Discrimination based on response-produced stimuli¹

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This study outlines a simplified operant conditioning procedure for investigating discrimination based on response-produced stimuli. The method, using concurrent schedules of reinforcement, greatly reduced the complexity of the procedures and the number of training sessions necessitated by a recently offered alternative technique. Calculations of Weber's Constant for discrimination between response-produced stimuli are presented and the relevance for learning theory of empirical studies concerning response-produced stimuli is indicated.

The ability of a wide range of organisms to solve discrimination problems has been well documented. In the typical discrimination experiment, the experimenter provides constant external cues or discriminative stimuli which the organism can utilize as a basis for responding. However, few studies have investigated discrimination behavior where there are no external, experimenter-provided discriminative stimuli; i.e., situations in which S must base his behavior upon response-produced cues.

Two recent studies (Rilling & McDiarmid, 1965; Pliskoff & Goldiamond, 1966) have demonstrated that pigeons can discriminate between the response-produced stimuli associated with performance on one fixed ratio (FR) schedule, and the response-produced stimuli associated with performance on a second, but different, FR schedule. In both experiments similar chained schedules were used. For example, Rilling and McDiarmid used a three key chamber in which the initial member of the chain was a multiple FR:FR schedule (e.g., mult FR 50 FR 5) programmed on the center key. If the smaller ratio was the initial member, only a response on the left key produced reinforcement. But if the initial member was the larger ratio, only a response on the right key produced reinforcement. Responses on the right key after the smaller ratio, and responses on the left key after the larger ratio were counted as errors and were followed by a time out period of 1 min. By decreasing the difference between the two FR schedules the authors determined that Ss could discriminate FR 50 from FR 45.

One problem encountered with chained schedules of the type used by both Rilling and McDiarmid and Pliskoff and Goldiamond is that they require relatively complex training procedures and/or a large number of preliminary experimental sessions before even the simplest discriminations are established. The present study offers an alternative procedure which avoids the difficulties encountered in estab-

lishing the initial discrimination with a chained schedule. It is hoped that research on the ability of infrahuman Ss to discriminate between response-produced stimuli will be facilitated by the availability of a simplified method for studying this problem.

METHOD

Subjects

The Ss were four male hooded rats selected from the colony maintained at Ohio University. The Ss were reduced to 90% free-feeding weight and maintained at that level throughout the experiment.

Apparatus

The apparatus was a two-lever Grason-Stadler rat chamber (Model No. 3125). The chamber was enclosed in a soundproof Grason-Stadler freezer chest. Automatic programming equipment was used and responses and reinforcements were recorded with impulse counters. White noise at an intensity of 90 dB SPL served to mask the noise of the programming equipment.

Procedure

All Ss were run one session per day five days per week. The maximum length of each session was 1 hr. However, if S obtained his total daily requirement of food before 1 hr. in the apparatus had expired, that session was immediately terminated. The reinforcement was a single 45 mg P. J. Noyes reward pellet.

Preliminary training. After initial lever-press training Ss were given a series of concurrent FR ext and/or concurrent FR FR sessions in order to establish a history of reinforcement on both bars. Concurrent FR ext sessions consisted of programming a relatively low FR on one lever (e.g., FR 3) and extinction on the other lever. Concurrent FR FR sessions consisted of programming relatively low FR schedules on both levers (e.g., FR 4 on the left lever and FR 2 on the right lever). During preliminary training and throughout the remainder of the experiment, reinforcement was delivered only when the number of responses specified by a given FR schedule was made without any intervening responses on the other lever. No more than nine, nor fewer than three, preliminary training sessions were administered.

Discrimination training. During all phases of discrimination training a conc FR FR schedule of

reinforcement was employed with one member of the schedule held constant at FR 10. That is, both levers were programmed on different FR schedules but one lever was always programmed on FR 10 whereas the other lever was programmed on another FR schedule. On the first day of discrimination training Ss were placed on a conc FR 10 FR 6 schedule, a ratio spread of 4.² The higher FR schedule was programmed on the lever preferred during the preceding preliminary training session. For example, if on the last day of preliminary training most of the reinforcements were obtained on the left lever, on the first day of discrimination training the FR 10 schedule was programmed on the left lever and the FR 6 schedule was programmed on the right lever. Daily sessions on conc FR 10 FR 6 continued until S reached the discrimination criterion of 75% of the reinforcements obtained on the lower programmed lever or until performance reached a stable level. On each of the sessions during which the conc FR 10 FR 6 schedule was employed the levers on which the FR 10 and FR 6 were programmed were not changed. Thus, if S began discrimination training with FR 10 on the left lever and FR 6 on the right lever, until the discrimination criterion was reached the FR 10 was programmed on the left lever and the FR 6 on the right lever.

