THE EFFECT OF TWO SCHEDULES OF PRIMARY AND CONDITIONED REINFORCEMENT

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Of 23 pigeons, 11 received continuous reinforcement for key pecking, and 12 received an FR 10 schedule of reinforcement. The birds were then tested without food, but with potential conditioned reinforcers presented either on the same schedule as in training, on the other schedule, or not at all. Each bird in the subgroup trained on CRF and tested with S^r's at FR 10 not only gave more responses in testing than did each bird in both subgroups receiving no S^r's, but also gave more responses than did each bird in the S^r subgroup receiving CRF training and S^r's at CRF. Cumulative records are presented to show the effects of different schedules of conditioned reinforcers.

The purpose of the present experiment was to consider the effect of potential conditioned reinforcers on maintaining an operant response. The conditioned reinforcers (S^r's) are presented without food during testing, either on the same schedule, or on a schedule differing from the one in effect during training. A control, in which no S^r's at all are presented, also follows training.

The work of Notterman and Dinsmoor indicated that the training schedule affects the strength of an S^r. Notterman (1951) found that the strength of an S^r is an increasing monotonic function of the total number of S^d trials in training. Dinsmoor (1952) tentatively concluded that the FI training increases the S^r power of a stimulus. Unlike Dinsmoor, Clayton (1956) found "no consistent evidence that a moderate degree of intermittence in reinforcement during either discrimination or extinction phases had favorable effects on secondary reinforcing properties" (1956, p. 380). Clayton suggested that her contrast with Dinsmoor's findings may have been caused by his animals on FI simply building up a higher rate of responding than his CRF group, so that they made a greater number of responses during extinction. This can be tested only by comparing each S^r group with a control, which differs only in that it receives no S^r during testing. Furthermore, because the S^r in both experiments was an S^d for the same operant in training, part of the S^r strength in testing may actually be S^d strength.

Following CRF training, Dinsmoor, Kish, and Keller (1953) presented an S^r on either a CRF or an FI 5 min schedule. They found no differences that were due to these schedules of S^r presentation. Although more responses might occur under an FI 5 min than under a CRF schedule, the CRF schedule of S^r presentation in the above experiment offers conditions which are more similar to training. According to Bitterman's discrimination hypothesis, the more similarity between training and testing, the more responses emitted in testing. However, this apparent similarity between training and testing schedules is complicated by the fact that in the above experiment the S^r which *followed* on operant in testing *preceded* the same operant in training.

Thus, many discrepancies exist in the above S^r experiments which consider the *same* operant in both training and testing. Therefore the present experiment deals with S^r at this level, rather than using S^r to condition a new response. It is desirable to discuss S^r strength by comparison with a No-S^r control; to eliminate any S^d effects by having the potential S^r *follow* the given operant in training as well as in testing; and to test the discrimination hypothesis by having two subgroups with only one difference between training and testing (*i.e.*, removal of primary reinforcement).

METHOD

An operant-conditioning apparatus was used (Ferster & Skinner, 1957), with grain

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presented by a Lehigh Valley Electronics No. 1347 feeder. The location of the response key, $\frac{3}{4}$ in. in diameter, was at the center of the panel, $9\frac{1}{2}$ in. from the floor. A cumulative recorder and digital counters recorded responses and reinforcements. White noise and houselights were present at all times.

Subjects

The subjects were 23 naive, male Silver King pigeons, 6 to 7 years old, maintained at 75% free-feeding weight.

Procedure

In Sessions 1-3 (Table 1), all birds received the same treatment, continuous reinforcement for key pecking. The total number of responses in Session 4, a simple extinction session, served as a criterion for placing birds into six subgroups. Each subgroup contained four birds, except one subgroup, which contained only three. An attempt was made to keep the median number of extinction responses per subgroup equal.

