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A COMPARISON OF RESPONSE PATTERNS ON FIXED-, VARIABLE-, AND RANDOM-RATIO SCHEDULES

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The behavior of individual pigeons on fixed-ratio, variable-ratio, and random-ratio schedules was examined. Within each type of ratio schedule the size of the ratio was varied in an irregular sequence. At various ratio sizes (5, 10, 40, 80) no differences were found among overall response rates (postreinforcement pause plus running response rate) as a function of ratio type. This similarity in overall response rates held despite noticeable differences in the microstructure of performance both within and across subjects; the primary performance difference on the three types of ratio schedules was the relatively longer postreinforcement pause duration on the fixed-ratio schedule. We concluded that the gross temporal characteristics of performance determined by the relative weightings of the postreinforcement pause and running response rate were primarily controlled by the type of ratio schedule (fixed, variable, or random), whereas the overall rate of responding was controlled by the size of the ratio.

Key words: fixed ratio, variable ratio, random ratio, key peck, pigeons

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Fixed-ratio (FR) schedules arrange for the delivery of a reinforcer immediately after a fixed number of responses have occurred. The behavior that occurs under this schedule has been frequently studied and described since 1938 (Skinner, 1938). Perhaps the most extensive early account was provided by Ferster and Skinner (1957). The FR variable most often investigated is ratio size. As FR size increases, the length of the postreinforcement (sometimes called preratio) pause (PRP) also increases whether pigeons (Felton & Lyon, 1966; Powell, 1968) or rats (Mazur, 1983) are subjects. Response rates, as a function of this same parameter, also have been reported. Whether or not the PRP duration is included, it has been reported that as FR size increases, response rate increases up to a point and then decreases (Barofsky & Hurwitz, 1968; Mazur, 1983). Other researchers, however, have reported that response rate simply decreases (Felton & Lyon, 1966; Korber, Cole, & Ramirez, 1981) or shows inconsistent changes (Powell, 1968) as FR size increases. Most of the above studies have examined FR size effects within a range of FR 10 to FR 160.

It is more difficult to locate studies that have manipulated ratio size in variable-ratio (VR) or random-ratio (RR) schedules, as Mazur (1983) has indicated. Priddle-Higson, Lowe, and Harzem (1976) examined changes in reinforcer magnitude and changes in VR size. They found a decrease in PRP and an increase in overall response rate (including the PRP) as VR size was increased from VR 10 to VR 40 to VR 80. Brandauer (1959) manipulated the probability of reinforcement (p) between 1.0 and .00167, thus effectively manipulating random-ratio (RR) size. He reported that individual subjects showed no consistent changes in response rate as a function of p, except that response rate was the lowest when $p = 1.0$ (same as FR 1). As p decreased from .1 to .00167 (an increase in RR size from RR 10 to RR 1,000), he reported that PRP increased. In a later study, Farmer and Schoenfeld (1967) varied probability of reinforcement from .08 to .001 and reported response rate and PRP functions that differed only slightly from those reported by Brandauer.

Although there is some consistency among the findings in the FR, VR, and RR studies just reviewed, particularly with respect to the positive relation between PRP duration and ratio size, all but one of these comparisons have been drawn across subjects. The exception is a recent study by Mazur (1983). The performance of one group of rats exposed to both

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FR and mixed-ratio (MR) schedules was compared to that of a second group of rats exposed to FR and RR schedules. An MR schedule is similar to a VR schedule, except that in Mazur's study the MR schedule only consisted of two randomly alternating FR sizes. Both groups received liquid reinforcers. Mazur reported that PRP duration increased as FR size and MR size (and minimum ratio size) increased, but in the second group of rats (FR and RR schedules) only 2 of the 4 subjects showed this relationship as RR size was increased. For both groups of subjects, overall response rate increased up to a ratio size of 20 and then decreased as the ratio size was increased to 40 and 80, regardless of whether the schedule was FR, MR, or RR. Furthermore, he reported that there were no differences in overall response rates when FR performance was compared to MR performance in the first group or when FR performance was compared to RR performance in the second group.

Clearly, Mazur's (1983) study is a step forward in facilitating comparisons between performances under various types of ratio schedules within individual subjects. However, his research design did not allow for comparisons of all three types of ratio performance within the same subject. To compare MR and RR performances, Mazur had to evaluate behavior across groups of subjects. Hence, one purpose of the present study was to expose each individual subject to the three types of ratio schedules: FR, VR, and RR schedules. Also, a VR schedule composed of many different-sized FR components was chosen instead of the two-component MR schedule Mazur used, simply because it is a more common schedule than the MR schedule. Finally, the present study used pigeons and solid-food reinforcers, whereas Mazur used rats as subjects and liquid reinforcers. As revealed in the appendix to Mazur's article, at a ratio size of 40, or particularly at 80, his rats typically failed to obtain the 40 reinforcers that were available in a session, regardless of the type of ratio programmed. The extent, if any, to which these short sessions (in terms of mean number of reinforcers obtained) influenced his data is unknown. By selecting pigeons and a solid reinforcer, we were relatively certain that all of the programmed reinforcers would be obtained, even at the higher ratios, thereby maximizing the amount of behavior that could be analyzed.

METHOD

Subjects

Four experimentally naive common barn pigeons of unknown age and gender served as subjects. Each pigeon was maintained throughout the experiment at approximately 80% of its free-feeding weight. All supplemental food was provided in the home cage no sooner than 30 min following an experimental session. Water was available at all times in the home cage.

