the second test which is almost a replica of the first.

An examination of the individual gradients suggests that the averaged gradients in Fig. 3 are not entirely representative of the generalization phenomenon for the single S. For some Ss the curves are bilaterally convex, for some, concave, and for others, concave on one side and convex on the other. Certain Ss, such as Animal E (Fig. 4, second test), exhibit linearity over a major portion of the gradient. The linearity observed over the central range of the averaged curve (Fig. 3) may well be the result of a random distribution of concavities and convexities.

It may also be noted in Fig. 4 that certain Ss show maximum responding at a point either $\pm 10 M\mu$ from the CS.

In some instances this contributes to the departure from symmetry of the averaged group curves (Fig. 1).

The generalization gradient as a function of differences in response strength.—The averaged gradients in Fig. 5 were obtained by dividing the 24 Ss (without respect to CS group) into three relatively homogeneous subgroups in terms of total responses for the first generalization test. As the total response level is reduced, the generalization gradient becomes uniformly flatter. Tests of trend differences over the right and left halves of the gradients separately permit rejection of the hypothesis that the curves are parallel. On the right side, the interaction $F = 22.4$ (8, 84 df ; $P < .001$) while F for vertical displacement is 19.8 (2, 21 df ; $P < .001$). The interaction F for the left halves is 5.15 (8, 84 df ; $P < .001$), while the vertical displacement $F = 19.5$ (2, 21 df ; $P < .001$). In a later section we shall analyze in greater detail the nature of these interactions.

Additional information concerning changes in the generalization gradient associated with changes in level of responding may be obtained from an analysis of the extinction process occurring during the generalization test.

The generalization gradients in Fig. 6 are based upon the total responses of all Ss and represent the average performance for successive blocks of 33 stimulus presentations. The gradient for the first quarter of the extinction series is relatively steep, and the gradients for the succeeding quarters become progressively flatter. These changes bear a strong resemblance to those shown by the response-strength subgroups in Fig. 5. Furthermore, the gradients for the successive stages of extinction (Fig. 6) display a departure from parallelism on both sides of the CS. The interaction F 's for the right and left halves of the gradients are 8.22 and 6.40, both significant beyond the .1% level for 12, 276 df . The similarities between the changes in the form of the generalization

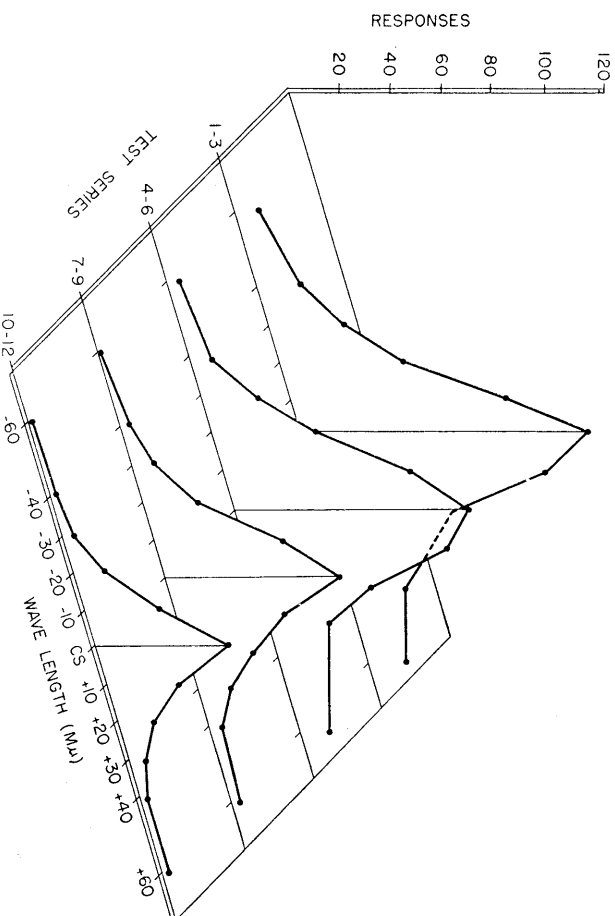


Fig. 6. Mean generalization gradients for successive fourths of first test.

