CHOICE BEHAVIOR AND THE ACCESSIBILITY OF THE REINFORCER¹

EDMUND FANTINO, NANCY SQUIRES,
NICOLA DELBRÜCK, AND CHRISTA PETERSON

UNIVERSITY OF CALIFORNIA, SAN DIEGO

In Experiment 1, matching of relative response rates to relative rates of reinforcement was obtained in concurrent variable-interval schedules when the absolute values of the two concurrent variable-interval schedules varied from 6 sec and 12 sec to 600 sec and 1200 sec. Increases in the duration of the changeover delay, however, produced decreases in the relative response rates and, consequently, some deviation from matching. In Experiment 2, matching of relative response rates to the relative duration of the reinforcer failed to occur when the equal variable-interval schedules arranging access to the two different reinforcer durations (1.5 and 6 sec) were varied in size from concurrent variable-interval 10-sec schedules to concurrent variable-interval 600-sec schedules.

An important generalization that has grown out of recent studies of choice behavior, utilizing concurrent schedules of reinforcement, is that the relative rate of responding on each of two unequal, concurrent variable-interval schedules matches the relative rate of reinforcement of responding on the two schedules.² This matching relation has been found with a variety of organisms, reinforcers, and procedures (Herrnstein, 1961; Catania, 1966; Shull and Pliskoff, 1967; Stubbs and Pliskoff, 1969; Silberberg and Fantino, 1970; Herrnstein, 1970; Schroeder and Holland, 1969; Baum and Rachlin, 1969). A second but less well documented generalization states that the relative rate of responding on equal, concurrent schedules matches the relative magnitude (duration) of the reinforcer delivered for responding on the two schedules (Catania, 1963; Brownstein, 1971). These two matching relations have served as the basis for much theoretical discussion (e.g., Premack, 1965; Baum

and Rachlin, 1969; Herrnstein, 1970; Rachlin, 1971). There is a sense in which the results hitherto collected in support of both of these matching relations are lacking in generality: the size of the basic schedules of reinforcement that were concurrently available to the organism has not been systematically varied while keeping the relative values of the schedules constant. With regard to rates of reinforcement, for example, there are considerable data to indicate that about two-thirds of an organism's choice responding on a concurrent variable-interval 60-sec variable-interval 120 sec (*conc* VI 60-sec VI 120-sec) schedule will be emitted to the VI 60-sec schedule, i.e., that matching will occur with these values. On the other hand, it is not clear that matching will occur if VI schedules with considerably shorter or longer average interreinforcement intervals are employed (e.g., *conc* VI 6-sec VI 12-sec or *conc* VI 600-sec VI 1200-sec schedules). The importance of the overall average interreinforcement interval has been documented in related experimental work by Fantino (1969a,b) and by Squires and Fantino (1971) utilizing the concurrent-chains procedure. Choice behavior in the concurrent-chains procedure was controlled by the relative reduction in the expected time to reinforcement signified by each of the stimuli (and their associated schedules of reinforcement) being chosen. When the stimuli were readily accessible (i.e., there were equal VI schedules with short average interreinforcement intervals in the initial links),

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²In a variable-interval (VI) schedule, the first response to occur after a certain time interval is reinforced. The interval of time varies around a specified average. In concurrent variable-interval (*conc* VI VI) schedules, there are two independent variable-interval schedules, each associated with a separate operant, that are in effect concurrently.

preference for the preferred alternative was great; when the stimuli were relatively inaccessible (equal VI schedules with long average interreinforcement intervals in the initial links) the organism was relatively indifferent to the difference between the alternatives. The present experiments, with simple concurrent schedules, seek to provide data on whether or not choice proportions (*i.e.*, the number of responses on one key divided by the total number of responses) for two different reinforcer durations, or for two different rates of reinforcement, may be determined in a roughly quantitative sense (*e.g.*, the matching relation) that has generality independent of the absolute overall rate of reinforcement.

