PERFORMANCE IN CONTINUOUSLY AVAILABLE MULTIPLE SCHEDULES

DOUGLAS ELLIFFE AND MICHAEL DAVISON

UNIVERSITY OF AUCKLAND

Three pigeons were given continuous access in their home cages to food reinforcement on two-component multiple variable-interval variable-interval schedules. The reinforcer rates in the two components were varied over seven experimental conditions, and a partial replication over five conditions was arranged one year later. When component reinforcer rates were unequal, ratios of component response rates were more extreme than ratios of obtained component reinforcer rates, a result which in a generalized-matching analysis is termed overmatching. This finding contrasts sharply with results obtained when multiple schedules are arranged in shorter sessions, in which performance is characterized by undermatching when subjects are deprived of food, and by matching, or equality between component response- and reinforcer-rate ratios, when deprivation is minimal. More molecular data obtained in two subsequent conditions suggested that this finding did not reflect local fluctuations or asymmetries in deprivation. Theories of multiple-schedule performance that predict that matching cannot be exceeded are disconfirmed by the present results.

Key words: multiple schedules, variable-interval schedules, continuous sessions, closed economy, sensitivity to reinforcement, overmatching, deprivation, key peck, pigeons

One of the most frequently investigated areas in the experimental analysis of behavior has been the allocation of behavior between alternative sources of reinforcement. These alternatives may be presented either simultaneously, in a concurrent schedule, or successively, in a multiple schedule. In both of these arrangements, the relation between the allocation of behavior and the distribution of reinforcers between alternatives has been shown to be well described by the generalized matching law (Baum, 1974):

$$\frac{B_1}{B_2} = c \left(\frac{R_1}{R_2} \right)^a, \quad (1)$$

where B refers to the rate of responses emitted, R to the rate of obtained reinforcers, and the subscripts 1 and 2 to the two response alternatives. The constant a describes the sen-

sitivity of the behavior allocation to the obtained reinforcer distribution, and the multiplier c describes bias, or a constant preference for one alternative that is not accounted for by the obtained reinforcer distribution. Concurrent-schedule experiments typically yield sensitivities in the range 0.8 to 1.0 (Baum, 1979; Wearden & Burgess, 1982). Multiple-schedule sensitivities are typically considerably lower, in the range 0.33 (Lander & Irwin, 1968) to 0.45 (Charman & Davison, 1982, 1983; Lobb & Davison, 1977).

Perhaps one reason for the continuing interest in concurrent and multiple schedules is that they provide an experimental analog of a common and important aspect of natural behavior: choice. Organisms in the natural environment are continually faced with choices between engaging in two or more patterns of behavior maintained by distinct sources of reinforcement, and the measurability of behavior and control over the environment afforded by an operant experiment make choice amenable to investigation. If laboratory results are to be applicable to natural settings, however, it is important that the laboratory experiment be functionally similar to the natural events that it models. Baum (1972) pointed out some potentially important differences between the usual laboratory situation and the natural environment. First, an experimental animal is

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typically maintained at a constant level of deprivation, or percentage of its free-feeding body weight when food is used as a reinforcer. This is achieved by manipulating the amount of supplementary postsession food given to the animal, in combination with the amount of food earned as reinforcers during the session. Consequently, the animal's total consumption of the reinforcer is entirely independent of its behavior during the experimental session. Hursh (1980) has described this situation as an open economy, as opposed to a closed economy in which the animal's only sources of a necessary commodity (here, food) are reinforcers produced by responding. In the natural environment an organism's consumption of food depends on behavior it emits that results in the availability of food, suggesting that the natural economy is much more closed than open. Second, the experimental session occupies only a very small proportion of the subject's time (usually about 1 hr each day). Baum (1972) suggested that this period is at once too significant and too insignificant, because the animal receives all its food during and immediately after the session, and yet the sessional behavior constitutes only a small part of its day's activities.

These two discrepancies between an experiment and the natural environment may be overcome by arranging for the subject to live permanently in the experimental situation and to receive all its food as reinforcers produced by responding on continuously available schedules. Here, the economy is closed and the data constitute a much larger sample of the animal's total behavior.