Apparatus

Two identical pigeon chambers (Colbourn Instruments Modular Small Animal Test Cage, model E10-10) with interior dimensions of 28.5 cm by 29 cm by 24 cm housed the pigeons individually during experimental sessions. One of the walls contained a houselight (GE 1820 bulb), three response keys (only the center key was operative), and an opening for food delivery. The circular response keys (2.5-cm diameter) were 8 cm apart, center-to-center, and were located 18.5 cm from the chamber floor. A microswitch located behind the center response key could be closed by a force of approximately 0.5 N through a distance of 1 mm. That response key was transilluminated with red light.

Reinforcement consisted of 3-s access to pigeon checkers (DeCarlos Feather Haven) available inside the food aperture (5.8 cm by 5.8 cm) centered 3.75 cm above the floor. The hopper, when raised, was illuminated by a white lamp located inside the food aperture while the keylight was darkened. Each chamber was enclosed in a ventilated, light- and sound-attenuating box. Masking noise and ventilation were provided by a blower mounted on the chamber as well as an exhaust fan located in the room.

Experimental events were controlled by a Commodore VIC-20® microcomputer system (Crossman, 1984) located in an adjacent room. A Commodore 1541® floppy disk drive recorded all critical events in real time (0.0167-s resolution) on floppy disks. A Gerbrands cumulative recorder provided a visual record of responding in all sessions of all conditions.

Table 1

Ranges of ratios in variable-ratio and random-ratio schedules across all sessions.

Schedule	Subjects			
	BP1	BP2	BP3	BP4
VR 5	1-20	1-20	1-20	1-20
VR 10	1-42	1-42	1-42	1-42
VR 40	1-215	1-215	1-215	1-215
VR 80	1-352	1-352	1-352	1-352
RR 5	1-12	1-26	1-22	1-17
RR 10	1-31	1-40	1-37	1-42
RR 40	2-129	1-111	2-135	3-160
RR 80	1-325	6-273	1-292	2-308

General Procedure

Training phase. The pigeons were exposed to a modified autoshaping procedure for 2 days in which the center key was illuminated by a red light for 6 s followed by food presentation and an intertrial interval (ITI) of 54 s. A key peck any time during this 6-s interval also produced a hopper lift. The autoshaping procedure was ended when at least 20 pecks occurred during a session in the presence of the keylight. Once key pecking had been established, each pigeon was exposed, one reinforcement schedule per day, to the following ascending series of FRs: 1, 5, 10, 20, 30, 40, 50, 60, 70, 80. During each session the houselight was illuminated. Whenever the FR contingency was met on the center response key, that key was darkened during reinforcement delivery. Each session ended after 30 hopper presentations.

Experimental phase. After this initial training, all subjects were exposed to the same sequence of ratio values (80, 10, 40, 5). At each ratio value the subjects were first exposed to the FR schedule, next the VR schedule, and finally the RR schedule. In addition, the FR 40 schedule was repeated following the RR 40 schedule. The values of the ratios that comprised the VR schedule were exponentially derived (Fleshler & Hoffman, 1962). Seven different sequences of 30 VR values were used. The sequences were rotated in a fixed order such that a specific schedule never appeared more frequently than once every seven sessions. The values of the RR schedule were generated by the random number generator in the Commodore VIC-20® microcomputer such that each response had a constant probability of being reinforced, and the sequence of random numbers varied each session (Harris, 1983). The ranges of component values for the VR and RR schedules across all sessions are shown in Table 1.

Each experimental condition lasted at least 10 and not more than 15 sessions. Experimental conditions could be changed only after five consecutive sessions of stable responding. Specifically, compared to the values in all the previous sessions, during the last five sessions there could be no new maximum or minimum

Table 2

Procedural data from last session of each condition.

Schedule	Number of sessions				Session time (minutes)				Random ratio actual value			
	Subjects				Subjects				Subjects			
	BP1	BP2	BP3	BP4	BP1	BP2	BP3	BP4	BP1	BP2	BP3	BP4
FR 80	10	15	15	15	20.25	15.98	29.89	17.78				
VR 80	13	11	15	15	17.47	13.96	32.01	23.25				
RR 80	10	15	13	14	13.66	13.65	32.48	17.90	64.73	85.87	83.84	69.03
FR 10	14	15	11	15	4.06	3.35	4.03	3.71				
VR 10	15	11	15	15	3.80	4.35	4.05	3.91				
RR 10	15	15	15	15	3.61	3.22	5.22	4.76	7.60	9.00	11.00	8.9
FR 40	11	15	15	15	9.82	7.14	13.40	8.83				
VR 40	15	10	11	10	8.87	7.18	12.31	8.60				
RR 40	15	14	15	15	7.31	7.46	13.28	10.43	30.57	41.80	45.93	52.80
FR 40 (2)[a]	15	11	15	15	9.70	7.39	10.32	9.58				
FR 5	15	10	15	15	2.84	2.54	3.18	2.68				
VR 5	11	15	15	15	3.05	2.61	2.79	2.98				
RR 5	15	15	15	15	2.51	2.76	3.04	2.71	4.00	5.70	5.10	4.00

[a] The number 2 in parentheses denotes the second exposure to a schedule.

