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ON THE FORM OF STIMULUS GENERALIZATION CURVES FOR VISUAL INTENSITY[1]

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Twelve pigeons were given successive discrimination training involving variable-interval reinforcement for key pecking in the presence of one intensity of monochromatic light randomly alternated with extinction for pecking during another intensity. All of the pigeons were then tested in extinction for generalization along the intensity dimension, and all showed a displacement of maximal responding from the positive stimulus in the direction opposite the negative stimulus. For six of the pigeons, for which the test included only three values beyond the positive stimulus, four showed peaked gradients but two did not, showing monotonic gradients with maximal responding to the most extreme test value. For another six pigeons tested over a wider range, all showed peaked gradients. Thus, when a sufficiently wide range of test values is employed, generalization gradients for visual intensity have the same peaked form as do gradients for qualitative visual dimensions such as wavelength or line angle.

Many studies in the literature report peaked generalization gradients following intra-dimensional discrimination training, with a peak shift from the positive stimulus (S+) in the direction away from the negative stimulus (S−) and a subsequent reduction from the peak level of responding. Three examples are studies by Hanson (1959), who employed the wavelength dimension; Bloomfield (1967), who used line tilt, and Riccio, Urda, and Thomas (1966), who used floor tilt. On the other hand, Heinemann and Chase (1970) reported two separate experiments demonstrating that generalization gradients for intensity of white noise, obtained after training pigeons to discriminate between two intensities, have the (monotonic) sigmoidal form of psychometric functions. Experiment I employed a two-key choice situation and Exp. II used the standard single-key free-operant method, yet the results were entirely comparable.

Pierrel and Sherman (1960) conducted a study in which white rats discriminated between two intensities of a pure tone. In their study, maximal responding was displaced to a stimulus 10 db removed from S+ in the direction opposite S−. This was the most extreme value in the generalization test series; it is thus impossible to determine whether additional test values would have resulted in a monotonic gradient or a peaked one. Heinemann and Chase (1970) speculated that differences in stimulus continua account for the observed discrepancy in the form of generalization gradients and they implied that the monotonic form may be typical of intensity dimensions. The present study sought to test this speculation with a visual intensity continuum.

METHOD

Subjects

Twelve experimentally naive domestic pigeons were maintained at approximately 75% of their free-feeding weight.

Apparatus

A single-key pigeon chamber, with associated automatic scheduling and recording equipment, was used. The interior of the chamber was painted flat black to reduce reflections. There was no houselight; thus, except for the feeder light during reinforcement periods, the only illumination in the experimental chamber was provided by the response key. Visual stimuli, produced by a Bausch and

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Lomb model 33-86-02 monochromator in conjunction with a pair of Kodak Type-M Carbon neutral density optical wedges, transilluminated the translucent response key. The monochromator was set at 580 nm throughout the experiment. The optical wedges were calibrated to vary the stimulus intensity from 0.70 to 70.0 mL (2.23 to 223 cd/m^2). Nine stimuli were equally spaced on a log of intensity scale in increments of 0.25 log units. The actual values of the stimuli were (in milliamberts) 0.70, 1.24, 2.21, 3.94, 7.00, 12.45, 22.14, 39.36, and 70.00 (1 mL = 3.18 cd/m^2). A Grason Stadler model 901 noise generator provided masking noise to the chamber at all times.

Procedure

On the first day, all of the pigeons were given magazine training and key pecking was conditioned. On this and on the two succeeding days, 40 pecks were reinforced (3-sec access to a hopper of mixed grain) on a continuous reinforcement schedule. Over the next four days, the time between reinforcements was gradually and unsystematically increased until a variable-interval one minute (VI-1 min) schedule was in effect. During this training, the key was illuminated with the stimulus that was to become the S+ during discrimination training.