Baum (1972) conducted an experiment of this type, in which concurrent variable-interval (VI) variable-interval schedules of food reinforcement were continuously available to a pigeon. Analyzing these data in terms of the generalized matching law (Equation 1), Baum found that the sensitivity parameter a approximated 1.0, or strict matching. Similarly, Graft, Lea, and Whitworth (1977) found that the performance of a group of 5 rats living in a complex maze and receiving all their food as reinforcers produced by bar pressing on concurrent VI VI schedules was characterized by undermatching in a generalized-matching analysis, and that this relation held for both the aggregate behavior of the group and for the behavior of the individuals within the

group. That is, the relation between response- and reinforcer-rate ratios was not different from that observed in normal short-session concurrent VI VI experiments.

Hursh (1980), however, noted several results from short-session laboratory experiments that cannot be replicated in a continuous experiment or closed economy. He contrasted data from Collier, Hirsch, and Hamlin (1972), in which rats' responding could produce food on continuously available fixed-ratio (FR) schedules, with data from Felton and Lyon (1966), where food-deprived pigeons' responding produced food on FR schedules in short sessions. In the latter experiment, response rate decreased with increasing FR requirement from a maximum of 1000 responses per hour at FR 45. In the closed-economy experiment of Collier et al., response rate increased steadily with increasing FR to an apparent asymptote of 3000 responses per hour at FR 240. Similarly, Hursh (1978) compared the effects of increasing VI mean interval length in open and closed economies. In the closed economy, response rate increased sharply with increasing VI length, whereas response rate in the open economy decreased gradually with increasing VI length.

These results, and others reported by Hursh (1980), suggest that there may be important functional differences between a typical, short-session experiment and a continuous, closed-economy experiment. Baum (1972) and Graft et al. (1977) showed, however, that these procedural differences did not affect sensitivity to reinforcement rate in concurrent VI VI schedules. The present study set out, in a manner analogous to Baum's experiment, to investigate the relation between response and reinforcer distributions in multiple VI VI schedules, arranged to run continuously.

METHOD

Subjects

Three homing pigeons served as subjects. Birds 251 (male) and 252 (female) had experience in responding on concurrent schedules. Bird 250 (male) had previously served in a multiple-schedule experiment. Not all birds participated in all experimental conditions. Water and grit were freely available to the subjects in their experimental cages.

Apparatus

Each bird lived in a cage 375 mm high, 375 mm wide, and 380 mm deep. The back, left, and right walls of the cages were made from solid metal; the top, floor, and front wall consisted of bars spaced 46 mm apart. Each cage contained two wooden perches, one mounted 75 mm from and parallel to the floor and right wall, and another mounted 75 mm from and parallel to the floor and front wall. The right wall contained three translucent response keys, 20 mm in diameter, 114 mm apart, and 223 mm above the perch. The right and center keys were dark and inoperative throughout the experiment. The left key could be transilluminated red or green and was operated by a peck of force exceeding 0.1 N. A hopper containing wheat was situated 138 mm below the center key. During reinforcer delivery, the hopper was raised and illuminated for 3 s, and the keylight was extinguished. Ambient lighting was automatically controlled, switching on at 6 a.m. and off at 7 p.m. each day. All experimental events were controlled, and data recorded, by conventional solid-state equipment situated in another room.

Procedure

Because all birds had extensive histories of food-reinforced key pecking, no preexperimental training was given, and Birds 251 and 252 were placed directly in the first experimental condition (Table 1). The two components of the multiple VI VI schedule were signaled by the color (red or green) of the left key, and were 150 s in duration. The schedules, number of days of training, and birds participating in each condition are shown in Table 1, together with the mean body weight of each bird over the last 5 days of each condition, expressed as a percentage of its free-feeding weight (FFW) obtained before the experiment commenced. The multiple schedule ran continuously, except for about 5 min between 12 noon and 1 p.m. (Conditions 1 to 7) or at 9 a.m. (Conditions 8 to 14) each day, when the birds were weighed and the data were recorded. Conditions 8 to 12 constituted a replication of Conditions 1 to 5. About 1 year of similar experimentation intervened between Conditions 7 and 8. Conditions 13 and 14 were taken from a subsequent experiment using the same subjects, again run un-

Table 1

VI schedule values in seconds, number of sessions of training, birds participating, and body weight of each bird in each condition. Body weights are expressed as a percentage of free-feeding weight (% FFW).