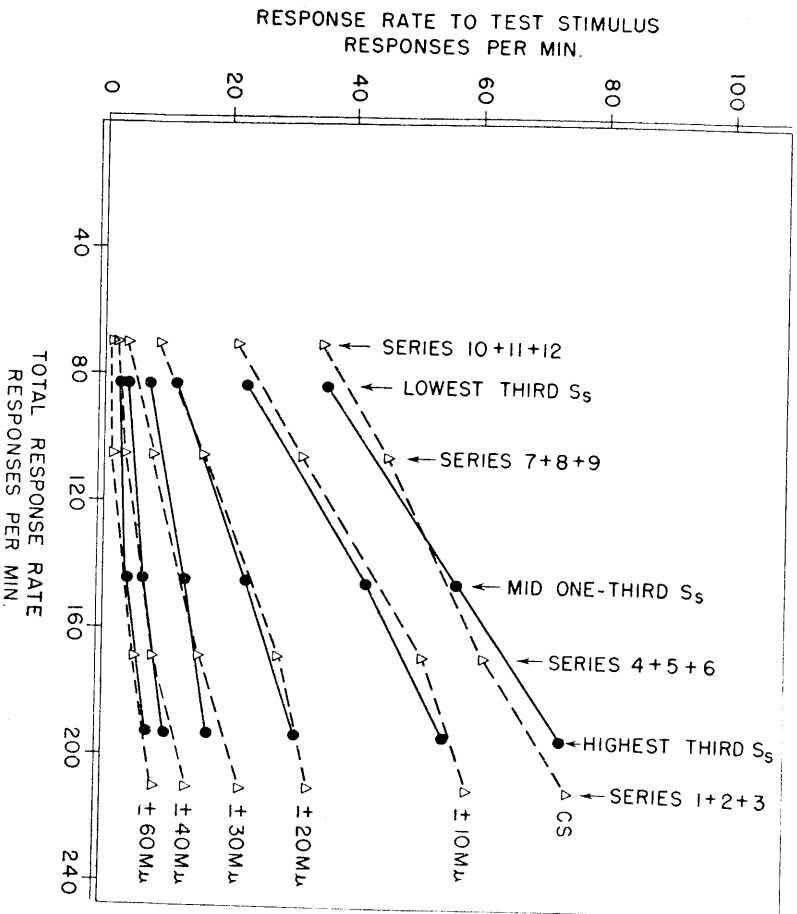


FIG. 7. Rate of responding for various test stimuli as a function of total response strength.

gradient during extinction (Fig. 6) and the changes associated with individual differences in response strength (Fig. 5) strongly suggest that both sets of changes may be represented by a common function. In order to obtain a graphical comparison of these changes, each bidirectional gradient for the first generalization test in Figs. 5 and 6 was first converted to a unidirectional gradient by averaging the response rates for $\pm 10 M\mu$, $\pm 20 M\mu$, etc., and converting to a common scale of responses per minute. Next, an index⁴ of the total rate of re-

⁴The index used was

$$R_{CS} + \sum_{n=1}^5 \left(\frac{[R_{+10M\mu} + R_{-10M\mu}]}{2} + \dots + \frac{[R_{+60M\mu} + R_{-60M\mu}]}{2} \right)$$

sponding (in responses per minute) was determined for each gradient. In Fig. 7 the values from each unidirectional gradient are plotted on ordinates erected at points corresponding to the total response strength for that gradient. The lines in this figure connect the same test stimulus values for the various gradients. Thus, the uppermost pair of lines connect the S_s values for the gradients in Fig. 5 and 6, the next pair of lines connect the values for $\pm 10 M\mu$, etc. These lines may be visualized as the contours of the surfaces in Fig. 5 and 6. The high de-

gree of correspondence between these lines indicates that changes in generalization as a function of response strength are the same whether the response strength varies within the individual, as in the course of extinction, or whether response strength is considered as a parameter characterizing the differences between individuals.

The transformation of the data to the form shown in Fig. 7 suggests the mathematical operation necessary to predict generalization at one level of response strength given the generalization function at a different level. The operation proposed by Hull (6) is multiplication by a constant. Miller (9) has suggested, in the context of a discussion of the effect of motivational changes on the gradient, that the conversion can be accomplished by adding a constant at every point on the gradient. If the multiplicative relation holds, then all the lines in Fig. 7 should pass through the point 0, 0, but if the additive relation obtains, then all the lines in this figure should be parallel to each other. The present results indicate that neither hypothesis alone provides a sufficient description of the situation. The additive relation appears to hold for values near the S_s , but the multiplicative relation must be invoked for values further removed from the S_s .

Discussion

The results of the present experiment do not appear to provide evidence for a correspondence between the discriminability function for wave length of light ($\Delta\lambda$ vs. λ) and the generalization process. Since some relationship is reasonable on logical and intuitive grounds, our results must be interpreted in the light of a number of possibilities. In the first place, the relationship may not, in fact, exist, because during generalization testing the δ is not making a comparative

judgment. In more formal terms, the analogy we have suggested between the generalization decrement and the difference limen may be misleading, because $p(R)$ in one situation refers to a simple conditioned response, while in the psychophysical experiment, $p(R)$ is associated with a complex of discriminatory responses.

The foregoing considerations, however, fall far short of excluding the possibility that a relationship does exist and that the present experiment has failed to disclose it. Our results are compatible with the notion that the wave-length discriminability function for the pigeon is much flatter than has been reported (5), flatter in fact than that for humans. It may also be that the discriminability differences in our situation are attenuated because the pigeon works in a dim light. As a check on the latter possibility a crude psychophysical experiment was performed on four human S_s using the method of minimal changes. The $\Delta\lambda$ function obtained was not appreciably different from that generally reported; it showed minima in the blue and yellow regions, a maximum in the green, and differences on the order of 5:1. The same results were obtained in the dark and in the presence of dim light.