EXPERIMENT 1: TESTING THE GENERALITY OF THE MATCHING RELATION BETWEEN CHOICE AND RATES OF REINFORCEMENT

METHOD

Subjects

Seven adult male White Carneaux and King pigeons were maintained at approximately 80% of their free-feeding body weights throughout the experiment. Five of the pigeons were experimentally naive; the other two (numbers 1 and 2) had been used in previous work with concurrent schedules.

Apparatus

The experimental chamber measured 12 by 12 by 11 in. (31 by 31 by 27.5 cm). The front wall contained two translucent response keys mounted 8 in. (20.5 cm) above the floor of the chamber and 5 in. (12.5 cm) apart. Key illumination was accomplished by means of colored stimulus lights mounted behind the response keys. The chamber also contained an overhead houselight and a solenoid-operated hopper. During grain presentations, the houselight and keylights were turned off and the hopper was illuminated with white light. Responses did not produce a feedback click.

Procedure

Throughout the experiment, the left key was transilluminated with orange light and the right key with blue light. Responses to the two keys were reinforced with 3-sec access to mixed grain according to two different and independent VI schedules of reinforcement. In

each pair of VI schedules, the average interreinforcement interval of one schedule was half that of the other. Three such pairs were used: *conc* VI 6-sec VI 12-sec, *conc* VI 60-sec VI 120-sec, and *conc* VI 600-sec VI 1200-sec. All VI schedules were designed by the method described by Segal (1964). The pigeons were exposed to the three pairs in different orders. A given pair remained in effect for at least 14 daily sessions of 40 reinforcements and until the pigeon's choice proportions met the following stability criterion: on the fourteenth day and every day thereafter until stability had been reached, the last nine sessions were divided into three blocks of three consecutive sessions and the means of the choice proportions for those three blocks were computed (m_1 , m_2 , and m_3). The behavior was considered stable when the means of the three blocks differed by 0.07 or less, and there was no trend in the choice proportions, *i.e.*, neither $m_1 < m_2 < m_3$ nor $m_1 > m_2 > m_3$. In only one of 32 cases did m_3 differ by more than 0.05 from either m_1 or m_2 . This typically took about 25 sessions. After each experimental condition, the position of the schedule providing the higher rate of reinforcement was switched to the other key.

During the first phase of the experiment, a changeover delay (COD) of 1.5 sec was used: after a response on one key, 1.5 sec had to elapse after the first response on the other key before a response on that key could be reinforced. All pigeons were exposed to each of the three pairs of schedules with this COD duration. Four of the pigeons were then studied under two additional conditions, *conc* VI 6-sec VI 12-sec with a COD of 0.15 sec, and *conc* VI 600-sec VI 1200-sec with a COD of 15 sec. In each of these conditions, the COD duration bears the same proportion to the average interreinforcement interval of the VI schedule as it did when the 1.5-sec COD was employed with *conc* VI 60-sec VI 120-sec. Finally, these same four pigeons were also exposed to an additional procedure in which the two VI schedules were no longer independent; when either VI timer scheduled reinforcement, both timers stopped until after that reinforcer had been obtained. This procedure ensures that the observed proportion of reinforcers equals that scheduled by the VI tapes; in effect, it is a type of "forced-choice" procedure and is referred to as such henceforth.

The VI schedules in the forced-choice procedure were VI 6-sec and VI 12-sec and the COD was 1.5 sec.

RESULTS

Columns iv-vii of Table 1A give the absolute and relative response rates for each pigeon on each schedule. The absolute rate (cols. iv and v) is simply the total number of responses on a key divided by the amount of time it was illuminated. Since these times were equal for both keys, the relative rate of responding, or choice proportion (col. vii) is simply the absolute rate on the key associated with the VI schedule with the shorter average interreinforcement interval (col. v) divided by the sum of the rates of responding on both keys (col. vi). There is no consistent relationship between the value of the VI schedules and the total absolute rate of responding (col. vi). The relative rates of responding (col. vii), however, increase as the average interreinforcement intervals of the VI schedules decrease. There is a single exception to this rule; the data of Pigeon #4 show a reversal, with the lowest choice proportion occurring on the *conc* VI 60-sec VI 120-sec schedule.