Condition	VI Schedules		Birds	% FFW	Sessions (Days)
	Red	Green			
1	60	60	251	93	14
			252	99	15
2	34	270	251	96	19
			252	100	14
3	270	34	251	96	17
			252	101	20
4	38	150	251	99	16
			251	99	15
5	150	38	251	99	15
			251	98	23
6	45	90	251	98	23
			252	102	20
7	90	45	251	97	20
			252	101	26
8	270	34	250	106	47
			251	97	47
9	38	150	252	95	47
			250	94	22
10	150	38	251	98	22
			252	97	22
11	34	270	250	91	22
			251	100	22
12	60	60	252	97	22
			250	92	20
13	70	420	251	100	20
			252	98	20
14	264	1520	250	91	34
			251	99	34
			252	96	34
			250	89	27
			251	91	27
			252	88	27
			250	75	79
			251	75	79

der conditions of continuous availability, in which overall arranged reinforcer rate was varied. In Condition 13 (multiple VI 70 s VI 420 s), data were recorded after every 20th component, or at approximately hourly intervals. In Condition 14 (multiple VI 264 s VI 1520 s), data were recorded after every green component, for Bird 251 only. These conditions were included to provide data at a more molecular level than that of the entire session.

For each bird, training was continued in a condition until a stability criterion had been met. This criterion required that the median relative number of responses emitted in the red schedule component over 5 days be within 0.05 of the median of the immediately preced-

Fig. 1. Number of responses per minute in the red (squares) and green (triangles) components as a function of the relative obtained reinforcer rate in the red component. The data are means based upon the last five sessions of Conditions 1 to 7 (top panel) and Conditions 8 to 12 (bottom panel).

ing 5 days. Experimental conditions were not changed until this criterion had been met five times, not necessarily consecutively. In Conditions 8 to 13, conditions were not changed until all 3 birds had met the criterion five times. Each VI schedule comprised intervals randomized from the first 12 terms of an arithmetic progression in which the smallest interval was one twelfth the mean interval.

RESULTS

The Appendix shows the numbers of responses emitted per minute and reinforcers obtained per hour in each component of the multiple schedule, together with the body weight of each bird expressed as a percentage of its free-feeding body weight. These data are means based upon the last five sessions in each condition. The time base for the calculation of rates was the time spent in each component excluding the time occupied by reinforcer delivery.

During Conditions 1 to 7, response rates were considerably lower than those typically obtained in short-session multiple-schedule experiments (e.g., Charman & Davison, 1982, 1983; Lander & Irwin, 1968; Lobb & Davison, 1977). Obtained reinforcer rates were between one sixth and one fourth of the arranged rates, reflecting the comparatively low response rates. For Birds 251 and 252, response rates during the replication series (Conditions 8 to 12) were not different from those in the identical schedules during Conditions 1 to 5 ($p > .05$ [sign test, Siegel, 1956]). Separate sign tests were conducted for each bird. Obtained reinforcer rates were generally higher during Conditions 8 to 12 than during Conditions 1 to 5, but still fell well short of the arranged rates. Throughout the experiment, obtained reinforcer-rate ratios were very similar to those arranged.

Figure 1 shows mean response rate (responses per minute) in each schedule component as a function of the mean obtained rel-

active reinforcer rate in the red component. In general, response rate in each component increased as the proportion of reinforcers obtained in that component increased. Response rates in the two components were approximately equal when reinforcers were equally distributed between the components (Conditions 1 and 12; multiple VI 60 s VI 60 s) and were most different when the reinforcer distribution was most extreme (Conditions 2, 3, 8, and 11; multiple VI 34 s VI 270 s and multiple VI 270 s VI 34 s).