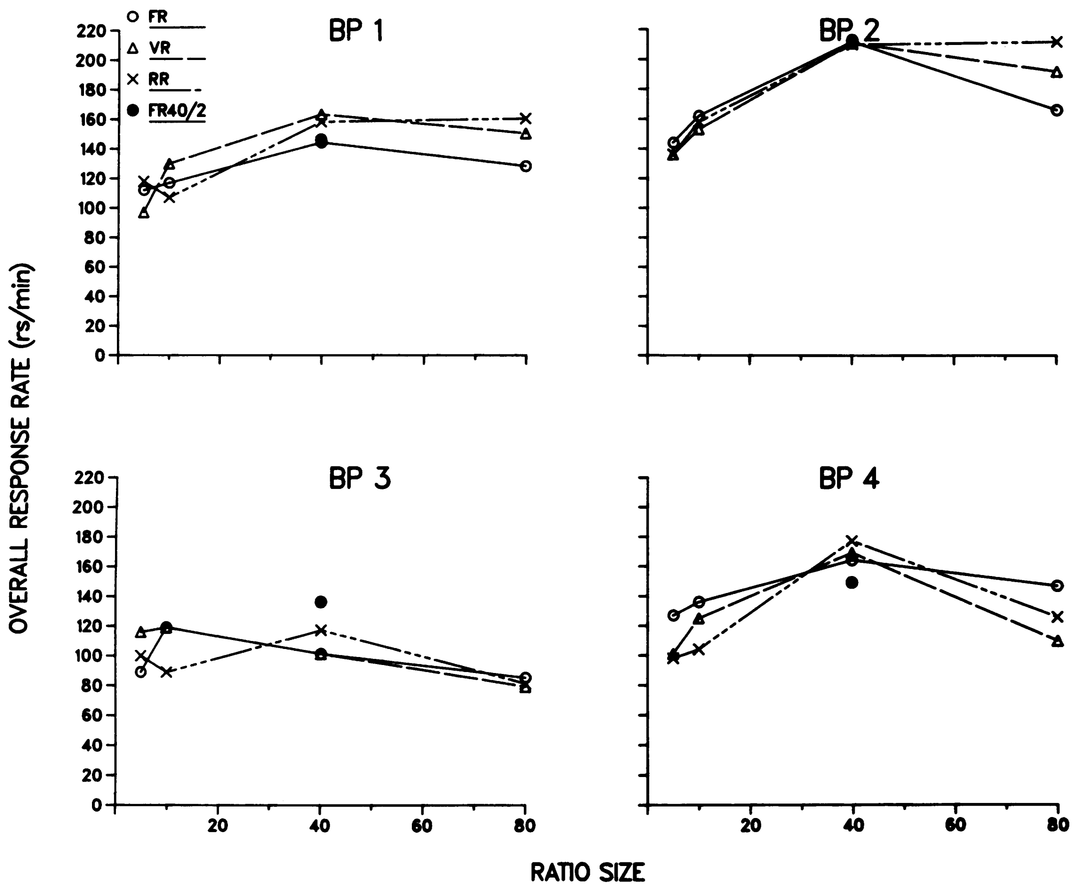

Fig. 1. Mean overall response rates for each of 4 pigeons during the last session of exposure to each ratio value of fixed-ratio, variable-ratio, and random-ratio schedules. These data include the postreinforcement pause, but the 90 s (total, for 30 reinforcers) of feeder time was removed prior to calculating the means. Filled circles indicate a replication of the FR 40 schedule.

values of mean PRP or mean interresponse time (IRT), nor could there be an increasing or decreasing trend in these two mean values. Table 2 shows the sequence of conditions, the number of sessions, and the actual reinforcement schedules.

RESULTS

Rather than presenting average individual data across the last five sessions as is often done, the data shown in the following figures are from the last session at each condition for each subject. This more conservative approach, although more likely to highlight variability within a subject, is, in our view, preferable because it represents behavior that is more typical of each individual subject. Moreover, by always choosing a specific session (in this case the last session) within a period of 5 days' stability, selection bias was discouraged. To indicate within-subject variability, the last 5-day ranges for mean PRP and mean IRT are shown in Table A1 in the Appendix. It is important to note that in all conditions all birds received 30 reinforcers (the maximum possible).

Response Rates

The overall response rates (including PRP, but not feeder time) for each subject at each ratio size are shown in Figure 1. Response rate increased between a ratio size of 5 and 40, and then either decreased or leveled off when the ratio size was increased to 80. This function was typical of FR, VR, and RR performance in all subjects except Bird BP3, who

