Effects of a fixed-ratio schedule of brief stimulus presentations on responding maintained by concurrent DRL schedules of reinforcement*

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Four pigeons were trained to stability under a concurrent DRL DRL schedule of reinforcement. In Phase A of the experiment, every 10th response in one component produced a brief (0.5-sec) magazine cycle. Response rate in this component increased sharply, but the increase was transient. Time allocation between the two component schedules was affected little by the introduction of brief stimuli. In Phase B, every 10th response in both components of the concurrent schedule produced a brief stimulus. Responses were reinforced with food under a DRL schedule in only one component. Response rate in the component in which only brief stimuli were available dropped to near zero levels. Time spent in this component also dropped sharply. These results were contrasted with other studies in which high rates of responding were maintained in one component of a multiple schedule in which only brief stimuli were presented.

Recently, a number of studies have indicated that brief stimuli which have been paired with food presentation can maintain responding for long periods of time. The conditioned reinforcing properties of brief stimuli have been measured in terms of changes in rate (Zimmerman, 1963, 1969) and temporal pattern (Thomas, 1969) of responding. However, Baum & Rachlin (1969) have suggested that measures of time allocation are likely to be more widely applicable to behavior than laws of response distribution. Similarly, Schuster (1969) has provided data that indicate that simply considering changes in rate of responding may not give a full account of the conditioned reinforcing strength of brief stimuli. He used a concurrent chains procedure in which food reinforcement rates were identical in the two terminal links (VI 30-sec). In one terminal link, pecks produced not only food reinforcement, but also a brief (0.7-sec) stimulus for each 11th response (conjoint VI 30 FR 11). Response rate in this terminal link was generally higher than in the terminal link without brief stimulus presentations. On the other hand, preference during the initial links (defined as the relative frequency of response on the key associated with the conjoint schedule) was lower for

the key associated with brief stimulus presentations.

The present experiment used a concurrent schedule so that the effects of brief (0.5-sec) magazine stimuli could be examined both in terms of changes in response rate and time allocation between the component schedules. Two equal-valued differential reinforcement of low rate (DRL) schedules were programmed concurrently, using a changeover key procedure (Findley, 1958). In one member of the concurrent schedule every 10th response also produced a 0.5-sec magazine presentation (cf. Randolph & Sewell, 1965). Since the food schedules were identical, any differences in response rate and time spent in the presence of the two DRL schedules could be attributed to the brief stimulus presentations. In a second part of the experiment, responding in one member of the concurrent schedule was reinforced with food according to a DRL schedule and every 10th response produced a brief stimulus. In the second member of the concurrent schedule, the only consequence of responding was that every 10th response produced a brief stimulus. Since schedules of brief stimulus

presentations were identical, differences in response rate and time allocation could be attributed to the DRL schedule of food reinforcement. Because of the changeover key procedure, for responding to occur in the component in which only brief stimuli were scheduled required that a stimulus correlated with primary reinforcement be removed by a switching response. It thus minimized the possibility of adventitious chaining between members of the concurrent schedule, which could serve to inflate the rate of responding to produce brief stimuli only.

SUBJECTS

The Ss were four adult male White Carneaux pigeons maintained at 80% of free-feeding weight. Each pigeon had previous experimental training.

APPARATUS

A pigeon chamber similar to that described by Ferster & Skinner (1957) was located in a sound-attenuating box. Two Gerbrands response keys were mounted 25 cm above the wire floor and 15 cm apart, center to center. The left key could be lit by either a red or green 6-W bulb. The right key could be lit by a yellow 6-W bulb. The aperture of the grain magazine was directly between and below the two response keys. A small metal "lip" at the bottom of the aperture prevented any grain from spilling out. Presentation of the grain was accompanied by offset of the key lights, the noise of solenoid operation, and onset of a white light located inside the magazine. Feeder cycles of two different durations were used: a 4-sec (food) cycle, and a 0.5-sec (brief stimulus) cycle. White noise was continually present in the experimental room. Data were recorded on a Gerbrands cumulative recorder and digital counters.

PROCEDURE

Preliminary Training

Pigeons 9 and 10 received no preliminary training. On Day 1, Pigeons 203 and 217 were shaped by successive approximations to peck the left green key. The first 60 key pecks were reinforced according to a continuous reinforcement schedule.

Experimental Training

Daily sessions were 2 h in duration. Each pigeon was trained to peck the left key for grain reinforcement. This

Table 1
Sequence of Schedules and Number of Sessions for Each Pigeon

Concurrent Schedules			Pigeon			
	Red Key	Green Key	9	10	203	217
Phase A	DRL	DRL	40	40	16	15
	DRL	Conjoint DRL FR	40	20	20	20
	DRL	DRL	10	20	10	20
Phase B	Conjoint EXT FR	Conjoint DRL FR	20	30	28	25
	DRL	DRL	25	15	25	20

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Fig. 1. The top panel represents response rate on the green key (dashed lines) and response rate on the red key (solid lines) as a function of sessions. The bottom panel represents percent of session spent in the presence of the green key. The baseline sessions are the last five run under that condition. The Phase A sessions are the first five and the last five run under that condition.

key could be lit by either a red or green color, each color associated with a particular schedule of reinforcement. The right key, illuminated yellow, was a changeover key. A single peck on this key changed the color appearing on the left key. This procedure makes explicit a switching operant and allows keypecking to come under the control of the schedules correlated with the two colors programmed on the schedule key (Findley, 1958).

Table 1 indicates the sequence of schedules correlated with the red and green key colors and the number of sessions under each condition.