The variation in relative response rate is accompanied by a corresponding change in the relative rate of reinforcement for responses on the two schedules. These observed relative rates of reinforcement (the proportion of reinforcements for the VI schedule with the shorter average interreinforcement interval) are shown in col. viii. The deviations of the relative rates of responding from these observed rates of reinforcement are shown in col. ix. The average of the absolute deviations of relative response rates from the observed relative rates of reinforcement (*i.e.*, the col. ix average) is 0.04, ranging from 0.00 on the *conc* VI 6-sec VI 12-sec schedule to 0.07 on the *conc* VI 600-sec VI 1200-sec schedule.

While the basic *conc* VI 6-sec VI 12-sec schedule gave almost exclusive responding on the VI 6-sec schedule, the forced-choice procedure, Table 1B, produced approximate matching of the relative response rate to the scheduled and observed rates of reinforcement.

The data of individual subjects from the schedules in which the COD duration was proportional to the average interreinforcement interval of the VI schedule are given in Table 1C. The averaged data from those two

schedules and the three basic schedules are shown in Figure 1. The closed circles represent the mean relative response rates from the three basic schedules, the open circles represent the mean relative response rates from the schedules in which the COD duration was proportional to the average interreinforcement interval of the VI schedule, and the number next to each circle is the average relative rate of reinforcement observed on that schedule. When the COD was decreased from 1.5 sec to 0.15 sec in the *conc* VI 6-sec VI 12-sec schedule, the relative response rate maintained by the VI 6-sec schedule dropped from 0.98 to 0.58. Increasing the COD from 1.5 to 15 sec in the *conc* VI 600-sec VI 1200-sec pair produced an increase in the average relative response rate from 0.61 to 0.70.

DISCUSSION

The results from the three basic schedules suggest that choice proportions were not determined exclusively by the scheduled relative rate of reinforcement, which was 0.67 in all

Fig. 1. Proportion of choice responses for the VI schedule with the shorter average interreinforcement interval as a function of the VI schedules in effect, averaged over subjects. The filled circles represent the three basic schedules in which the COD duration was 1.5 sec. The open circles represent the schedules in which the COD duration was proportional to the average interreinforcement interval of the VI schedules: *conc* VI 600-sec VI 1200-sec with a COD of 15 sec, *conc* VI 60-sec VI 120-sec with a COD of 1.5 sec, and *conc* VI 6-sec VI 12-sec with a COD of 0.15 sec. The numbers next to the circles give the average rate of reinforcement observed for that schedule.

Table 1

Absolute response rates on each key for each pigeon on each schedule, total response rates (responses/min) and relative response rate on the VI schedule with the shorter average interreinforcement interval (IRI). The data are the means of the last three sessions of each condition. The relative rate of reinforcement obtained for responses on the VI schedule with the shorter average interreinforcement intervals and the absolute deviations of the relative response rates from the relative rates of reinforcement are also shown. Column averages are shown for vi through ix. 1A contains the data from the three basic schedules, in which the COD was always 1.5 sec; 1B shows the results for the forced-choice procedure, and 1C shows the results from the schedules in which the COD was proportional to the average interreinforcement interval of the VI schedules. All VI and COD values are in seconds.