During training sessions, each response to be reinforced produced: key light on, feeder light on, noise of feeder coming up, and grain, for 2.5 sec. A total of 65 S_r's was given in Sessions 1 and 2 (see Table 1); a total of 55 S_r's per session was given in Sessions 3, 5, 6, and 7. During testing, the potential S_r's consisted of: key light on, feeder light on, and noise of feeder coming up. The feeder, which was empty and covered, was raised for only 0.5 sec. The hole through which the bird gained access to the feeder was not covered. Table 1 shows the schedules on which each subgroup was trained and tested. During training, each bird received the same number

of reinforcements per session. After the first 3 days of testing (Sessions 8, 9, and 10), nearly all responses were given in the first 15 min of a 50-min test session; therefore, the last four test sessions were reduced to 20 min.

RESULTS AND DISCUSSION

The Kendall Rank Correlations between the number of responses in Session 4 (simple EXT) and the number of responses in Session 8 (first test day) are not significant for any subgroup. For no subgroup did the bird that gave the fewest responses and the bird that gave most responses in Session 4 remain at the same extremes in Session 8. Thus, the relative number of responses given in simple EXT does not aid in predicting the relative number of responses given in testing (with or without S_r) after retraining.

Following either training schedule, testing with S_r's at FR 10 results in more responses than does testing with S_r's at CRF; and either of these S_r schedules results in more responses than does testing with no S_r's at all. For any one of the three test schedules, more responses are given by the subgroup trained on FR 10 than on CRF. These group relations hold not only in terms of the median total number of responses (Table 2), but also in terms of the median number of responses per session (Fig. 1). A noticeable exception occurs on the first test day, where more responses are given by the subgroup trained on CRF than by the subgroup trained on FR 10, with each receiving S_r's at FR 10. The curves were fitted simply to indicate how responding decreases from one session to the next. The sharpest drop for all subgroups occurs from the first test day

Table 1
Schema of the Experimental Design

Sessions 1-3 (Training)	Session 4	Sessions 5-7 (Training)	Sessions 8-15* (Testing)	Subgroup
CRF	Simple EXT (40 min)	CRF	S _r at CRF Control (No S _r) S _r at FR 10	CRF-CRF CRF-No S _r CRF-FR10
		FR 10	S _r at CRF Control (No S _r) S _r at FR 10	FR10-CRF FR10-No S _r FR10-FR10

* Sessions 8-11 lasted 50 min each
Sessions 12-15 lasted 20 min each

Fig. 1. Median number of responses for each subgroup during the test sessions. The curves were fitted by eye.

to the second, and is largest for subgroup CRF-FR10.

Plots of the number of responses for each bird show a decrease from the first test session to the second, but not all curves continue to decrease as smoothly as indicated in the group curves. For birds trained on CRF, the highest points on any given session are always those of the three CRF-FR10 birds. There are only two exceptions: (1) on the second test session, when one bird from subgroup CRF-CRF gave more responses than did two birds from subgroup CRF-FR10; and (2) on the last test session (Session 15), when one bird from CRF-FR10 was surpassed by a bird from each of the other two subgroups. However, on this last session, three birds gave zero responses, and the maximum was only 39 responses.

Because of the difficulty of reading a figure with 11 or 12 curves, these individual curves are not shown. Table 2 gives the number of responses each bird makes on the first test session, and the total over all the eight test sessions. Like the individual curves, this table shows that each bird in subgroup CRF-FR10 gave more responses than did any bird in either subgroup CRF-No S^+ or CRF-CRF.

This finding with S^+ is in line with the well-known observation that FR schedules of primary reinforcement produce more responses than does a CRF schedule. It is not in line with the discrimination hypothesis, since the presentation of S^+ 's at FR 10 results in a condition which differs more from CRF training than does presentation of S^+ 's at CRF.

Unlike the above findings following CRF training, there is overlap among birds from the different subgroups trained on FR 10 (Table 2). Overlap is even found between subgroup FR 10-FR 10 and subgroup FR 10-No S^+ .

Presentation of S^+ 's can dramatically reverse the usual differences found in extinction, following FR vs. CRF training. That is, each bird in the subgroup FR 10-No S^+ gave more responses than did any bird in the subgroup CRF-No S^+ , as might be predicted. However, each bird in the subgroup trained on CRF, with S^+ 's at FR 10, gave *more* responses than did any bird in the subgroup trained on FR 10, with no S^+ .