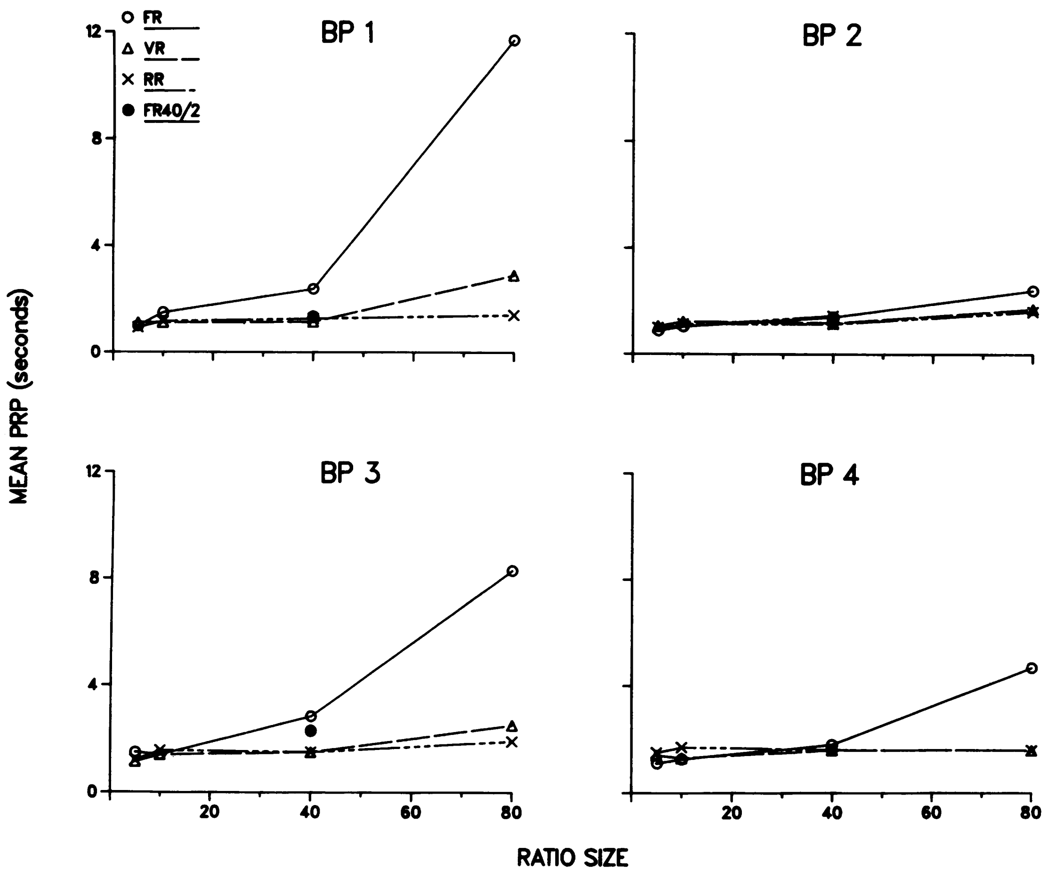

Fig. 2. Mean durations of postreinforcement pause (PRP) for each subject during the last session at each ratio value of fixed-ratio, variable-ratio, and random-ratio schedules. Filled circles indicate a replication of the FR 40 schedule.

showed essentially a flat curve between the ratio sizes 5 and 40. Additionally, there were no discernible differences among overall response rates on the FR, VR, and RR schedules. The detached data point (filled circle) in each graph represents the second exposure to FR 40 and in most cases recoverability was demonstrated. For Bird BP3, the second exposure to FR 40 produced a response rate that was somewhat higher than the first exposure. The relatively close correspondence between the response rates of first and second exposures to FR 40 also suggests that the technique of presenting individual data from a single session yields data that are both representative and reliable.

Postreinforcement Pause (PRP)

The mean duration of pauses following reinforcement is shown in Figure 2 for each bird under each condition. Particularly for the FR schedule, the PRP increased as ratio size was increased for all birds, although the changes in PRP were not as marked for BP2 as for the other birds. This may seem surprising because Bird BP2's overall response rate decreased substantially at FR 80 and VR 80 (see Figure 1). As will be discussed below, increases in the lengths of IRTs combined with the modest increases in the duration of the PRPs accounted for the reduction in overall response rate for this bird. The second exposure to FR 40 produced PRP durations that were quite similar to the PRP obtained during the first exposure to FR 40. By far, the largest increase in PRP occurred when ratio size was increased from FR 40 to FR 80.

The PRP durations for the VR and RR schedules sometimes increased slightly between the ratio sizes of 5 and 80, but this effect was modest at best, and was not nearly as large as that observed under the FR schedules. There