<i>i</i>	<i>ii</i>	<i>iii</i>	<i>iv</i>	<i>v</i>	<i>vi</i>	<i>vii</i>	<i>viii</i>	<i>ix</i>	
<i>Schedule</i>	<i>COD</i>	<i>Sub-ject</i>	<i>Response rate:</i>			<i>Relative</i>		<i>Absolute Devia-tions (viii-vii)</i>	
			<i>VI with longer mean IRI</i>	<i>VI with shorter mean IRI</i>	<i>Total</i>	<i>Resp. rates</i>	<i>Reinf. rates</i>		
A. BASIC SCHEDULES									
1) VI 600-sec VI 1200-sec	1.5 sec	1	19.0	23.1	42.1	0.55	0.60	0.05	
		2	22.7	42.3	65.0	0.63	0.67	0.04	
		3	39.2	52.6	91.8	0.57	0.65	0.08	
		4	18.5	45.4	63.9	0.72	0.68	0.04	
		5	22.7	29.8	52.5	0.57	0.64	0.07	
		6	25.6	42.9	68.5	0.62	0.71	0.09	
		7	26.7	36.4	63.1	0.58	0.69	0.11	
	Column	Av.			63.8	0.61	0.66	0.07	
	2) VI 60-sec VI 120-sec	1.5 sec	1	32.7	51.6	84.3	0.61	0.68	0.07
			2	36.6	74.9	111.5	0.67	0.65	0.02
3			26.3	49.8	76.1	0.65	0.70	0.05	
4			15.9	25.3	41.2	0.60	0.68	0.08	
5			24.2	45.0	69.2	0.65	0.69	0.04	
6			35.2	67.1	102.3	0.66	0.71	0.05	
7			21.8	56.8	78.6	0.72	0.71	0.01	
Column		Av.			80.5	0.66	0.69	0.05	
3) VI 6-sec VI 12-sec	1.5 sec	1	0.0	51.3	51.3	1.00	1.00	0.00	
		2	0.0	54.4	54.4	1.00	1.00	0.00	
		3	0.0	54.2	54.2	1.00	1.00	0.00	
		4	14.2	66.7	80.9	0.82	0.83	0.01	
		5	0.0	83.4	83.4	1.00	1.00	0.00	
		6	0.0	38.6	38.6	1.00	1.00	0.00	
		7	0.0	60.0	60.0	1.00	1.00	0.00	
	Column	Av.			61.2	0.98	0.98	0.00	
B. FORCED-CHOICE									
VI 6-sec VI 12-sec	1.5 sec	4	20.7	43.5	64.2	0.68	0.69	0.01	
		5	30.0	59.1	89.1	0.66	0.68	0.02	
		6	17.7	36.8	54.5	0.69	0.69	0.00	
		7	45.5	35.6	81.1	0.56	0.67	0.11	
	Column	Av.			72.2	0.65	0.68	0.04	
C. COD VARIATION									
1) VI 600-sec VI 1200-sec	15.00 sec	4	23.4	27.2	50.6	0.55	0.67	0.12	
		5	12.0	35.1	47.1	0.75	0.72	0.03	
		6	23.7	50.7	74.4	0.68	0.68	0.00	
		7	12.7	52.3	65.0	0.80	0.68	0.12	
	Column	Av.			59.3	0.70	0.69	0.07	
2) VI 6-sec VI 12-sec	0.15 sec	4	22.7	28.6	51.3	0.56	0.69	0.13	
		5	28.8	56.3	85.1	0.66	0.69	0.03	
		6	31.2	49.8	81.0	0.61	0.69	0.08	
		7	23.7	23.4	47.1	0.50	0.62	0.12	
	Column	Av.			66.1	0.58	0.67	0.09	