Another factor in our experiment which might act to distort the expected relationship is brightness variation, since no attempt was made to equate the test stimuli for brightness or incident energy. This might have the consequence of increasing the slope of gradients passing into regions of lower visibility, and might account for the asymmetry of the gradient for 600 $M\mu$. If, however, brightness were an important factor over all, it would be difficult to account for the high degree of similarity among the gradients plotted on a wave-length continuum. The extent to which brightness can be invoked as a variable is inversely proportional to the degree of relationship between changes in response rate and wave length.

Finally, serious consideration must be given to the possibility that the relationship between generalization and discrimination is much more complex than

we have supposed. Before any general statement can be made concerning the independence of discriminability and stimulus generalization, the problems raised by the present experiment must be explored with other continua, species, and techniques.

With respect to the issue of changes in the form of the generalization gradient with changes in response strength, our findings may be compared most directly with those of Margoliuss (8), who investigated changes in generalization as a function of number of conditioning trials. In terms of the rate of responding measure, Margoliuss found increases in the absolute and relative amounts of generalization as the number of training trials increased. Margoliuss' interpretation of his findings is equivalent to what we have designated as the additive relation. It will be recalled that for the present results, the additive hypothesis was tenable for the major area of the curve including values near the CS, and high response strengths, but for remote values of the stimuli and for low response strengths the additive relation fails. This suggests the possibility that the empirical gradient is comprised of two components, one which is linear on a wave-length scale and changes additively, and another which is curvilinear and changes multiplicatively. It may be that the second component is contributed by random responding and responding to extraneous stimuli accompanying the beginning of a trial. This separation of components implies that if the contribution of the second component was reduced, either experimentally or analytically, the additive relation would become more conspicuous.

SUMMARY

An experiment was performed to test the hypothesis of a relationship between the discriminability of spectrum colors and stimulus generalization along the wave-length continuum. Four groups of six pigeons were trained to peck at a disc illuminated by monochromatic lights corresponding to 530, 550, 580, and 600 *mμ*. Bidirectional generalization gradients were obtained from measures of response rate during extinction. These gradients were of highly com-

parable forms for the various spectral regions tested. The results open the possibility of an independence between the generalization decrement and the discriminability of stimuli.

Changes in the generalization gradient accompanying changes in response strength were investigated. A close correspondence was found between changes in the form of the gradient during extinction and changes associated with individual differences in response strength. In both cases the changes appear to be describable by means of a combined additive and multiplicative relationship.

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(Received for early publication August 8, 1955)

Journal of Experimental Psychology

VOL. 51, No. 2

FEBRUARY, 1956

RESPONSES TO MATERIAL PRESENTED DURING VARIOUS LEVELS OF SLEEP

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Recently, there has been an increased interest in the possibility of learning during sleep. A critical review of the few scientific studies in this field to date lead to the conclusion that the evidence supporting claims of learning during actual sleep is inconclusive. The chief criticism against the existing studies is their failure to continuously determine the sleep state of Ss during the stimulus input period (16).

After considerable exploratory work (15), the present experiment was designed to study the effect of presenting material at different levels between wakefulness and deep sleep on the ability of Ss (a) to respond to it immediately, and (b) to recall it later upon awakening. It was hypothesized that learning during sleep was improbable.

METHOD

Subjects

Twenty-one male experimental Ss were used. In order to facilitate the detection of gradual

changes which occur in the EEG between wakefulness and light sleep, it was necessary to use only Ss having a persistent occipital alpha rhythm when awake and relaxed with their eyes closed. Ten Ss were junior college students, nine were scientists, and two were policemen. Results from students and policemen were combined since they were similar on critical variables. Means and SD's of descriptive variables for the experimental subgroups were determined. For the scientist group, these values were: age, 30.6 yr. ± 5.0 ; IQ, 122.6 ± 6.0 ; items correct on pretest, 11.7 ± 3.4 . For the college men and policemen combined, these values were: age, 23.2 yr. ± 6.3 ; IQ, 108.6 ± 4.7 ; items correct on pretest, 6.8 ± 3.0 .

Forty junior college males and 24 male scientists acted as a control group without regard for their alpha rhythm. These Ss were used to obtain an estimate of the probability of correct answers being chosen on a multiple-choice test, since it seemed unlikely that educated Ss would select their answers to unknown questions solely by chance. This control group was first given a pretest to determine the number of test questions known without training and before seeing the multiple-choice alternatives. With no intervening training and after items correct on the pretest were removed, the pretest significantly predicted scores on the multiple-choice test. This prediction was not significantly improved when IQ or age was added in a multiple-regression equation.

Control and experimental subgroups were matched on means and variances of their IQ, age, and pretest scores. Only the variances of the age and IQ of the college subgroups were unmatched.²

¹ The authors wish to acknowledge the valuable assistance of Louie W. Mason, Jr. and James L. Barnes in the analysis of the data in this study. Appreciation is expressed to the faculty and students of Santa Monica City College, to the Santa Monica Police Department, and to the volunteer Ss within The RAND Corporation for their cooperation throughout the project.

² Supporting and additional statistics along with data by S have been deposited with the