GENERALIZATION AND DISCRIMINATION AS A FUNCTION OF THE S^D - S^A INTENSITY DIFFERENCE¹

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Three groups of four rats were trained on an auditory-intensity discrimination for 21 days. The S^D - S^A intensity difference for Group I was 10 db; for Group II, 20 db; and for Group III, 30 db. Following the initial discrimination training, the animals were tested for generalization of the bar-press response to seven novel S^A 's which were presented intermingled with the original S^D and S^A values. *Conclusions:* (1.) The amount of simple discrimination training required to obtain fairly stable differences in S^D and S^A responding is an inverse function of the magnitude of the stimulus difference between S^D and S^A . (2.) Generalization gradients obtained immediately following simple discrimination training exhibit a maximum displaced from S^D in a direction also away from S^A . (3.) Gradients obtained following continued exposure to the multivalued S^A situation show a fairly stable maximum at the S^D value. (4.) Although the gradients tend to fall off systematically on either side of the continuum as distance from S^D is increased, they decrease most rapidly on the S^A limb of the gradient.

The present investigation was suggested by a discrimination study carried out by Frick (1948). He trained five groups of rats on a light-intensity discrimination, and the difference in light-intensity between S^D and S^A varied among the five groups. His results indicated that the rate of responding in S^A was functionally related to the intensity difference, the S^A rate increasing as the S^D - S^A difference decreased. Hanson (1959) also used a discrimination training procedure in which several groups of birds were trained on different S^D - S^A stimulus differences. In this case, a wavelength continuum was used, and generalization gradients were obtained following discrimination training. He found that with decreasing S^D - S^A differences, the time required to meet a discrimination criterion increased. He also noted that as the S^D - S^A separation became less, the postdiscrimination generalization gradient was displaced along the stimulus continuum in a direction away from S^A .

Our interest in the present study was to carry out an extension of the Frick procedure with three values of S^D - S^A auditory-intensity difference. Simple discrimination training was maintained for a considerably longer period

than in the Frick study, and, presumably, relatively more stable differential responding was established (Sherman & Pierrel, 1961). The original discrimination training was followed by the development of a second, multi- S^A -valued discrimination (generalization).

METHOD

The subjects for this experiment were 12 male albino rats of the Sprague-Dawley strain bred in the Barnard colony. They were 90-110 days old at the start of experimentation. The animals were reduced to 80% of their free-feeding weights over a period of about 3 weeks before the start of experimentation, and they were maintained at an 80% weight value throughout the experiment. The base weight from which the 80% value was calculated was changed weekly in an effort to parallel increases in free-feeding weight exhibited by animals in this age range.

Four identically constructed, sound-shielded operant spaces were used. A detailed description of the animal enclosures and control and recording equipment has been given elsewhere (Pierrel & Sherman, 1960; Sherman & Pierrel, 1961). The first phase of the experiment was termed Discrimination Training I. When the 80% body weight criterion had been met, the rats were randomly assigned to three groups of four and trained as follows:

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Day 1. The animals were placed in the experimental enclosures in the presence of the sound intensity which was to serve as S^D in the subsequent discrimination training. Each rat was allowed to remain in the enclosure until 100 regular reinforcements had been collected for bar pressing.

Day 2–Day 22. Discrimination training sessions were carried out in which S^D and S^A were two sound intensities of a tone of 4 k cps. In the following, zero db is taken as 100 db above 0.0002 dyne/cm². Other values are presented in terms of decibels of attenuation from this reference value. For all groups, the S^A intensity was zero db. The treatment of the three groups differed only in the S^D intensity used. The S^D intensities were: Group I, 10 db; Group II, 20 db; and Group III, 30 db.

