The development of stimulus control in a three-member chained schedule

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Following VI training to peck a "blank" key, two groups of 10 pigeons each were trained for 20 days with a chained schedule (chain VI 40 sec, VI 40 sec, VI 40 sec). For Group 1 the stimulus sequence was: (S_3) blank key, (S_2) white line, and (S_1) a 555mμ light, which was reinforced. For Group 2, S_2 and S_1 were reversed.

Generalization tests administered after 5 and 20 chain-training sessions indicated: (a) differences in response rate to S_1 and S_2 which had developed in training were maintained in extinction, (b) a reliable generalization gradient was present with only S_1 after five training days but was present in both stimulus positions after 20 days.

In a chained schedule, responding to one external stimulus produces a second one; responding to the second stimulus produces a third, etc., with a primary reinforcer terminating the chain (Ferster & Skinner, 1957). The closer a component stimulus is to primary reinforcement, the higher the rate of responding normally emitted in its presence. However, a higher response rate to a component stimulus does not signify a greater degree of control exercised by that stimulus. A relative measure of generalization, which equates for differences in response rate resulting from the position of a component in the chain, allows a direct comparison of the degree of stimulus control exercised by different component stimuli. The present study used such a comparison to: (a) study the development and maintenance of differential responding to component stimuli; (b) determine if rate differences observed in training are maintained in generalization testing in extinction (i.e., are under external stimulus control); and (c) compare the degree of stimulus control developed by stimuli at different positions in the chain at different stages of training.

Method

Subjects. Twenty adult homing pigeons at 75% of free feeding weight were used.

Apparatus. Two Grason-Stadler pigeon chambers were employed. In-line display cells, fitted with Kodak Wratten filters Nos. 99, 73, and 72B provided stimuli with peak wave lengths at 555, 576, and 606 mμ, and a white line 7/8 in. high x 1/8 in. wide on a dark field, at angles of 30°, 60°, and 90° (vertical).

Procedure. After magazine training, Ss were given a day each of continuous reinforcement, fixed ratio of five responses per reinforcement (FR 5), and FR 10. Next there were daily 1 1/2 h sessions of VI 1/2, VI 1, and VI 2 min for three days each, and VI 5 min for five days. Up to this point, the key was unilluminated ("blank").

On Day 19, chain training was begun. For Group 1 ($N=10$) the order of stimuli was (S_3) blank key, (S_2) vertical line, (S_1) 555 mμ; for Group 2 the order of the S_2 and S_1 was reversed. A VI 40 sec schedule governed stimulus change and also governed food reinforcement during S_1 .

Generalization tests in extinction were administered after the fifth and twentieth chain training session, with 30°, 60°, and 90° and 555, 576, and 606 mμ employed in the order of presentation used in training (e.g., blank, line, color). Stimulus change was not response contingent, and no food reinforcement intervened between the S_1 presentation (or generalized S_1) and the reappearance of the blank key (S_3). The test used 15 different sequences of three stimuli with stimulus presentations for 20, 30, 40, 50, and 60 sec irregularly ordered (mean=40 sec). The blank (S_3) was presented in all 15 stimulus sequences with each of the other test stimuli presented five times, for a total of 3 min and 20 sec each.

Results

A consistent differentiation in response rates quickly developed. By Day 5 of chain training, response rate to S_3 had dropped to a very low level. Even by the end of Day 1, response rate was highest to S_1 and intermediate to S_2 , and this difference persisted thereafter. The ordering of response rates $S_1 > S_2 > S_3$ held for all Ss by Day 3 and for some was true at the end of Day 1, despite the fact that S_3 had been the original training stimulus.

On Test 1 the mean number of responses to S_1 (pooled over both groups) was 346.91; for S_2 it was 117.15 ($t=9.83$, $df=19$, $p<.01$). On Test 2, for S_1 , the mean was 279.73 responses; for S_2 , 166.47 ($t=4.47$, $df=19$, $p<.01$). Thus the different response rates to S_1 and S_2 observed during training were under the control of the component stimuli.

For each S on each generalization test the measure used was the percentage of total responses given to the various stimuli along a given dimension. The means of these gradients for Tests 1 and 2 are presented in Figs. 1 and 2. As Fig. 1 shows, a decremental generalization gradient was obtained for the S_1 position with both dimensions: for color S_1 , $F=37.82$ ($df=2/18$, $p<.01$); for line S_1 , $F=16.44$ ($df=2/18$, $p<.01$). For the S_2 position, however, evidence for the existence of a gradient was lacking in both cases.

As Fig. 2 shows, on Test 2 all four conditions yielded significant gradients: color S_1 , $F=22.39$ ($df=2/18$, $p<.01$); color S_2 , $F=25.58$ ($df=2/18$, $p<.01$);

Fig. 1. Mean relative wavelength and angularity generalization gradients for S_1 and S_2 on Test 1.

line S_1 , $F=5.56$ ($df=2/18$, $p<.05$); and line S_2 , $F=10.54$ ($df=2/18$, $p<.01$). On Test 2 there was no interaction between test stimuli and training stimulus position, thus no difference in slope of the gradient as a function of the position of the stimulus in the chain was found.

Discussion

The introduction of a chained schedule has sudden and drastic effects on response rate, increasing the rate to S_1 while depressing the rate to S_3 . These rate differences are under the control of the component stimuli, and are maintained during generalization testing in extinction.

After five sessions of chain training, only the S_1 position yielded a reliable decremental gradient. Later on (after 20 sessions), both S_1 and S_2 positions yielded comparable gradients. Thus stimulus control, operationally defined as stimulus generalization slope, de-

Fig. 2. Mean relative wavelength and angularity generalization gradients for S_1 and S_2 on Test 2.

velops sequentially from the goalbox forward, much in the manner suggested by Hull's "goal gradient hypothesis" (1932). The temporal course of this progression and its limits both in time and in number of intervening component stimuli remain to be determined.

References

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Notes

1. This study was supported in part by Research Grant RO 1 HD-00903-04 under the direction of the second author. It was performed by the first author in partial fulfillment of the requirements for the M. A. degree in Psychology at Kent State University, 1966, and was reported by the second author at the April, 1966, meeting of Eastern Psychological Association in New York.
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