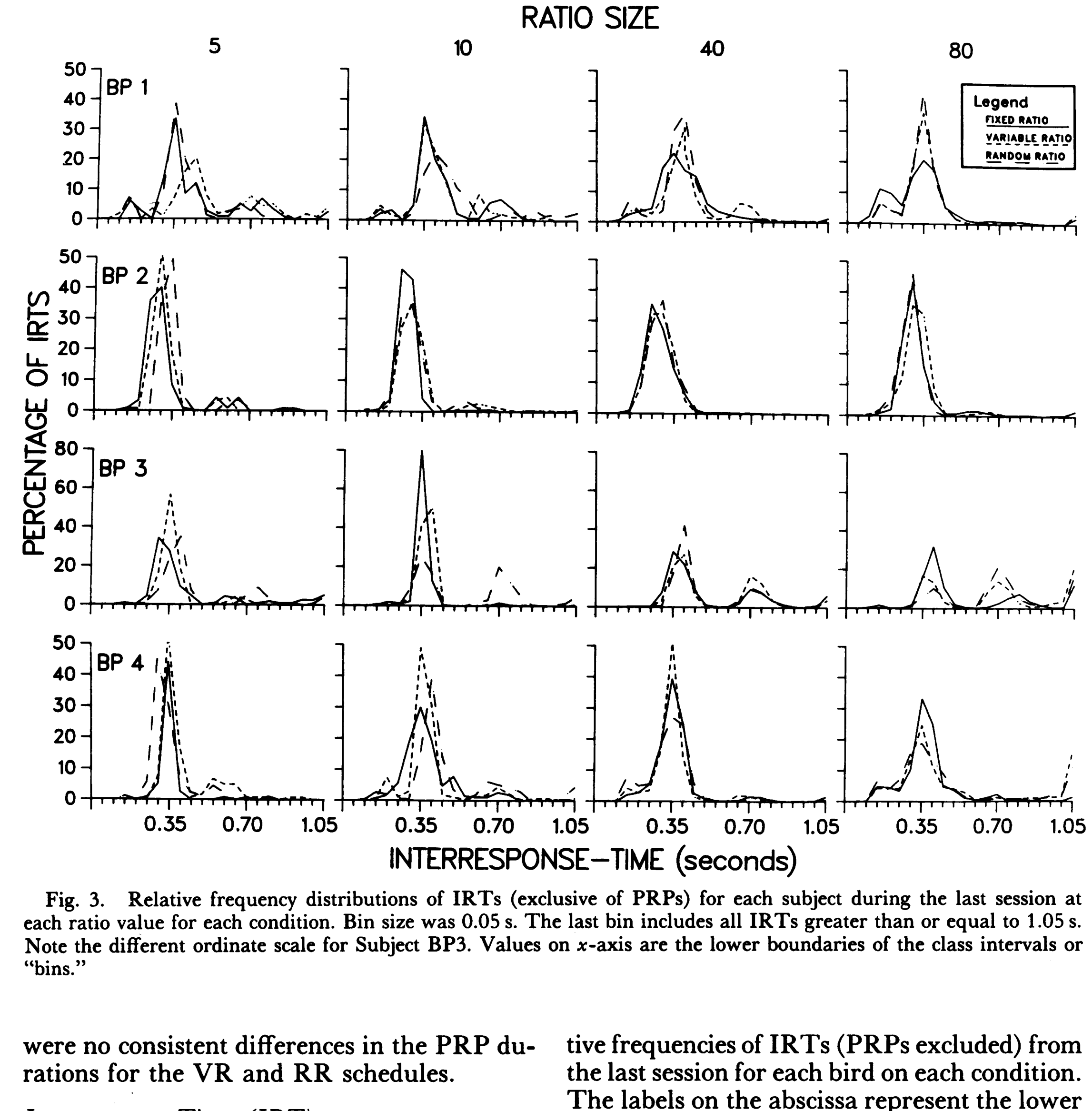

Fig. 3. Relative frequency distributions of IRTs (exclusive of PRPs) for each subject during the last session at each ratio value for each condition. Bin size was 0.05 s. The last bin includes all IRTs greater than or equal to 1.05 s. Note the different ordinate scale for Subject BP3. Values on x-axis are the lower boundaries of the class intervals or "bins."

were no consistent differences in the PRP durations for the VR and RR schedules.

Interresponse Time (IRT)

As seen in Figure 1, overall response rates often decreased between ratio sizes of 40 and 80. In the case of the FR performance, such a rate decrease could easily be a result of increases in PRP durations at a ratio size of 80. However, for the VR and RR schedules PRP duration did not increase very much at a ratio size of 80 (see Figure 2). It follows that the response rate decrease at VR 80 and RR 80 must have been a function of increases in the duration of another temporal variable, namely the time between responses, or IRT.

IRT distributions. Figure 3 shows the relative frequencies of IRTs (PRPs excluded) from the last session for each bird on each condition. The labels on the abscissa represent the lower boundary for each category of IRTs; thus the 0.35 category contains the percentage of IRTs that were between 0.35 s and 0.39 s in duration. The rightmost category includes all IRTs that were 1.05 s or longer. In general the 0.35-s category contains the modal IRT, although a second mode around 0.70 s is apparent in many of the records. It is also interesting to note that within a subject the overall shapes of the IRT distributions are very consistent across ratio sizes and types.

In comparing the IRT distributions under the FR schedule with those observed under the VR and RR schedules, a number of differences