The animals were run daily at the same hour.³ Group I was run at 4:00 A.M., Group II at 8:30 A.M., and Group III at 1:00 P.M. Sessions were 4 hr, 1 hr consisting of S^D . The S^D periods ranged from 1 to 3 min, whereas the S^A intervals ranged from 2 to 9 min. The order of alternation of lengths of S^D and S^A periods was a predetermined “random” order taken from the Gellerman series designed to avoid simple alternation sequences. The change in intensity from S^D to S^A was controlled by a fader amplifier which changed signal level without the production of transients audible to the human ear. This was effected by fading the signal amplitude down to zero and then back to some predetermined intensity level. The fade-out, fade-in sequence required a tenth of a second. To prevent the “fade” from serving as an added S^D for intensity change, fades were “randomly” inserted within S^D periods. The mean inter-reinforcement interval within S^D was 1 min. The program of reinforcement intervals was obtained from a randomized geometric progression.

Day 22–Day 43. In the second part of the experiment, testing for generalization was carried out: This phase of the experiment was termed Discrimination Training II. Under these conditions, the 3 hr of the experimental

sessions previously devoted to S^A were now subdivided such that each of eight S^A 's was presented for an equal time (one of these being the S^A of Discrimination Training I). The S^D used in the first phase of training continued to appear for the same amount of time and in the same temporal positions within the session. The same VI schedule of reinforce-

PLAN OF STIMULUS PRESENTATION

GROUP

SOUND LEVELS IN DECIBELS ATTENUATION

Fig. 1. Diagram of stimuli used in discrimination training and generalization.

ment in S^D was continued as in Discrimination Training I. The stimuli presented to the three groups are shown diagrammatically in Fig. 1.

RESULTS AND DISCUSSION

For all of the data treatment of Discrimination Training I, the total number of responses in S^A has been divided by 3.0 to correct for the disproportionate amount of session time devoted to S^A as compared with S^D .⁴ In the treatment of the data of Discrimination Training II, the total number of responses in S^D has been divided by a constant to correct for the larger proportion of session time then devoted to S^D as contrasted with each of the 8 S^A 's. The histograms of Fig. 2 (all data processed as indicated for Discrimination Training I) allow a comparison of the daily session

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⁴Responses during the first 30 min of each session were omitted from these calculations to eliminate the more variable behavior evident at the start of each day's run.

totals for the four rats in each group on the first, tenth, and twentieth days of Discrimination Training I and II. The total number of responses for S^D , S^A , and $S^D + S^A$ has been given for each group. The S^A total for Discrimination Training II includes responding across all 8 S^A 's.

A comparison of the three groups in the first phase of the experiment shows that all of the response totals are inversely proportional to the magnitude of the difference between S^D and S^A , and that these response differences among groups tend to become progressively more marked as the training continues. The Day 1 comparison between S^D and S^A totals dramatically defines the

Fig. 2. Response totals for S^D , S^A , and $S^D + S^A$ on Days 1, 10, and 20 for both phases of discrimination training. Each block of histograms represents a single group total.

"difficulty" of the discrimination, setting the three groups apart in the ratio of S^A to S^D responses. This result supports Frick's earlier observation that S^A responding is related to the magnitude of the difference between S^D and S^A . The greater number of responses occurs when the S^D - S^A difference is small.

When Day 20 histograms of Discrimination Training I are contrasted with those of Day 1, Discrimination Training II, a deterioration of the S^A/S^D ratio is evident in all groups. However, as the second phase of training continues, there is a progressive improvement in the ratio as the new multivalued S^A discrimination is formed. This effect has been previously noted by the present investigators (Pierrel, 1958; Pierrel & Sherman, 1960; Sherman & Pierrel, 1961). It appears that the over-all response levels for all groups are maintained throughout Discrimination Training II at about the same level as that attained at the end of Phase I.

Figure 3 is a day-by-day plot of the S^A/S^D ratios for a single representative rat from each group throughout Discrimination Training I. All animals show the most marked development of differential behavior within the first week of training. At this early stage (about Day 4 or 5), the three groups seem to be clearly separated, with the S^A/S^D ratio magnitude inversely proportional to the S^D - S^A separation. However, as training progresses, the three animals (and groups) seem to achieve about the same level of discrimination ($S^A/S^D \approx 0.10$), with some suggestion of the development of a rough asymptote in the final week.