Figures 2 and 3 show log response-rate ratio as a function of log reinforcer-rate ratio for each bird in Conditions 1 to 7 (Figure 2) and in Conditions 8 to 12 (Figure 3). Straight lines were fitted to these data, which represent each of the last five sessions in each condition, by the method of least squares. The equations of the fitted lines are shown on the graphs, together with the standard deviations of their slopes and intercepts. In these equations, the slope is the sensitivity parameter a in Equation 1, and the intercept is the log of the bias parameter c . All slopes were more than two standard deviations greater than 1.0. No intercept was more than two standard deviations from zero. The proportion of the total data variance accounted for by the fitted line (r^2) exceeded .97 in all cases. The data were thus well described by the generalized matching law (Equation 1) with sensitivity greater than 1.0 and with no bias.

Figure 4 shows the mean response rate (responses per minute) in the red and green schedule components in successive 20-component blocks over the last five sessions of Condition 13 (multiple VI 70 s VI 420 s). These data show that each subject spent about half of the 24-hr session responding in both components of the multiple schedule at approximately constant rates, and about half of the session not responding. This period of nonresponding corresponded quite closely to the period during which the room lighting was switched off each day.

Figure 5 shows mean point estimates of sensitivity to reinforcer rate (calculated by assuming zero bias) for each subject in successive 20-component blocks during the last five sessions of Condition 13. These estimates were calculated only for blocks in which the reinforcer rate in the red component exceeded five reinforcers per hour. During the period of re-

Fig. 2. The logarithm (base 10) of the ratio of response rates in the red and green components as a function of the logarithm (base 10) of the ratio of obtained reinforcer rates. The data represent the last five sessions for each of Conditions 1 to 7. For each bird, the best fitting straight line, its equation, and the standard deviations of slope and intercept are shown.

sponding each day, there was no systematic trend in sensitivity for any bird (nonparametric trend test, Ferguson, 1965).

During the last session of Condition 14 (Bird 251, multiple VI 264 s VI 1520 s), response rates were recorded separately in each red component and the immediately following green component. There were 288 such pairs of components (red followed by green) in a session. The numbers of red/green pairs falling in each of four categories were recorded: responding in both components (137); responding in the red component but not in the following green component (9); responding in the green component but not in the preceding red component (11); and responding in neither component (131). Of the red/green pairs, 268 (93.3%) fell in either the first or last of these categories. Of the pairs in which the subject responded in neither component, 127 (99.7%) occurred during the part of the session that the subject typically spent not responding on the schedules in Condition 13 (Figure 4). The point estimate of sensitivity to reinforcer rate for Bird 251 in Condition 14 was 1.53.

The mean reinforcer rate arranged by the multiple schedule was one reinforcer per minute throughout Conditions 1 to 12. The Appendix and Table 1 show that although the obtained reinforcer rate fell considerably below this, the rate obtained was sufficient for the subjects' body weights to be maintained at close to their free-feeding levels. This part of the experiment was therefore conducted under conditions of minimal deprivation.

DISCUSSION

The major finding of this experiment was that the relation between response allocation and reinforcer distribution on continuously available multiple VI VI schedules was well described by the generalized matching law (Equation 1) with an a value much greater than 1.0. This result is in marked contrast to

Fig. 3. The logarithm (base 10) of the ratio of response rates in the red and green components as a function of the logarithm (base 10) of the ratio of obtained reinforcer rates. The data represent the last five sessions for each of Conditions 8 to 12. For each bird, the best fitting straight line, its equation, and the standard deviations of slope and intercept are shown.

Fig. 4. Mean number of responses per minute in the red (squares) and in the green (triangles) components during successive 20-component blocks over the last five sessions of Condition 13.

the body of findings of undermatching in the multiple-schedule literature (e.g., Charman & Davison, 1982, 1983; Lander & Irwin, 1968; Lobb & Davison, 1977).