three schedules. Instead, choice proportions increased as the average interreinforcement interval of the VI schedules decreased. This is consistent in principle with Fantino's (1969*a, b*) finding that choice proportions increase with an increase in the accessibility of the reinforcer in concurrent-chains schedules. Unlike Fantino's results, however, the present results are confounded by the fact that the changes in relative response rate produced a corresponding change in the relative rate of reinforcement. Since the choice proportions in the basic schedules did match the observed relative rate of reinforcement (even though they deviated greatly from the scheduled rates) these data are consistent with the matching formulation developed by Herrnstein (1961, 1970). These data also support Squires and Fantino's (1971) model, which requires matching in simple concurrent schedules, though not in concurrent-chains schedules. While the observed relative rates of reinforcement are important, since only they make direct contact with the organism's behavior, the relation between choice and the scheduled rates are also of interest, since only the latter may be stated *a priori* in terms of the scheduled distribution of interreinforcement intervals, the COD, and other variables directly under the experimenter's control. The observed rates of reinforcement resulting from the organism's interaction with the effects of these scheduled variables cannot be specified before an experiment is conducted. Only the scheduled rates, therefore, can be utilized for *a priori* choice predictions.

The present variations in relative response rates when the COD was proportional to the VI value cannot be explained by changes in the observed relative rates of reinforcement, because in those schedules the mean observed relative rate of reinforcement remained approximately constant (0.67 to 0.69), while the mean relative response rates on these schedules varied from 0.58 to 0.70. The relationship of the COD duration to the average interreinforcement interval of the VI schedule appears to be a crucial variable in determining choice proportions. This finding is consistent with the results of previous investigators who have found that increasing the COD will result in an increase in the relative rate of responding maintained by the preferred VI schedule (Shull and Pliskoff, 1967) or in the relative amount of time spent in the presence of the

stimuli associated with the preferred schedule (Brownstein and Pliskoff, 1968). Variation of the COD does not affect choice proportions when a forced-choice procedure is used. Stubbs and Pliskoff (1969) obtained approximately constant choice proportions over a wide range of COD values (2 to 32 sec) when the relative number of reinforcements for responding on the two schedules was fixed. The one forced-choice schedule used in the present experiment produced similar results. The insensitivity of choice proportions to COD duration in the forced-choice procedure may be attributed to the fact that in such schedules the failure to changeover to the non-preferred schedule frequently is penalized by a decrease in overall rate of reinforcement; responses that occur on the preferred key after a reinforcement has been scheduled for a response on the non-preferred key, for example, delay not only that reinforcement but the next reinforcement associated with the preferred key as well. Further, the delay is proportional to the length of time during which responding on the preferred key continues. At the extreme, exclusive responding on one key would postpone all reinforcements indefinitely. This relationship holds regardless of the COD duration. In regular concurrent variable-interval schedules, on the other hand, the advantage of frequent changeovers does depend upon the COD. When the COD is of brief duration, frequent changeovers will increase the overall rate of reinforcement; when the COD is of long duration, the advantage of changeovers is diminished.

As a whole, the data in this experiment are largely consistent with the matching principle. The case for consistency is perhaps strengthened by the fact that the manipulation of both VI and COD value was rather extreme and was frankly intended to produce large deviations from matching.

EXPERIMENT 2: TESTING THE GENERALITY OF THE MATCHING RELATION BETWEEN CHOICE AND THE DURATION OF THE REINFORCER

METHOD

Subjects

Six adult male King pigeons were maintained at 80% of their free-feeding body

weights; all were experimentally naive at the beginning of the experiment.

Apparatus

The same as in Experiment 1.

Procedure

Responses on each key were reinforced according to identical VI schedules: *conc* VI 10-sec VI 10-sec, *conc* VI 60-sec VI 60-sec, or *conc* VI 600-sec VI 600-sec. The pigeons were exposed to the three pairs of concurrent schedules in different orders. A COD of 1.5 sec was used throughout. In each of the schedules, the duration of the reinforcer for responses to one key was 1.5 sec and for the other it was 6 sec. All other procedural features were the same as in Experiment 1. After each pigeon had been exposed to each of the three different pairs of *conc* VI schedules, the forced-choice procedure, described in Experiment 1, was instituted with *conc* VI 10-sec schedules.

