FI LENGTH AND PERFORMANCE ON AN FI FR CHAIN SCHEDULE OF REINFORCEMENT

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In a chained FI FR schedule, manipulating the length of the FI component produced changes confined almost entirely to the FI performance; increasing the interval length increased the total number of responses emitted per reinforcement. The configuration of the fixed-interval scallop was clearly modified as the interval length was increased, with the larger intervals becoming flatter (*i.e.*, a larger proportion of the total responses earlier in an interval). Measurement of the postreinforcement pause is suggested as a possible indicator of fixed-interval scalloping.

An earlier study in this laboratory was of the interactions between FR size and FI performance in an FI FR chain schedule of reinforcement (Hanson & Witoslawski, 1959). As the FR requirement was increased, responding during the FI portion of the schedule decreased, although the typical fixed-interval distribution of responding was preserved. A clear negative relationship was reported between FI responding and FR magnitude.

The present experiment is a study of the same chain schedule. However, the length of the fixed-interval component was systematically varied, while the ratio component was maintained at 20 responses.

METHOD

Subjects

The subjects were two male albino rats (Holtzman) approximately a year old at the beginning of the study. The animals were maintained at 300-g body weight by restricted feeding of lab chow.

Apparatus

A Foringer lever-pressing apparatus, equipped with a telegraph-key type lever, and the necessary auxiliary automatic programming equipment was used.

Procedure

The reinforcer was approximately 0.25 cc of sweetened condensed milk, delivered by a motor-driven dipper. A buzz presented with the dipper was the conditioned reinforcer. A

click stimulus (10 per sec) was presented whenever the FR component was programmed; no stimulus accompanied the FI component.

Daily experimental sessions were 2 hr long. Supplementary rations, which were necessary to maintain the experimental weight, were fed immediately after the session to insure constant deprivation time. The feeding schedule was carefully observed during holidays, although experimental sessions were skipped.

Before the data reported in this study were collected, both rats had been exposed extensively to FI's of 2, 4, 8, and 16 min, the FR requirement remaining at 20 responses. The various values of the FI were selected at random. No change in FI was made before behavioral stability was observed. For the present study, these FI values were programmed in a different order for each subject. Again, the value of the FI was not changed until the performance was considered stable, *i.e.*, no apparent changes for at least five sessions. The order of FI presentations of the data analyzed was Rat 258, 16 min, 8 min, 2 min, and 4 min; and Rat 266, 2 min, 16 min, 8 min, and 4 min.

RESULTS AND DISCUSSION

Figures 1 and 2 show sections of the cumulative records of the performance under each of the schedule conditions. In each case, Intervals 5-9 from the session immediately preceding a change in the interval value are given. The off-set of the response pen was

Fig. 1. Cumulative records of the performance on a chain FI FR schedule of reinforcement. The length of the interval was varied from 2 to 16 min, and the fixed ratio remained at 20 responses. The left side of the figure shows a plot of serial cumulative-response distributions as percentages for each of the four conditions.

used to indicate when the interval requirement had been completed. After the first response had put the ratio contingency in effect, the pen was returned to the normal position. Performances on a particular value of an interval stabilized quickly after a change, and the tracings shown can be considered as representative. The left side of Fig. 1 shows the per cent serial cumulative-response distributions for each of the four conditions tested. Responses were collected for each $1/8$ th of the interval and are plotted as percentages of total responses. Data from the last three sessions of each condition were analyzed.

The two rats showed great similarities in performance, although Rat 258 had a higher overall response rate. Under all conditions, the FI responding showed the same general type of temporal patterning as was reported earlier (Hanson & Witoslawski, 1959). However, as the serial distributions show, the configuration of the scallop was to some extent dependent on its length. Responding in the longer intervals was less likely to increase rapidly to a high rate following the postrein-

Fig. 2. Cumulative records of the performance on a chain FI FR schedule of reinforcement. The length of the interval was varied from 2 to 16 min, and the fixed ratio remained at 20 responses. The left side of the figure shows a plot of serial cumulative-response distributions as percentages for each of the four conditions.

forcement pause, and it consisted mainly of short bursts of responses with an overall acceleration to a high terminal rate. The rate of ratio responding was unaffected by any value of interval programmed. The elapsed time for the emission of the ratio requirement showed no relationship to FI length. Ratio responses 1 through 10 did require an average of $2/100$ to $3/100$ of a minute longer to be emitted than responses 11 through 20; but this difference existed for all conditions.

Figure 3 shows the number of FI responses emitted per interval plotted against interval length. The data plotted were collected from the last three sessions of each condition. The functions indicate a clear positive relationship between the two variables. As the interval increased, the total responding per interval increased. The trend of these functions raises several interesting problems. An extremely short interval would be comparable to a

Fig. 3. Mean responses per reinforcement plotted against length of the fixed interval.

chain CRF FR 20 schedule of reinforcement, so that we could expect only minimal responding. At extremely large values of the interval, we might well expect an inversion in the observed relationship. A suggested decrease in responding at FI 16 for Rat 266 would tend to support such a notion. With Rat 258, we attempted to study a 32-min interval. Such an interval value requires many sessions for sufficient schedule exposure. The animal sickened after 180 hr (340 reinforcements), so that a satisfactory comparison was prevented; at that time, however, the rat was emitting approximately 300 responses per reinforcement, suggesting that the function was still accelerating.

Figure 4 shows the mean percentage of the time per interval devoted to the postreinforcement pause (PRP). The data analyzed are the same as those treated in the preceding figure. The relationship depicted is clear: the longer the interval, the smaller the proportion of the interval time devoted to the PRP. The FI 2 point for Rat 266 is of interest because it exceeds 100%. This rat did not respond to a high percentage of intervals in this condition until after the FI requirement had already expired. The cumulative-response tracings in Fig. 1 and 2 indicate that the scallops for FI 2 are typified by proportionally long pauses followed by an

Fig. 4. Left ordinate, mean percentage of the interval devoted to the postreinforcement pause; right ordinate, index of curvature. Both measures plotted vs. the length of the fixed interval scheduled.

abrupt transition to a high terminal rate. In contrast, performance during FI 16 was characterized by proportionally short PRP's, with a long gradual acceleration to high terminal rates.

The index of curvature (Fry, Kelleher, & Cook, 1960) is also included. It is plotted in Fig. 4. The two measures would appear to be sensitive to the same variables, and, at least in the present context, highly correlated. The PRP measure is simple and has the advantage that it can be directly recorded. Both measures appear to correlate well with the observable changes in the cumulative-response tracings in Fig. 1 and 2.

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