All of the pigeons were given discrimination training starting on the eighth day. For three of them (No. 1, 2, 3) the stimulus presented during reinforced periods (S+) was 12.45 mL (39.6 cd/m^2) while the stimulus presented during non-reinforcement (S−) periods was 3.94 mL (12.5 cd/m^2). This was counterbalanced by three pigeons (4, 5, 6) for which these S+ and S− values were reversed. An additional three pigeons (7, 8, 9) had an S+ of 22.14 mL (70.5 ad/m^2) and an S− of 70.00 mL (223 ad/m^2) counterbalanced by three pigeons (10, 11, 12) with an S+ of 2.21 mL (7.30 cd/m^2) and an S− of 0.70 mL (2.23 cd/m^2). Discrimination training consisted of random alternations of 50-sec S+ and S− periods (except that no more than two S+ or S− periods occurred successively) separated by 10-sec blackout or no-stimulus intervals. Responses during S+ were reinforced on a VI-1 min schedule, responses during S− were not reinforced. The pigeons were given daily 40-min sessions (20 S+ periods and 20 S− periods) until reaching a criterion of 10 sequential S− periods with a total of three or fewer responses while responding during the intervening S+ periods was maintained. On the following day, the pigeons were given a 5-min reinforced warmup session on the discrimination followed immediately by an intensity generalization test. The test, conducted in extinction, consisted of eight blocks of nine randomly alternated stimuli that varied in intensity from 0.70 mL to 70.00 mL (2.23 to 223 cd/m^2) in 0.25 log unit increments. These stimuli were presented for 50-sec periods separated by 10-sec blackout intervals.

RESULTS AND DISCUSSION

In this study, four different intensity discriminations were used, each involving a 0.5 log unit S+S− difference. There were no systematic differences in difficulty attributable to the choice of training stimulus values. The criterion was achieved in from two to 11 sessions except by one bird, which failed to approach criterion in 24 sessions and was replaced. For each bird the number of training sessions required is indicated in Fig. 1, which also presents the relative generalization gradients of all 12 birds. All showed essentially zero responding in the vicinity of S− and a displacement of maximal responding from S+ in the direction opposite S−. In four of the first six cases, the generalization gradients were peaked, whereas in two (birds 1 and 4), they were monotonic. In view of the possibility that a wider range of test stimuli would more consistently reveal a peaked gradient, Birds 7 to 12 were tested with six stimuli beyond the S+ value rather than just three. In every one of these cases a peaked gradient was obtained. Note that for Bird 7, the peak was at a stimulus three values removed from S+, covering a magnitude of 0.75 log units. In Bird 10, responding was almost equal to values two and three steps beyond S+. A shift of comparable magnitude in the gradients of Birds 1 and 4 would have artifactually produced a monotonic gradient with these birds. Although it is, of course, impossible to be certain that the gradients of these two birds would have been peaked if a wider range of test stimuli had been used, the evidence suggests strongly that this is the case.

Clearly, the inference that intensity dimensions typically yield monotonic gradients must now be rejected. Such gradients may be char-