RESULTS

Table 2A, col. vi, shows that choice proportions increased as the average interreinforcement interval of the VI schedules decreased. Column vii shows that the relative number of reinforcers was also a function of VI schedules; the relative number of reinforcers for responses on the preferred key increased as the average interreinforcement interval of the VI schedules decreased. Thus, the organism produced more of the reinforcers of longer duration. A statistic that takes this into account is Neuringer's (1967) measure in terms of "relative access to reinforcement", *i.e.*, the proportion of reinforcer time provided by a schedule. Reinforcer time for a given schedule is the number of reinforcements observed on that schedule multiplied by the duration of each reinforcer. Proportion of reinforcer time is then the reinforcer time provided by one schedule divided by the total reinforcer time provided by both schedules combined. Column viii of Table 2 shows that proportion of reinforcer time increases as the average interreinforcement interval of the VI schedules decreases. The deviations of the choice proportions from the proportion of reinforcer time are shown in col. ix. The average of the individual deviations is 0.11 and the deviations are particularly large with either VI 60-sec or VI 600-sec schedules. Figure 2 shows relative re-

sponse rates as a function of the proportion of reinforcer time. The horizontal line at 0.80 represents the matching of relative response rates to the scheduled proportion of reinforcer time. The diagonal line represents the matching of relative response rates to observed proportion of reinforcer time. The data points do not correspond to either function.

The data from the forced-choice procedure are shown in Table 2B and Figure 2 (open circles). The choice proportions for all subjects are lower than the obtained proportion of reinforcer time. The average deviation is again large (0.14).

DISCUSSION

Choice proportions matched neither the scheduled proportion of reinforcer time nor the observed proportion of reinforcer time (Figure 2). These results ostensibly are inconsistent with those of previous experimenters who have obtained matching to the relative duration of the reinforcer with simple concurrent variable-interval schedules (Catania, 1963; Brownstein, 1971). Catania, however, found matching in just two of three subjects; moreover, his study included only one comparison (3 sec and 6 sec) other than an equality point (4.5 sec for both schedules). The main point of his study was not to demonstrate that choice proportions generally matched the relative duration of the reinforcer but instead to show that choice procedures were more sensitive to experimental manipulations than single response procedures. Brownstein, using a procedure with response-independent reinforcement, found matching for two pairs of reinforcer duration (2 and 4 sec, and 1.5 and 4.5 sec) in addition to an equality point (3 sec for both schedules). While procedural differences might account for the matching found by Brownstein and the clear deviation from matching found in this study, the present authors favor an explanation in terms of COD duration. Each of Brownstein's three pigeons was exposed to a different COD duration, the value chosen because it had been found to produce matching to relative rates of reinforcement in that pigeon in a prior study (Brownstein and Pliskoff, 1968). This COD duration ranged from 2 sec for one bird to 7.5 sec for another, whereas the COD in the present experiment was always 1.5 sec. The results of Experiment 1 showed that CODs of longer

Table 2

Absolute and relative response rates for each pigeon on each schedule, the relative number of the longer duration reinforcers and the proportion of reinforcer time observed for the schedule associated with the longer reinforcer duration. The data are means of the last three sessions on each condition. The deviations of the relative response rates from the proportion of reinforcer time (col. viii-col. vi, except for the average deviations, which are column averages) are given in col. ix. 2A gives the results of the three basic schedules, and 2B gives the results from the forced-choice procedure.

