THE USE OF A BEHAVIORAL STIMULANT IN THE STUDY OF STIMULUS GENERALIZATION¹

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Pipradrol, a CNS stimulant, has been shown to affect the performance of pigeons trained in the operant situation (Dews, 1956). In the present study, the drug was used to modify response rates during tests of stimulus generalization in the pigeon.

METHOD

Subjects

Fifteen male, White Carneaux pigeons (Palmetto Pigeon Plant), maintained at 70-80% free-feeding body weight by restricted feeding, were used.

Apparatus

An automatic key-pecking apparatus especially designed for the study of stimulus generalization was used. A monochromatic light source illuminated the key with any desired wavelength. Details of the apparatus have been published elsewhere (Hanson, 1959).

Procedure

All pigeons were magazine-trained and conditioned to key peck with monochromatic light of 550 millimicrons on the key. After two daily sessions during which 50 continuous reinforcements were given, all birds received 165 minutes of VI 1 training to the same stimulus (550 millimicrons). Daily sessions consisted of sixty 30-second work periods separated by 10-second blackouts. The tenth daily session consisted of 120 such work periods. After the tenth and final day of training, the pigeons were divided into two groups: the experimental group $N = 10$, and the control group $N = 5$.

All pigeons received generalization tests consisting of the repeated presentation of 11 monochromatic stimuli ranging from 490 to 640 millimicrons under extinction conditions. Each stimulus was presented 10 times for 30 seconds according to a predetermined schedule of random permutations of the 11 stimuli. Ten-second blackouts separated presentations. A different randomized schedule was used for each bird. On the day following the first test, a second identical test was given. No training intervened between tests.

Approximately 80 minutes preceding generalization testing, the pigeons were injected intramuscularly with

either 8 milligrams per kilogram of pipradrol³ dissolved in saline or with a comparable volume of saline. The injection was given at two sites in the pectoral muscle.

RESULTS AND DISCUSSION

The course of the rates of responding during generalization testing is shown in Fig. 1. The average number of responses emitted during 5.5-minute periods of the test (the time required, ignoring blackouts, for a single presentation of each of the test stimuli) is plotted against elapsed test time. The control group shows an orderly decrease, typical of extinction, in the number of responses emitted during testing for both Tests 1 and 2. The average number of responses emitted in the first 5.5-minute period of the second test is higher than the number of responses emitted during the last period of the first generalization test. This increase in responding (spontaneous recovery) is significant at better than the .05 level of confidence by the Mann-Whitney U test (Siegel, 1956).

The course of extinction was clearly different for the experimental group. The average rate of responding during the first period of the first test was significantly lower than that of the control group (.05 level by the Mann-Whitney U test). The response rates did not decrease during the course of extinction for either the experimental group or the control group. No significant differences were found between the average rates of responding for Periods 1 and 10 of the first generalization test. The average rates of responding of the experimental group during the first period of the second test are significantly lower than the average rates in the final period of the first test ($P < .05$ by the Mann-Whitney U test). During the second generalization test as during the first, the rate of responding of the drugged group did not decrease significantly.

From the data in Fig. 1, it would appear that pipradrol has a pronounced effect upon the behavior recorded during generalization testing. The initial rate of responding is lower for the drugged group, but this response level is sustained, essentially without decrement, during both test sessions. Thus, there is little evidence for experimental extinction within sessions and none for "spontaneous recovery" between sessions. It would seem safe to conclude that the compound injected was behaviorally active during the major part of generalization testing.

The generalization gradients in Fig. 2 were constructed by plotting the average number of responses

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Fig. 1. Rates of responding during generalization testing. During each 5.5-minute period, each of the 11 test stimuli was presented once.

Fig. 2. Mean generalization gradients for the drug and control groups.

Fig. 3. Generalization gradients in terms of percentage of total responses. Each point represents the group average for two stimulus presentations, at the stage of testing when the rates of responding of the drug and control groups were equal.