It has been indicated that birds in subgroup CRF-FR 10 gave not only more responses than any bird in *both* control subgroups, but also

Table 2

Total Number of Responses for each Bird: (a) In the First Test Session; (b) In All Eight Test Sessions

Subgroup	Number of Responses		Median
	First Test Session	All Eight Test Sessions	
CRF-CRF	73	217	298
	159	297	
	168	300	
	582	1037	
CRF-No S ^r	50	84	147
	47	112	
	97	182	
	211	377	
CRF-FR10	1024	1489	1706
	908	1706	
	1189	1956	
FR10-CRF	17	275	1261
	686	1096	
	783	1426	
	1529	1987	
FR10-No S ^r	267	564	704
	310	620	
	628	843	
	828	1433	
FR10-FR10	287	762	2032
	795	1466	
	1279	2598	
	887	2696	

more responses than any bird in the S^r subgroup, CRF-CRF. The superiority of this CRF-FR 10 subgroup is nicely demonstrated by a measure used by Miles (1956, p. 497), who expressed the "relative effectiveness of the secondary reinforcement stimulation" by a ratio of the number of responses for an S^r subgroup over the number of responses for its control subgroup. In Fig. 2, this ratio is plotted against sessions. The ratio does not show a consistent increase or decrease over sessions for any S^r subgroup. Because the curve for subgroup CRF-FR10 lies well above the other three curves, this combination of training on CRF and testing on FR 10 produces a relatively more effective S^r than any of the other three combinations used.

The FR 10 training schedule produces more responses in simple extinction than does the CRF training schedule. Therefore, if the training schedule alone were the most important variable during S^r tests, each bird in the subgroup FR10-CRF should give more responses than does each bird in subgroup CRF-CRF, and similarly for subgroups FR10-FR10 vs.

subgroup CRF-FR10. This is not the case (Table 2). If the S^r schedule alone were the most important variable during the S^r test, each bird in subgroup CRF-FR10 should give more responses than does each bird in subgroup CRF-CRF, and similarly for subgroups FR10-FR10 vs. FR10-CRF. Although this does hold for the first comparison, it does not hold for the latter. The FR10-FR10 subgroup even showed overlap with the FR10-No S^r subgroup. If the discrimination hypothesis holds,

Fig. 2. Median number of responses for each S^r subgroup divided by the median number of responses for its control for each test session.

the CRF-CRF subgroup should give more responses than each of the other two subgroups receiving CRF training; and the FR10-FR10 subgroup should give more responses than each of the other two subgroups receiving FR10 training. This is not the case.

Thus, the evidence argues against explanations on the basis of the training schedule alone, the S^r schedule alone, and the discrimination hypothesis. By all of the above comparisons, the CRF-FR10 combination of schedules is most effective. It is the only combination in which the ratio of responses to reinforcements is higher in testing than in training. It is suggested, therefore, that the most effective combination may be that in which the test schedule requires more responses per reinforcement than does the training schedule.

The schedule of S^r presentation affects the shape of the cumulative-response curve. Figure 3 presents sample records from the three most interesting subgroups: FR10-FR10, FR10-CRF, and CRF-FR10. The hatch marks indicating each S^r presentation are omitted for the FR10-CRF subgroup. Following FR 10 training, responses tend to occur at a high rate or not at all for the subgroups FR10-No S^r and FR10-FR10, whereas the responses are more evenly distributed for subgroup FR10-CRF. For the subgroup trained on CRF and tested with S^r at FR 10, the rate is at first slow

and irregular, and then becomes fast and more stable, to the extent of being a straight line for one bird. Kelleher (1961) also found that in contrast with other schedules, an FR schedule of S^r presentation produced high response rates. With the two subgroups receiving S^r at FR 10, the pauses that do occur as testing continues frequently follow an S^r presentation. These effects of scheduling imply that the conditioned stimuli are more than discriminative stimuli which simply evoke responding with each presentation.

Fig. 3. Individual cumulative-response records made during the first two test sessions by birds from three different subgroups. Hatch marks indicate each S^r presentation, except in the middle record where S^r was presented at CRF. The arrows in the top record indicate pauses after S^r presentation.

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