One possible interpretation of the discrepancy between the present results and those obtained when multiple schedules are arranged in short sessions was suggested by a reviewer of an earlier version of this paper. It is that the effectiveness of food as a reinforcer

Fig. 5. Mean point estimate of sensitivity to reinforcer rate for each subject during successive 20-component blocks over the last five sessions of Condition 13.

may not remain constant throughout a 24-hr session. That is, food may be mildly reinforcing until the pigeon has eaten a number of times, and then be less reinforcing for a while. Such a pattern of fluctuating effectiveness of the reinforcer might be expected to produce a pattern of behavior in which periods of responding on the schedules alternate with periods of nonresponding. If this were the case, it would be likely that the pigeon would begin a period of eating, or responding on the schedules, while the component signaling a higher reinforcer rate was in effect, and that food might therefore be a relatively ineffective reinforcer for a larger proportion of the low reinforcer-rate component than of the high reinforcer-rate component. An asymmetry in the effectiveness of the reinforcer of this kind might be expected to increase the response differential between the two components, leading to a more extreme response-rate ratio.

Conditions 13 and 14 were included in the present experiment to assess interpretations of this kind. Although the overall reinforcer rate arranged by the multiple schedule, and hence the level of deprivation, in these conditions differed from that arranged in the first 12 conditions, the similarity in sensitivity values (Figure 5) and in all other procedural parameters suggests that the molecular patterns of behavior observed in Conditions 13 and 14 would be comparable to those in the main part of the experiment.

The way in which response rates in the red and green components changed during successive 20-component blocks in Condition 13

(Figure 4) provided no evidence for asymmetric effectiveness of the reinforcer in the two components. During that part of the day-long session which the birds spent responding on the schedules, either response rate remained relatively constant within each component or, for Bird 250, changes in response rate in one component were positively correlated with changes in response rate in the other component. This is supported by the individual-component data from Bird 251 in Condition 14, described above, which suggest that the occurrence of responding in a particular component was highly and positively correlated with the occurrence of responding in the preceding component, and that local, isolated pauses in responding in either component very seldom occurred.

This last point also suggests that the data recorded for a block of 20 components were representative of performance in each of those components. However, it is apparent from Figure 4 that the sessional data represent an average of two quite different response modes: responding at a relatively constant rate in each component, and responding in neither component. Each of these modes of responding characterized the performance during about half of the session. This means that the sessional component response rates (Figure 1) were considerably less than those occurring during the part of the session that was spent responding. However, this difference does not imply that the ratios of these sessional rates differed from those in the "working" part of the session, because response rates during Blocks 14 to 27 were very close to zero (Figure 4). As a result, the generalized-matching analysis of the data was unaffected by the observed within-session patterns of responding. Additionally, because obtained component reinforcer-rate ratios were used in the analysis, the sessional sensitivity values could not be affected by within-session alternation between periods of responding and not responding. The foregoing suggests that although the component response rates across a session were not representative of behavior at every point within the session, as is normally assumed in a short-session experiment, behavior during the time spent responding was quite homogeneous. An appeal to asymmetric within-session fluctuations in effectiveness of the reinforcer, or in molecular patterns of behavior,

cannot account for the observed sessional overmatching.

It is conceded that the component-by-component analysis of Condition 14 only weakly demonstrates homogeneity within blocks of 20 components, which are still relatively molar samples of the continuous behavior, and that therefore some sorts of local fluctuations may not have been revealed. However, inasmuch as the subjects received all food (and extraneous) reinforcers within the continuous, closed, experimental economy, it is likely that the reinforcer rates controlling their behavior allocation were also highly molar. That is, the amount of food received in a component, or in an hour, is less likely to be a critical variable than the amount received in a day. A molar measurement interval is thus perhaps best able to reveal regularities in the data and, we suggest, is most likely to be relevant to describing naturally occurring behavior.