Under the baseline condition, responses in the presence of both red and green key colors were reinforced according to DRL schedules. For Pigeons 9 and 10, the DRL value was 30 sec, and for Pigeons 203 and 217, it was 20 sec. Under a DRL 30-sec schedule, a response is reinforced if 30 sec or more have elapsed since the last response or since the termination of the magazine cycle if the previous response was reinforced. A 10-sec limited hold contingency was used with each DRL schedule. This specifies that reinforcements are available for only a limited period of time. This procedure was used to minimize the possibility that a long sequence of

responses might occur during one component to "mediate" the DRL interval of the second component (cf. McMillan, 1969). Since this was never observed to occur and since available reinforcements were invariably obtained, no further reference will be made to the limited hold.

After response rates appeared stable for five consecutive sessions, Phase A was instituted. Schedules of food reinforcement remained the same in the presence of both red and green keys. However, every 10th response in the presence of the green key produced a 0.5-sec brief stimulus (conjoint DRL FR 10). The only exception to this was if the 10th response terminated an IRT greater than the DRL value. In that case, the 4-sec food cycle took precedence. This procedure remained in effect until the five-session stability criterion was met. Then the baseline condition was reinstated.

In Phase B, every 10th response in the presence of both red and green keys produced a brief stimulus. However, only responses in the presence of green could be reinforced with food according to the DRL schedule. This procedure was in effect until the five-session stability criterion was met and was followed by a return to the baseline condition.

RESULTS

Phase A

When every 10th response in the presence of the green key resulted in a 0.5-sec brief stimulus, each pigeon showed an abrupt increase in response

rate within the first session. This increase tended to continue for two to three sessions before a gradual decline in rate began. Nevertheless, mean response rate on the green key for the first five sessions of Phase A was more than double that obtained in the last five baseline sessions for three of the four pigeons (Nos. 9, 10, and 203). Pigeon 217 showed a 20% increase. With continued training, response rate on the green key returned to a rate comparable to that obtained under the baseline. The top panel of Fig. 1 shows this effect for Pigeon 203. The data obtained from this pigeon are similar to those obtained from the other three. Response rate in the presence of the unchanged red key tended to remain constant throughout.

Time spent in the presence of the green key was not greatly affected by the schedule of brief stimulus presentation. The data for Pigeon 203 (bottom panel of Fig. 1) represent the largest effect obtained from any of the pigeons. Pigeons 9 and 10 showed decreases in exposure to green, and Pigeon 217 showed little or no change.

Phase B

When the only consequence of responding on the red key was a 0.5-sec brief stimulus, response rate for each pigeon dropped to near zero levels within 20 sessions. This result is shown for Pigeon 10 in the upper panel of Fig. 2 and is representative of what was found for each pigeon. Response rate in the food reinforced component tended to remain quite constant. Pigeon 10 showed a small increase, but Pigeons 9 and 203 showed rate decreases. None of these changes in the food reinforced component were greater than 2 responses/min.

Time spent in the presence of the red key gradually dropped to very low levels for each pigeon. This is shown for Pigeon 10 in the bottom panel of Fig. 2 and accurately resembles the data of the other pigeons.

Reinstatement of the DRL schedule in the presence of the red key produced a rapid recovery both in response rate and exposure to the red key to levels comparable to those obtained under the original baseline. This recovery was complete within one to two sessions.

DISCUSSION

In a concurrent chain experiment by Schuster (1969), responses in one terminal link were reinforced with food according to a VI 30-sec schedule. Responses in the other terminal link were also reinforced under an identical schedule. In addition, every 11th response in this second terminal link produced a brief stimulus which had been paired with food delivery. Although this procedure

Fig. 2. Same as Fig. 1, except that Phase B is shown. Percent time is relative to the red key.

produced a relatively higher response rate, entry into this terminal link was less preferred, as indicated by relative response rate in the initial links. Merely considering response rates in the terminal link might have given a misleading picture of the reinforcing strength of the brief stimulus. Baum & Rachlin (1969) have argued that measures of time allocation are likely to be more widely applicable to behavior than laws of response distribution. In Phase A of the present study, responses in the presence of two concurrently available key colors were reinforced under the same schedule of food reinforcement. When every 10th response in one member of the concurrent schedule also produced a brief stimulus, response rate increased sharply. Time allocation, on the other hand, changed relatively little. Again, merely examining response rates would not have given a complete account of the effects of the brief stimuli.

Thomas (1969) and Thomas & Johanson (1970) were able to maintain responding in one component of a multiple schedule when the only consequence of responding was a brief stimulus which was paired with food in the second component of the multiple schedule. Catania (1966) has stated that concurrent schedules may be considered multiple schedules in which the control of the alternation from

one schedule to the other is controlled by the experimental S rather than the E. In the Thomas (1969) and Thomas & Johanson (1970) studies, their pigeons were required to spend a substantial part of the session in the presence of stimuli in which responses were never reinforced with food. Phase B of the present study indicates that given an alternative (by using a concurrent schedule), pigeons will spend almost the entire session in the component in which responses may be reinforced with food.

Finally, the manner in which food delivery and brief stimuli are scheduled may be an important factor in experiments examining the effects of brief stimuli. Thomas (1969) used FR schedules, while Thomas & Johanson (1970) used FI schedules. Response rate to produce brief stimuli was much lower in the latter study and patterns of responding were not characteristic of food-maintained FI responding. Similarly, since food delivery was programmed according to a DRL schedule in the present study, any increases in response rate due to the brief stimuli were likely to result in a decrease in the frequency of food. This may account for the fact that the rate increase in Phase A was transient.

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