On the session after reaching criterion on conc FR 10 FR 6 the ratio spread was reduced to 3 by changing the schedule to conc FR 10 FR 7. In this, and in all subsequent reductions in the ratio spread, each reduction was accompanied by a shift in the position of the lever on which the higher FR was programmed. For example, if during the tenure of the conc FR 10 FR 6 schedule the FR 10 was programmed on the left lever and the FR 6 was programmed on the right lever, on the day after criterion

Table 1. Summary of Discrimination Performance

S #	Last Discriminable Concurrent Schedule	Minimum Discriminable Ratio Spread (Δ FR)	K
517	FR 10 FR 7	3	.30
768	FR 10 FR 9	<1	<.10
606	FR 10 FR 8	2	.20
609	FR 10 FR 8	2	.20

was reached FR 7 was programmed on the left lever and FR 10 was programmed on the right lever. By shifting the schedules in this manner, the higher FR was always programmed on the previously preferred lever. Subsequent reductions of the ratio spread and shifts in the levers continued until a schedule was reached on which S failed to develop a preference for the low FR lever and reached a stable level of performance below criterion.

RESULTS AND DISCUSSION

The last discriminable concurrent schedule and the minimum discriminable ratio spread for the four Ss is presented in Table 1. An inspection of Table 1 reveals that one S reached the 75% criterion on the conc FR 10 FR 9 schedule, two Ss discriminated FR 10 from FR 8, and one S discriminated FR 10 from FR 7. Figure 1 presents the percentage of reinforcements obtained on the lower programmed lever for the 16 daily sessions for S 768. The general form of the curves for the other three Ss are the same. An inspection of Fig. 1 indicates a relatively rapid development of the discrimination at all values of the concurrent schedules employed. After a reduction in the ratio spread, and a concomitant shift in the lever on which the lower FR schedule is programmed, there is an immediate and

Fig. 1. Percentage of reinforcements obtained on the lower programmed lever for S 768.

precipitous drop in the percentage of reinforcements obtained on the lower programmed lever. However, during subsequent sessions on the new schedule the percentage of reinforcements obtained on the lower FR lever increases. For all schedules the discrimination criterion of 75% of the reinforcements obtained on the lower FR lever was reached with a maximum of five sessions. An inspection of the data for the other three Ss revealed that in no case did a successful discrimination take less than three or more than five sessions to develop. In contrast, Rilling and McDiarmid (1965) found that with a chained schedule procedure 120 sessions were necessary to establish a preliminary discrimination between FR 35 and FR 15. In addition, in the three Ss where a failure to discriminate was observed, stable performance levels were reached within two or three sessions. For Ss 517, 606, and 609, the preference for the lower programmed bar stabilized at about 40%, 40%, and 15%, respectively.

It is also possible to express the present data in psychophysical terms. When this is done, the data provide preliminary values of Weber's Constant for discrimination between response-produced stimuli. Accordingly, given the value of the smallest discriminable ratio spread (ΔFR) and the value of the standard schedule (FR 10), Weber's Constant ($K = \Delta FR / FR$) may be calculated. The values of K for the three Ss that failed to discriminate at some ratio spread are presented in Table 1. An inspection of this table reveals that K varies from .20 to .30. And, although K for S 768 is indeterminate for a standard schedule of FR 10, K is at most .10. These values compare favorably with those obtained by previous researchers using: (a) more complicated chained schedule procedures; (b) pigeons as experimental Ss; and (c) higher FR values of the standard schedule. If a 75% criterion of correct responses is applied to data obtained by Rilling and McDiarmid (1965) and Pliskoff and Goldiamond (1966) and Ks are computed for their published curves, Ks for the two Ss used by Rilling and McDiarmid are approximately .14 and .22, and Ks for the two Ss used by Pliskoff and Goldiamond are approximately .33. However, additional data obtained on the same species of Ss using the same procedures and a wide variety of values of the standard schedule are needed to determine the applicability of Weber's Law to dis-

crimination between response-produced stimuli in infrahuman Ss.

Aside from the intrinsic interest in the psychophysics of response-produced stimuli, data of the kind gathered in the present experiment may have some importance for learning theory. Accordingly, a number of theoretical positions ascribe crucial roles to response-produced stimuli. For example, Hull (1931), Miller and Dollard (1941), Smith and Guthrie (1921), and Spence (1960) maintain that response-produced stimuli can serve as stimuli to which responses can be conditioned. However, there is little empirical evidence of the ability of Ss to use these stimuli as cues for responding. The present study indicates that Ss can make relatively fine discriminations between the stimuli produced by lever-pressing and provides a simplified method for further investigating the ability of infrahuman Ss to discriminate between these response-produced stimuli. However, it should be emphasized that the present study cannot precisely specify the response-produced stimuli being used by the Ss. One obvious possible cue is the number of responses required to obtain a reinforcement. However, although the difference in the amount of time it takes to make 10 as compared to 9 responses is typically small, it is conceivable that this time differential may be utilized as a cue for responding.

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Notes

1. This research was in part supported by a grant from the Ohio University Research Committee.
2. The term "ratio spread" is defined as the difference between the two FR schedules; i.e., ratio spread equals the value of the larger FR minus the value of the smaller FR.

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