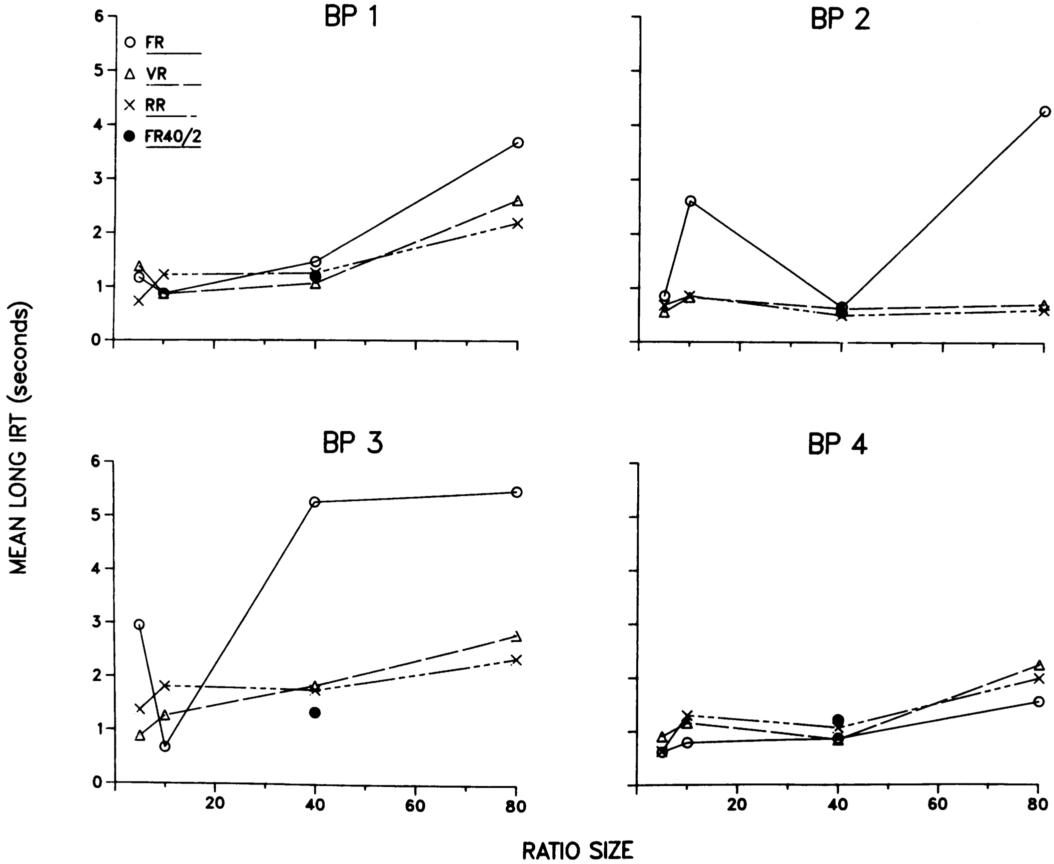

Fig. 4. Mean long IRT durations (exclusive of PRPs) for each subject at each ratio value. Long IRTs were defined as those which equaled or exceeded the top 1% of each subject's IRT distribution. Filled circles indicate a replication of the FR 40 schedule.

are apparent. At various ratio sizes the IRT distributions for VR and RR schedules are shifted slightly to the right (longer IRTs) of those distributions observed for the FR schedule. However, as ratio size was increased, the changes in the relative frequencies of IRTs are difficult to characterize, and they differ among birds. For example, as ratio size was increased for Subjects BP3 and BP4, both birds tended to increase the relative frequency of outliers (IRTs longer than 1.05 s) particularly at FR 80. In the case of Bird BP3, the outliers increased under all three types of ratio schedules, but for Bird BP4 only the outliers for VR and RR schedules showed a substantial increase at the ratio size of 80. For Birds BP1 and BP2, the relative frequency of outliers did not appreciably increase at the larger ratio sizes (40 and 80). As ratio size was increased, the IRT distributions tended to flatten and spread out for some birds (BP3 and BP4), but this change was not evident in the performances of Birds BP1 and BP2. This means that the consistent changes in overall response rates shown in Figure 1 cannot be simply attributed to changes in the PRP or in the relative frequencies of long IRTs, although these certainly may play a role. Another possibly important temporal variable is the duration of the long IRT.

Long IRT durations. Rather than arbitrarily use 1.0 s or longer as the definition of a long IRT as Mazur (1983) did, in the present study a long IRT was defined relative to each individual subject's behavior. Specifically, a long IRT was any IRT duration that was located in the top 1% of the relative frequency distribution. Because at the lower ratio values the 99th percentile contained only a few IRTs, this variable must be interpreted cautiously. Figure 4 shows the mean durations of these

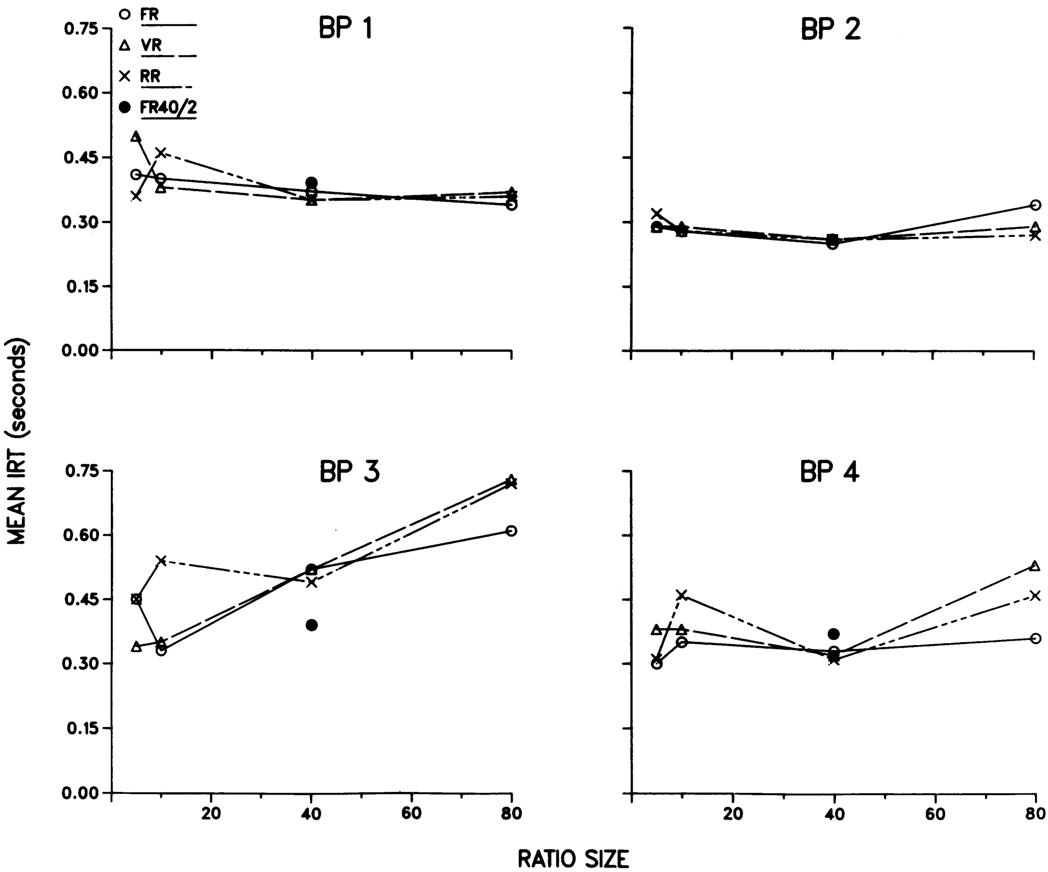

Fig. 5. Mean IRT durations (exclusive of PRPs) for each subject at each ratio value of fixed-ratio, variable-ratio, and random-ratio schedules. Filled circles indicate a replication of the FR 40 schedule.