Fig. 4. The group average percentage of stimulus presentations to which one or more responses were emitted plotted against wavelength of stimulus.

emitted to each stimulus during testing against the wavelength of that stimulus. The gradients for the first and second tests were plotted separately. The average gradients produced during the first test by the two groups appear to be very similar in shape and height, and no significant differences between them were demonstrable. The gradient produced by the experimental group during the second test is markedly higher than that of the control group; both curves, however, would appear to belong to the same family of multiplicative curves published by Guttman and Kalish (1956). No gross changes or effects other than those attributable to changes in the total number of responses emitted are apparent.

This lack of effect on the gradient is supported by the curves in Fig. 3. To eliminate any difficulties in interpretation due to different response rates (interest being focused on possible effects on the shape of the gradient), only those data were plotted which were collected during the fourth and fifth presentations of the 11 stimuli in the first generalization test and during the first and second presentations of the 11 stimuli in the second test. At these times in the experiment, the response rates were essentially equal for the two groups. (See Fig. 1.) The per cent total average responses to each wavelength were plotted against wavelength. As was true for the original gradients, no significant differences are demonstrable between the two groups.

Figure 4 shows the percentage of the total number of individual stimulus presentations, *i.e.*, 30 seconds' exposure to one of the 11 stimuli, during which one or more responses were emitted during generalization testing, plotted against wavelength. The curves are bowl-shaped and essentially symmetrical around 550 millimicrons. For the first generalization test the curves are very similar, with only a nonsignificant difference in height separating them. These curves indicate that in the region where high rates of responding were found (*i.e.*, those stimuli close to the reinforced stimulus), nearly every stimulus presentation elicited one or more responses. In the second test the rates of the control group were lower and the general form of the curve is "contracted," *i.e.*, fewer stimuli elicited responses. In the experimental group, however, the over-all rates were high during the second test, and the per cent response curve is approximately that of the first test.

If the effect of the drug studied had been to lessen the stimulus control exerted by the earlier training, or if the effect of the drug was to increase responding to all stimuli additively, the experimental curves produced would be flatter. That this was not the case is apparent.

The effective control of responding along the wavelength continuum is dependent on both the over-all rate of responding and upon the proximity of a particular stimulus to the original positive stimulus. As the over-all rate of responding drops during generalization testing, the range of the stimuli eliciting responding decreases until, in the last stages of extinction, only the conditioned stimulus and one or two surrounding stim-

uli are responded to. This relationship is presented graphically in Fig. 5. The average number of responses emitted to any particular series of the 11 stimuli is plotted against the number (group average) of stimuli that elicited one or more responses. No curve has been fitted to the data, but a logarithmic function clearly represents them. When the response rate during generalization testing is low, the number of "active" stimuli is small. When the momentary response rate is high, the number of stimuli responded to is large.

The response rates for the pipradrol-treated animals did not drop appreciably during the generalization tests, as Fig. 1 shows. The points plotted for this group in Fig. 5 do not diverge appreciably from a function representing the control group; this fact may be considered additional evidence that the effect of this dose of pipradrol was to modify the over-all response rate but not the shape of the generalization gradient.

Fig. 5. Responses emitted to any individual series of the 11 stimuli, versus number of stimuli in the series eliciting one or more responses. (The filled points represent the data from the first generalization test.)

The data in Fig. 5 are strong evidence for the belief that if preliminary training is constant, the factors controlling responding during any single stimulus presentation during generalization testing are essentially *independent* of the serial effects of the testing procedure, and are mainly determined by: 1) the relationship along some dimension of the test stimulus to the conditioned stimulus; and 2) the momentary response rates obtaining during testing. The present experiment would suggest that these factors can be independent of factors controlling over-all response rates.

SUMMARY AND CONCLUSIONS

Responding during generalization testing was modified by the administration of pipradrol. Although the pattern of responding occurring during testing was changed, no modifications in the gradients collected were detected.

The control of responding during generalization testing appears to be independent of both over-all response rates and the serial effects of the testing procedure. The essential controls during testing would appear to be the test stimulus-conditioned stimulus relationship on the test dimension and the momentary response rate.

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