Herrnstein (1970) suggested that the relation between component response and reinforcer rates in multiple VI VI schedules could be described by the following equation:

$$B_1 = \frac{kR_1}{R_1 + mR_2 + R_e}, \quad (2)$$

where B and R refer to response and reinforcer rates, k is the maximum response rate, and m describes the interaction between the two schedule components, ranging from zero (no interaction) to one (maximum interaction). R_e is a measure of the reinforcer rate for behavior not measured by the experimenter. The ratio of response rates in the two components is therefore given by:

$$\frac{B_1}{B_2} = \left(\frac{R_1}{R_2} \right) \cdot \frac{(R_2 + mR_1 + R_e)}{(R_1 + mR_2 + R_e)}. \quad (3)$$

Herrnstein and Loveland (1974) pointed out that when R_e increases relative to the defined reinforcer rates R_1 and R_2 , Equation 3 predicts that the response-rate ratio will become more extreme, approaching the reinforcer-rate ratio. They suggested that this would occur if the subject was made less deprived of the scheduled reinforcers. Herrnstein and Loveland conducted an experiment in which they investigated the effect of varying deprivation on the ratio of response rates in two constant but unequal components of a multiple VI VI schedule. They found that, as deprivation was

decreased, response ratios approached reinforcer ratios, and that response and reinforcer ratios were equal at maximum body weight (zero deprivation). Charman and Davison (1983) extended this result in a parametric manipulation of both deprivation and reinforcer ratios in multiple VI VI schedules, and found that sensitivity to reinforcer rate, in a generalized-matching analysis, increased to near matching ($a = 1.0$) as deprivation was decreased to zero.

Like those of Herrnstein and Loveland (1974) and Charman and Davison (1983), the first 12 conditions of the present experiment were conducted under conditions of minimal or zero deprivation, and produced sensitivities higher than those typically shown by food-deprived subjects in short-session multiple-schedule experiments. Unlike those two experiments, however, the present experiment found significant and replicable overmatching, rather than matching. This result is inconsistent with an interpretation in terms of Herrnstein's (1970) multiple-schedule equation (Equation 3), which clearly predicts that as deprivation is decreased, response-rate ratios will approach reinforcer-rate ratios and that the limiting case is one of equality between these variables (i.e., $a = 1.0$ in Equation 1). Equation 3 can predict overmatching ($a > 1.0$) only if the interaction parameter m is allowed to take values greater than 1.0. Such values of m are not consonant with Herrnstein's theory. In general, the overmatching result cannot be explained by any account that postulates a single extraneous-reinforcer term that increases, relative to the defined reinforcer rates, as deprivation decreases.

McLean and White (1983) took an approach to multiple-schedule performance different from that adopted by Herrnstein (1970). They attributed changes in absolute component response rates to concurrent interactions between scheduled and extraneous reinforcers within each component, rather than to interactions between reinforcer rates in the multiple-schedule components, giving:

$$\frac{B_1}{B_2} = \left(\frac{R_1}{R_2} \right)^a \cdot \frac{(R_2^a + bR_{e2}^a)}{(R_1^a + bR_{e1}^a)} \quad (4)$$

For the present data, it is reasonable to set both concurrent bias and sensitivity (b and a in Equation 4) to 1.0, because the extraneous

reinforcers, R_{e1} and R_{e2} , must be measured in food-reinforcer units, and because Baum (1972) has shown that concurrent-schedule sensitivity approximates strict matching in a closely similar continuous procedure.

As McLean and White (1983) showed, Equation 4 predicts that multiple-schedule sensitivity, in a generalized-matching analysis, is determined by the values of the extraneous reinforcers relative to the scheduled reinforcers, a conclusion that parallels that of Herrnstein and Loveland (1974). However, McLean and White's approach differs from Herrnstein's (1970) approach in that the extraneous-reinforcer rates in the two components are not assumed to be identical. This means that the limits to multiple-schedule sensitivity predicted by Equations 3 and 4 differ. Equation 4 also predicts that multiple-schedule bias is an inverse function of the extraneous-reinforcer ratio, R_{e1}/R_{e2} . Using concurrently arranged VI reinforcer schedules as an experimental analog of extraneous reinforcement, McLean and White verified both these predictions of their model. Specifically, when R_{e1} was greater than R_{e2} , multiple-schedule performance was biased toward B_2 , and vice versa, and when the absolute levels of R_{e1} and R_{e2} were increased, multiple-schedule sensitivity increased.