long IRTs for each bird for the last session of exposure to each schedule. Although there are a number of reversals, as ratio size was increased the mean duration of long IRTs tended to increase. In all cases and for all three schedule types (except for Bird BP2 at VR 10), at a ratio size of 80 the mean duration of long IRTs was longer than at any other ratio size. Table A2 in the Appendix contains the ranges of the mean long IRTs for the last five sessions of exposure to each condition. As the data in Figure 4 suggest, the duration of the mean long IRT at FR 80 was longer than at VR 80 or RR 80 for all birds except BP4. However, it should be noted that the ranges at a ratio size of 80 show considerable overlap, although the top values, as well as the absolute values, of the ranges are greatest for the FR 80 condition for Birds BP1, BP2, and BP3. The extremely long IRT at FR 40 for BP3 resulted from one 10.3-s IRT that occurred in the last session under this condition.

Mean IRT. The mean IRTs calculated across the various ratios are shown in Figure 5. Again the data represent the behavior of individual subjects during the last session at each ratio size on each condition. These curves show a large degree of variability among subjects. On the basis of the mean duration of long IRT data shown in Figure 4, it might be expected that the duration of the mean IRT would be longer at 80 than at the other ratio sizes. However, at a ratio size of 80 there are many more IRTs averaged together than at smaller ratio sizes, and thus the effect of an increase in the mean duration of long IRTs is masked. This was true even though for some birds (notably BP3 and BP4) there was a slight increase in the frequency of long IRTs (see Figure 3).

In summary, overall response rates were influenced by changes in PRP duration and by changes in the frequency and duration of IRTs of various lengths. Moreover, the extent to which a particular temporal variable affected overall response rate differed not only among but within subjects as well. For example, in the case of Bird BP4, overall response rate decreased at a ratio size of 80 under the RR and VR schedules, but very little reduction in rate was observed under the FR schedule (see Figure 1). A close look at Figure 5 for Bird BP4 shows that this large drop in response rate was correlated with a substantial increase in mean IRT duration for both the VR and RR schedules, but the PRP was about the same duration at FR 40 as at FR 80 for this bird (see Figure 2). The factors that contributed to the increase in mean IRT duration were an increase in the frequency of long IRTs (Figure 3) as well as increases in the duration of the long IRTs (Figure 5).

In contrast, the lowest overall response rate at a ratio size of 80 for Bird BP1 was observed at FR 80 (see Figure 1). However, in this instance, the mean IRT played much less of a role. In fact, the mean IRT at 80 was slightly shorter for FR 80 than either RR 80 or VR 80 (see Figure 5). By far, the variable that contributed most to the decline in overall response rate for this bird at FR 80 was the large increase in PRP length (see Figure 2).

In other words, as ratio size was increased, changes in overall response rates occurred as a function of changes in both the mean PRP and the mean IRT duration. The mean IRT duration was, in turn, subject to changes in both the frequency and duration of long IRTs in combination with the absolute number of IRTs. As the absolute numbers of IRTs increased, the effects of long IRTs were dampened.

DISCUSSION

There were no large or reliable differences in response rate between the three different types of ratio schedules, despite differences in the microstructures of performance across subjects. The most consistent effects obtained in the present experiment were due to ratio size rather than to ratio type. For example, overall response rate sometimes increased slightly with increases in ratio size and then leveled off or decreased slightly. A similar finding has been reported previously for FR schedules (Barofsky & Hurwitz, 1968; Mazur, 1983) although there are also discrepant results (cf. Powell, 1968, 1970). Mazur (1983) compared behavior of one group of rats on FR and MR schedules to that of another group on FR and RR schedules. For all three schedules, the decreases in overall response rates at ratio values of 40 and 80 were substantially larger than those in the present experiment. An examination of the data in the appendix to Mazur's article reveals that, unlike the birds in the present experiment, many of his subjects did not obtain all of the available reinforcers. It seems likely that very long PRPs, IRTS, or both may have occurred (Mazur did not report IRT durations longer than 1.0 s) and thus produced the relatively larger decreases in mean overall response rate that he observed. However, overall response rate is a complex measure that can be affected by changes in PRPs, IRTS, or both, as previously mentioned in the Results section. Insofar as changes in IRT patterns are concerned, the present data do show that response rate decreases can be comprised of either an increase in the relative frequency of long IRTs or in their durations (cf. Bird BP2 and Bird BP4).

Performances under the VR and RR schedules were virtually indistinguishable in terms of the variables examined in the present study. This finding is not surprising, because though different methods of programming were used for the VR and RR schedules, the resultant mixtures of small, intermediate, and large ratio requirements were sufficiently alike as to produce similar patterns of responding. When there were a few consistent differences due to ratio type, they usually were apparent only at the largest ratio, 80. For example, FR performance differed in two respects. For 3 of 4 subjects, mean PRPs were longer, and there was some suggestion that the durations of the mean long IRTs were also longer under the FR schedule at 80 compared to VR and RR schedules. Mazur (1983) also reported longer PRPs in rats' responding maintained by FR schedules, in contrast to MR and RR schedules. However, Suboski (1965), who exposed two groups of rats to small ratios (FR 16 vs. VR 16), found no differences in overall response rates, running response rates (excludes PRP), or PRPs in the group that first experienced the VR 16 schedule. In the other group that was first placed on the FR 16 schedule and then the VR 16 schedule, PRPs were slightly longer on the FR 16 schedule.