<i>i</i>	<i>ii</i>	<i>iii</i>	<i>iv</i>	<i>v</i>	<i>vi</i>	<i>vii</i>	<i>viii</i>	<i>ix</i>
<i>Schedule</i>	<i>Subject</i>	<i>Response rate:</i>			<i>Relative</i>			<i>Deviations (viii-vi)</i>
		<i>1.5-sec reinf.</i>	<i>6-sec reinf.</i>	<i>Total</i>	<i>Resp. rates</i>	<i># reinf.</i>	<i>Reinf. time</i>	
A. BASIC SCHEDULES								
1) VI 600-sec	A	23.0	52.7	75.7	0.70	0.50	0.80	0.10
	B	35.0	60.3	95.3	0.63	0.51	0.81	0.18
	C	22.0	70.0	92.0	0.76	0.49	0.79	0.03
	D	59.6	66.0	125.6	0.53	0.51	0.81	0.28
	E	30.2	58.8	89.0	0.66	0.50	0.80	0.14
	F	29.1	55.1	84.2	0.65	0.50	0.80	0.15
	Column	Av.			93.6	0.66	0.50	0.80
2) VI 60-sec	A	43.7	81.3	125.0	0.65	0.57	0.84	0.19
	B	35.1	81.4	116.5	0.70	0.60	0.86	0.16
	C	21.5	61.7	83.2	0.74	0.50	0.80	0.06
	D	35.7	60.8	96.5	0.63	0.52	0.82	0.19
	E	14.1	52.6	66.7	0.79	0.68	0.88	0.11
	F	7.2	24.6	31.8	0.77	0.64	0.88	0.11
	Column	Av.			86.6	0.71	0.59	0.85
3) VI 10-sec	A	1.7	54.2	55.9	0.97	0.94	0.98	0.01
	B	9.9	51.7	61.6	0.84	0.79	0.94	0.10
	C	0.3	35.7	36.0	0.99	0.99	0.99	0.00
	D	5.2	55.3	60.5	0.91	0.93	0.98	0.07
	E	4.3	71.4	75.7	0.94	0.83	0.95	0.01
	F	3.6	37.1	40.7	0.91	0.84	0.95	0.04
	Column	Av.			55.1	0.93	0.87	0.97
B. FORCED-CHOICE								
VI 10-sec	A	39.8	57.2	97.0	0.59	0.48	0.79	0.20
	B	26.5	47.2	73.7	0.64	0.48	0.79	0.15
	C	15.9	41.2	57.1	0.72	0.49	0.79	0.07
	D	27.3	46.1	73.4	0.63	0.47	0.78	0.15
	E	22.2	65.1	87.3	0.74	0.47	0.78	0.04
	F	18.3	23.0	41.3	0.56	0.48	0.79	0.23
	Column	Av.			71.6	0.65	0.48	0.79

duration produce larger choice proportions. It is likely, therefore, that matching would also be obtained with the present schedules if an appropriately longer COD were used, or that Brownstein would have obtained deviations from matching with shorter (or longer) CODs.

Several investigators have reported data supporting Premack's (1965) suggestion that rate and amount of reinforcement are interchangeable in their effects upon choice. These studies (Neuringer, 1967; Rachlin and Baum, 1969; Ten Eyck, 1970) did not use simple concurrent schedules, however. In any case, the present studies indicate that rate and duration of re-

inforcement are not interchangeable; rate of reinforcement affects choice in a directly proportional manner (Experiment 1), whereas the duration of the reinforcer does not. Todorov (1972) reported a study of concurrent schedules in which rate and duration were covaried. The two variables were not interchangeable; rate of reinforcement had a more direct effect on choice than did duration of the reinforcer. Thus, Todorov's results and those of the present experiment are compatible in suggesting that rate of reinforcement has a more potent effect upon choice than does reinforcer duration. In particular, the present experi-

Fig. 2. Proportion of choice responses for the longer reinforcement duration as a function of the proportion of reinforcer time provided by those responses. The proportion of reinforcer time is the number of reinforcements obtained for responses to a key multiplied by the duration of those reinforcers, divided by the sum of the number of reinforcements multiplied by their durations for both keys. If choice proportions matched proportion of reinforcer time, the points should fall along the diagonal. If choice proportions matched the relative duration of reinforcer, the points should fall along the horizontal line at 0.8. Neither line provides an adequate description of the choice proportions however.

ments indicate that relative rates of responding match relative rates of reinforcement but undermatch relative reinforcer duration.

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