Under the present, continuous, procedure, the subjects' body weights were maintained at close to their free-feeding levels. Following Herrnstein and Loveland (1974) and Charman and Davison (1983), this suggests that the obtained extraneous-reinforcer rates were high relative to the scheduled-reinforcer rates. Also, the subjects obtained their total consumption of both food and extraneous reinforcers during the experimental session. This implies that demand for extraneous reinforcers again remained relatively high, and constant, at least with respect to variations in the distribution of scheduled reinforcers between components. Thus, the ratio of obtained extraneous-reinforcer rates in the two components must have varied inversely with the ratio of component scheduled-reinforcer rates. (We assume that, within each component, responding maintained by food reinforcers is constrained by responding maintained by extraneous reinforcers, and vice versa [Staddon, 1982], and that the slope of the feedback function for extraneous reinforcers is greater than

zero.) As McLean and White (1983) showed, unequal component extraneous-reinforcer rates produce multiple-schedule bias. Under a continuous procedure, however, this bias covaries with the component scheduled-reinforcer ratio.

In summary, it is clear that no published model of multiple-schedule performance except that of McLean and White (1983) can immediately explain the overmatching result. An account in terms of overall deprivation can explain neither the present results nor the difference between these results and those of Herrnstein and Loveland (1974) and Charman and Davison (1983). Further, the present data provide no evidence for an explanation in terms of local fluctuations in deprivation, or asymmetries between the two schedule components.

Finally, the difference between the present multiple-schedule results and the concurrent-schedule findings of Baum (1972) and Graft et al. (1977) suggests that the question of the applicability of conventional laboratory results to natural events is not a simple one; it awaits further elucidation of the controlling aspects of the usual experimental situation. In particular, the difference in the effects of short and continuous sessions on concurrent- and multiple-schedule performances argues that, despite the generality of the generalized matching law as a descriptor of the resulting behavior, it provides at best an incomplete model of the behavior, and the search for an independent model of multiple-schedule performance remains important.

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APPENDIX

Responses per minute and reinforcers obtained per hour in the red and green components and percentage of free-feeding body weight (% FFW), for each bird. The data are means computed over the last five days of each condition.

Condi- tion	Responses/min		Reinforcers/hr		% FFW
	Red	Green	Red	Green	
Bird 250					
8	0.56	8.16	3.43	22.77	106
9	5.40	0.73	12.47	2.87	94
10	1.08	6.36	4.34	18.26	91
11	5.32	0.36	15.80	2.11	92
12	3.40	3.13	9.07	8.42	91
13	14.24	2.33	14.74	3.39	89
Bird 251					
1	4.86	6.52	12.27	13.02	93
2	7.83	0.43	23.84	3.83	96
3	0.45	6.53	3.90	23.91	96
4	7.76	0.67	22.77	5.89	99
5	0.56	6.75	5.98	20.38	99
6	5.67	1.73	16.68	7.96	98
7	1.84	6.65	7.93	17.39	97
8	0.40	10.78	4.21	25.88	97
9	7.01	0.80	19.47	5.83	98
10	0.74	7.88	5.60	21.61	100
11	8.27	0.41	21.73	3.91	100
12	3.12	2.51	12.46	12.58	99
13	11.39	0.80	21.33	4.58	91
14	15.70	1.48	7.95	1.69	75
Bird 252					
1	2.40	2.78	10.91	11.22	99
2	6.23	0.55	21.02	3.64	100
3	0.59	7.30	3.58	22.95	101
6	5.71	1.36	16.96	7.36	102
7	2.48	8.09	8.56	17.06	101
8	0.71	14.59	4.44	29.88	95
9	10.75	1.32	22.35	6.67	97
10	0.92	8.13	6.20	23.60	97
11	7.83	0.54	23.36	4.04	98
12	2.41	3.06	11.92	12.77	96
13	11.98	1.34	23.16	4.47	88