Mazur (1982) has proposed a quantitative model that predicts the moment-to-moment probability of a response on ratio schedules. One prediction from this model is that PRPs should be longer on FR schedules than on VR or RR schedules, as was the case in the present study, at least at the higher ratio values. According to the model, this is because the probability of a response being reinforced following a previously reinforced response is low and the proximity to reinforcement is small, particularly at the larger ratios. Further evidence in support of this aspect of Mazur's model was provided by Bonem and Crossman's (1984) finding that adding a single unsignaled FR 1 component into a baseline of 29 FR 50 components (making the schedule more "VR-like") greatly reduced the PRP and mean long IRT after only two or three sessions. The results from the present study extend many of Mazur's (1983) findings to a different species (pigeons vs. rats) and to a different type of reinforcer (solid vs. liquid), indicating the robustness of the ratio contingency.

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APPENDIX

Table A1

Range (last five sessions) for mean PRP and mean IRT for each schedule.

	Subjects							
	BP1				BP2			
	Mean PRP		Mean IRT		Mean PRP		Mean IRT	
	Low	High	Low	High	Low	High	Low	High
FR 5	0.93	1.04	0.35	0.41	0.81	0.88	0.25	0.29
VR 5	0.83	0.99	0.50	0.58	0.78	0.94	0.26	0.29
RR 5	0.86	1.07	0.36	0.46	0.87	1.01	0.30	0.33
FR 10	1.21	1.49	0.36	0.36	0.97	1.08	0.24	0.28
VR 10	1.01	1.35	0.38	0.42	1.02	1.11	0.26	0.29
RR 10	1.0	1.15	0.40	0.57	1.05	1.22	0.28	0.33
FR 40	1.59	2.58	0.37	0.42	1.29	2.15	0.25	0.29
VR 40	1.03	1.10	0.34	0.36	1.0	1.06	0.25	0.26
RR 40	1.07	1.18	0.33	0.35	0.95	1.07	0.26	0.29
FR 40 (2)[a]	1.27	2.19	0.36	0.41	1.10	1.36	0.25	0.26
FR 80	6.72	13.57	0.32	0.38	2.11	2.76	0.30	0.34
VR 80	1.81	2.73	0.33	0.38	1.33	1.57	0.28	0.31
RR 80	1.30	1.49	0.36	0.39	1.30	1.77	0.26	0.28

[a] The number 2 in parentheses indicates the second exposure to the schedule.

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APPENDIX

Table A1 (*Continued*)

Subjects							
BP3				BP4			
Mean PRP		Mean IRT		Mean PRP		Mean IRT	
Low	High	Low	High	Low	High	Low	High
0.97	1.41	0.36	0.45	1.05	1.58	0.30	0.34
0.88	1.06	0.32	0.37	1.29	1.53	0.35	0.41
1.26	0.96	0.39	0.45	1.26	1.68	0.30	0.35
1.25	1.47	0.32	0.33	1.22	1.34	0.34	0.36
1.13	1.28	0.33	0.35	1.21	1.30	0.37	0.39
1.22	1.52	0.37	0.54	1.27	1.67	0.38	0.49
1.91	2.79	0.37	0.52	1.49	1.70	0.31	0.33
1.35	1.51	0.48	0.57	1.33	1.51	0.31	0.34
1.25	1.48	0.46	0.54	1.45	1.57	0.30	0.31
2.07	2.53	0.36	0.42	1.33	1.52	0.31	0.37
3.88	10.07	0.46	0.64	1.86	2.52	0.34	0.36
2.04	2.68	0.69	0.69	1.49	1.76	0.41	0.53
1.67	1.98	0.72	0.80	1.44	2.04	0.46	0.48

APPENDIX

Table A2

Range of mean long IRTs over last five sessions of each schedule.

	Subjects							
	BP1		BP2		BP3		BP4	
	Low	High	Low	High	Low	High	Low	High
FR 5	0.85	1.24	0.60	0.90	0.91	2.95	0.59	1.30
VR 5	1.18	2.21	0.50	0.61	0.40	1.15	0.85	1.75
RR 5	0.68	1.58	0.60	0.77	1.14	1.45	0.57	0.78
FR 10	0.75	1.13	0.53	2.75	0.65	1.70	0.71	0.88
VR 10	0.80	1.42	0.61	1.34	0.50	1.28	0.91	1.3
RR 10	0.98	3.48	0.63	0.94	0.73	1.85	1.11	1.35
FR 40	1.42	1.73	0.66	3.92	1.22	5.11	0.82	0.94
VR 40	0.91	1.12	0.63	0.69	1.33	1.93	0.74	1.11
RR 40	0.75	1.24	0.50	1.04	1.43	2.21	0.83	1.0
FR 40 (2)[a]	1.25	2.15	0.45	1.10	1.01	2.74	0.84	1.2
FR 80	1.45	4.12	1.85	4.44	2.76	6.11	1.21	1.65
VR 80	1.44	3.47	0.72	2.08	2.35	2.95	1.58	2.23
RR 80	2.17	3.41	0.61	1.66	2.16	2.52	1.86	2.84

[a] The number 2 in parentheses indicates the second exposure to the schedule.