*RELATIVE RATE OF RESPONSE AND RELATIVE
MAGNITUDE OF REINFORCEMENT IN
MULTIPLE SCHEDULES¹*

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Pigeons were trained on a multiple schedule in which the duration of access to grain reinforcement was varied independently in the two components. The relative response rate in one component was an increasing function of the relative duration of reinforcement in that component. The similarity of this interaction to that found in multiple schedules of different reinforcement frequency is discussed. Extinction data were also similar to those obtained after training on multiple schedules of different reinforcement frequency.

A pigeon's rate of responding in a single-key free operant situation is insensitive to changes in magnitude of reinforcement under maintained conditions (Catania, 1963b; Keesey and Kling, 1961). However, in some procedures where different magnitudes of reinforcement are associated with different stimuli, magnitude of reinforcement has qualitatively the same effect as does frequency of reinforcement: the greater the magnitude of reinforcement associated with a given stimulus, the higher will be the rate of response in its presence.

Keesey and Kling found this effect for the first minute or so after a stimulus change in what was essentially a three-ply multiple schedule with components of 40-min duration. They also obtained rate differences correlated with differences in magnitude of reinforcement both by introducing a stimulus previously associated with one magnitude of reinforcement when subjects were responding in another stimulus associated with another magnitude of reinforcement, and by alternating the stimuli in extinction. In a concurrent VI 2 VI 2 schedule with a different magnitude of reinforcement associated with each key, Catania (1963b) found a function for absolute rate *vs* absolute magnitude of reinforcement qualitatively the same as that for

absolute rate *vs* absolute frequency of reinforcement in concurrent schedules (Catania, 1963a). Because a concurrent schedule may be seen as the special case of a multiple schedule, where the subject rather than the experimenter controls the component durations, and because of the findings of Keesey and Kling, it might be expected that in a MULT VI VI schedule varying magnitude of reinforcement in the two components would have the same effects as varying frequency of reinforcement. The present experiment investigated this situation.

METHOD

Subjects

Two adult, male, White Carneaux pigeons were maintained at 80% of their free-feeding body weight ± 15 g throughout the experiment. Previous training consisted of shaping and 100 regular reinforcements for pecking a white key.

Apparatus

A Lehigh Valley pigeon chamber was used. Programming and recording equipment was located in a separate room.

Procedure

Subjects were run five days a week for 1-hr sessions on MULT VI 2 VI 2 with the key alternately red for 3 min and green for 3 min. A single arithmetic VI 2 min tape ran continuously throughout both key colors, but reinforcements not collected at the end of one component could not be collected in the next.

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The duration of the grain hopper presentation could be varied independently in red and green. Subjects were exposed to various combinations of reinforcement magnitudes as shown in Table 1 in order of presentation. For the last two combinations of magnitude values the components were of 2-min duration. The experiment was interrupted for three weeks between the initial training on 9.0 sec hopper time in green, 2.25 sec in red, and training on the final two points.

Immediately after training on 9.0 sec hopper time in green, 1.0 sec in red, subjects were extinguished in a single session until responding had reached a low level. The key continued to change color every 2 min throughout extinction.

RESULTS

Reinforcement magnitude was manipulated by varying the duration of grain hopper presentation. While it is unlikely that the amount actually consumed per reinforcement varies with this measure in an entirely linear fashion, the average weight gain per experimental session did increase with the average reinforcement duration.

Table 1 shows the mean absolute rate of response for both birds, corrected for hopper time, for the last four days at each combination of magnitudes. With constant magnitude in one component, the rate in the other component tends to vary directly with the magnitude in it, but the changes in over-all rate, especially for Bird 7, are such that this is not always the case. Response rate in a color associated with a constant magnitude of reinforcement did not remain constant. Nor did it vary inversely with the magnitude of rein-

forcement in the other color, as might be expected from the contrast effects found when holding frequency of reinforcement in one component of a MULT VI VI schedule constant while varying frequency in the other component. Thus, there is no entirely consistent relation between absolute rate of responding and absolute magnitude of reinforcement.