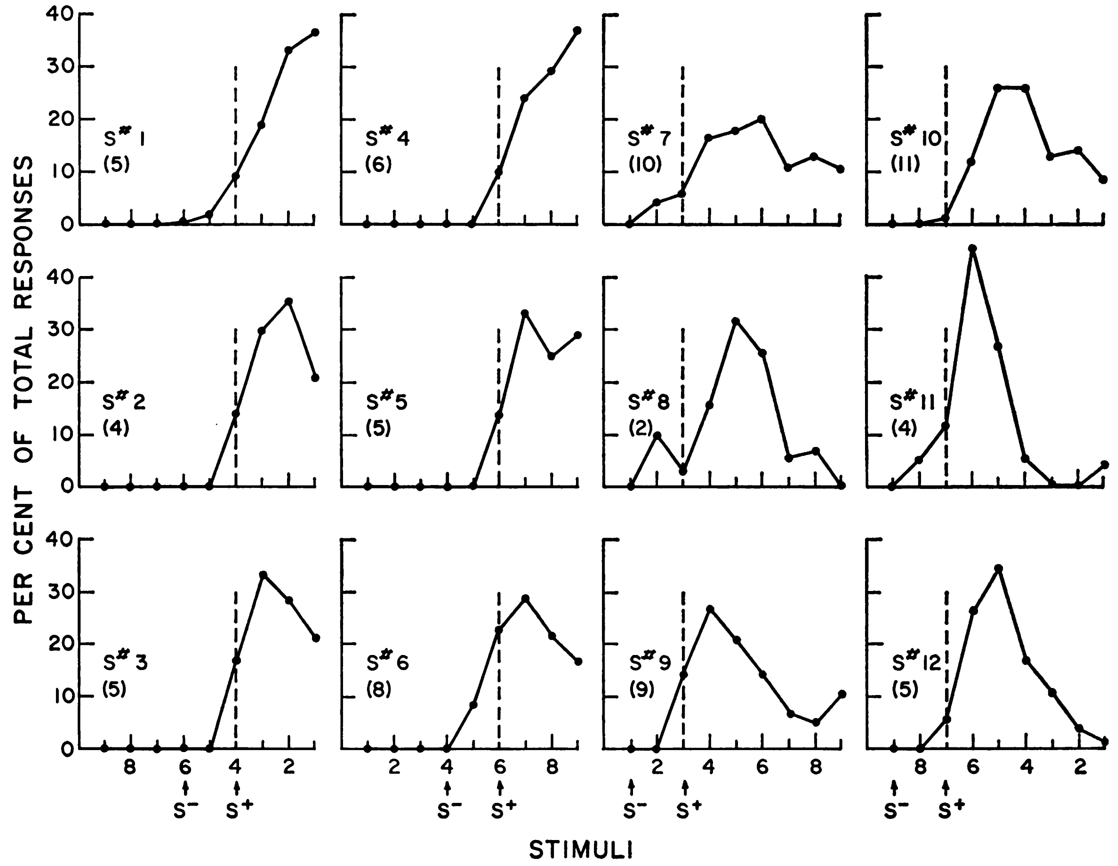

Fig. 1. Relative generalization gradients of the 12 subjects. The vertical dashed line indicates the location of S+, and to facilitate comparison, S− is plotted to the left of S+ in all cases. The code numbers plotted on the abscissas correspond to the following intensity values (in mL): 1 = 70.00; 2 = 39.36; 3 = 22.14; 4 = 12.45; 5 = 7.00; 6 = 3.94; 7 = 2.21; 8 = 1.24; and 9 = 0.70 (1 ml = 3.18 cd/m^2).

acteristic of auditory intensity continua, but a more parsimonious interpretation is available. Suppose that intensive and qualitative dimensions both typically yield post-discrimination gradients of the same peaked form. Contradictory evidence from the Pierrel and Sherman (1960) and the Heinemann and Chase (1970) studies might be explicable on the assumption that the peak shifts obtained in these studies were too great to be encompassed by the range of test stimuli employed. Hanson (1959), Thomas (1962) and others have shown that the more difficult the problem (*i.e.,* the more similar the S+ and S− values) the greater the peak shift. Although Heinemann and Chase did not report on the discrimination performance of their subjects in their Exp. 2, in which the procedure was roughly comparable to that used here, their birds received over 80 days of training and it may be presumed that the discrimination was an extremely difficult one. Monotonic gradients were indeed obtained in this experiment, but there were only three test stimuli beyond S+, covering a range of 9 db with two birds and 19 db with two others. Similarly, in Pierrel and Sherman's (1960) experiment there were only two test values covering a range of 10 db beyond the S+ value. The present results suggest the hypothesis that peaked generalization gradients would have been obtained in these experiments if a wider range of test stimuli and/or a less difficult discrimination had been used. This is, of course, sheer speculation, but the hypothesis that intensive and qualitative dimensions yield comparable gradients is intuitively appealing, and available evidence seems insufficient to reject it. The need for further study with additional species and other stimulus dimensions should be obvious.

The use of a wider test series in the Heinemann and Chase study might have served still another important purpose. It is true that generalization functions they obtained for single-key and choice situations were comparable over the range of test stimuli employed (19 db in the former case, 22 db in the latter). However, monotonic functions may yet be typical of choice situations, or they may extend over a wider range of stimuli than is true for the single-key method, yet this difference, if one exists, could easily have been missed. In view of several differences between choice and non-choice behavior in other respects, the claim that intensity generalization functions are comparable in the two situations also needs further support.

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