Figures 4, 5, and 6 are single-session gradients of a representative animal from each group showing the course of Discrimination Training II on Days 1, 7, 13, and 21.

There is evidence of a displacement of the maximum away from S^D in a direction also away from S^A . This displacement of the maximum was noted by Hanson (1959), who presented gradients obtained under extinction conditions, and by the present investigators (Pierrel & Sherman, 1960) under conditions similar to those in Group II of the current experiment (20 db S^D - S^A difference). This effect appears to occur chiefly in the very early stages of Discrimination II. (See Day 1, Fig. 5 and 6.) We might expect to find data most analogous to that of Hanson's generalization gradients early in Discrimination II, before the additional discrimination training of our procedure has produced its maximum effect. A displacement is evident in at least 1 of the 4 hr of the Day 1 sessions for 9 out of 12 animals. As the multi- S^A -valued discrimination training of Phase II is continued, all

Fig. 5. Total responses per session as a function of intensity level. Each curve represents one session of Discrimination Training II. Every point on each curve represents the data for a single Group II animal for a given session.

Fig. 4. Total responses per session as a function of intensity level. Each curve represents one session of Discrimination Training II. Every point on each curve represents the data for a single Group I animal for a given session.

Fig. 6. Total responses per session as a function of intensity level. Each curve represents one session of Discrimination Training II. Every point on each curve represents the data for a single Group III animal for a given session.

groups develop a fairly stable maximum at the S^D intensity.

It is clear that the S^A of Discrimination Training I continues to produce an effect on the gradients obtained throughout Discrimination Training II. In general, a concave function results when the values between S^D and S^A are plotted. All Group II and Group III functions have their minima at the original S^A . Group I (S^D - S^A difference only 10 db) shows a minimum to the left of S^D toward the extreme of the continuum. This is not surprising in view of the previously noted increase in responding to the original S^A with increasing proximity of S^D and S^A . For Group II (Fig. 5), the S^D lies in the middle of the intensity continuum with S^A at one extreme. These gradients show a marked asymmetry. Response rates, at comparable distances to the right and left of S^D , are consistently lower on the S^A end of the gradient. The same effect is seen in Fig. 4 and 6, when rates are examined at intensities on either side of and equidistant from S^D .

From the evidence provided by earlier experiments, it is suggested that this asymmetry is the result of S^D and S^A control rather than an effect produced by any aversive or intensive properties of the stimuli. In two previous discrimination studies (Pierrel, 1958; Pierrel & Sherman, 1960), the present investigators included groups of animals which were "mirror images" of one another; *i.e.*, the S^D intensity for one group served as the S^A for its counterpart and vice versa. This was done in an effort to note possible differences in either the development of simple discriminated behavior or gradient form as a function of absolute intensity *per se*. In these studies the development of both the simple and multi-valued discrimination was highly similar for the mirror-image pairs. It was suggested that if

the animals do exhibit stimulus preferences or aversions as a function of *absolute* intensity, these effects are rapidly overridden in this type of discrimination training. The important variable in determining gradient form appeared to be the location of S^D and S^A along the stimulus continuum rather than the *absolute* intensity magnitudes used. Further studies will be necessary to determine whether or not there are any S^D - S^A difference values for which the absolute intensity can influence either the shape of the gradient or the displaced maximum effect.

With the accumulation of Discrimination II sessions, all animals in all groups show development of increasingly orderly functions. These gradients tend to be concave functions between S^D and S^A and J-shaped in the direction opposite to S^A . The achievement of a fairly smooth and stable curve form occurs earliest on Group III and last in Group I. The time required for the development of a stable "generalization" gradient appears to be inversely related to the magnitude of the S^D - S^A difference.

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