Other research involving multiple or concurrent schedules has shown that relative rate of response may have an orderly relation to the independent variables. Figure 1 shows the relative frequency of responding in green as a function of the proportion of total reinforcement duration in green. Also shown are points from Reynolds' (1963) experiments 1 and 2, selected to cover the same numerical range of the independent variable. It appears that the same linear function would describe both sets of data. Discrepancies in the center of the plot are attributable to color preferences: two of Reynolds' birds had relative rates well above 0.5 when relative reinforcement frequency was 0.5; one of our birds was below 0.5 when relative reinforcement duration was 0.5. Whether this similarity of functions would hold with other absolute reinforcement durations remains to be shown.

Recent work by Williams (personal communication) and in this laboratory (Nevin and Shettleworth, in preparation) has demonstrated a temporal contrast effect in multiple schedules of reinforcement frequency. Immediately after the change into the component which provides the lower frequency of reinforcement there is a very low response rate followed by acceleration to a higher steady rate; immediately after the change from the low to the high frequency component there

Table 1

Sequence of reinforcement durations and mean responses per minute for the last four sessions at each set of duration values. (* indicates 2-min components and mean for last three sessions.)

Hopper time/rft. (secs.)		Number of Sessions	Bird 4		Bird 7	
Green	Red		Green	Red	Green	Red
4.5	4.5	20	51.5	51.2	55.3	63.2
4.5	9.0	15	50.0	60.9	60.3	75.2
4.5	4.5	5	not computed		67.3	65.4
4.5	2.25	15			55.7	32.3
9.0	2.25	15	56.3	34.8	61.8	38.4
*9.0	2.25	8	57.4	33.7	53.5	28.9
*9.0	1.0	8	58.4	32.2

Fig. 1. Responses in green relative to total responses as a function of reinforcement duration in green relative to total reinforcement duration. Also shown is Reynolds' (1963) data for responses in one component of a multiple schedule relative to total responses as a function of the reinforcement frequency in that component relative to total reinforcement frequency.

is a high rate followed by slight deceleration to a lower steady rate. Even the largest magnitude difference used (in which we observed that the birds were barely able to collect any grain in the 1.0-sec magnitude component) did not produce any consistent effects of this sort.

In extinction following training on a MULT VI VI schedule the response rate in the presence of the former low reinforcement frequency stimulus declines earlier and faster than does that in the presence of the former high reinforcement frequency stimulus (Gol-

lub and Urban, 1958). Figure 2 shows that exactly this effect was found in the present experiment, where the stimuli had been associated with different magnitudes of reinforcement. The points shown in the figure were obtained by dividing the total number of responses in a stimulus during each 36-min period of the extinction session by the total number of responses in that stimulus during the first 36 min of extinction. Thus, had the rates fallen in the same way in both stimuli the curves would have coincided. But for both birds, the rate relative to initial rate for red

Fig. 2. Proportion of initial rate in red or green in successive 36-min periods of extinction.

(formerly associated with 1.0 sec hopper time) is always lower than that for green (formerly associated with 9.0 sec hopper time) except in the first period, where both must be 1.00, and the last period, when responding had become very infrequent in both stimuli.

DISCUSSION

Varying relative magnitude of reinforcement in the two components of a MULT VI 2 VI 2 schedule of reinforcement has the same effect on the relative rates of responding as does varying relative frequency of reinforcement in a MULT VI VI. This finding parallels the similarity between magnitude and frequency of reinforcement previously found in concurrent schedules.

Since there is no effect of magnitude of reinforcement on a pigeon's absolute rate of

responding in a single-key, single magnitude situation, the differences in rate found in the present experiment constitute an interaction. Yet neither of the contrast effects often associated with rate differences in MULT VI VI schedules appears: response rate in a stimulus associated with a constant magnitude of reinforcement does not vary systematically with changes in the magnitude of reinforcement in the other schedule component. Even with a very large difference between the magnitudes of reinforcement, there is no temporal contrast effect associated with the change from one component to the other.

Previous work with multiple schedules has suggested that orderly changes in relative rates are correlated with contrast effects (Reynolds, 1961, 1963). However, since an identical relative rate function was obtained in the absence of contrast effects, we suggest that the form of the relative rate function by itself can provide no information about the presence or absence of contrast.

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