

CHOICE AND RATE OF REINFORCEMENT^{1,2}

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Pigeons' responses in the presence of two concurrently available (initial-link) stimuli produced one of two different (terminal-link) stimuli. The rate of reinforcement in the presence of one terminal-link stimulus was three times that of the other. Three different pairs of identical but independent variable-interval schedules controlled entry into the terminal links. When the intermediate pair was in effect, the pigeons distributed their (choice) responses in the presence of the concurrently available stimuli of the initial links in the same proportion as reinforcements were distributed in the mutually exclusive terminal links. This finding was consistent with those of earlier studies. When either the pair of larger or smaller variable-interval schedules was in effect, however, proportions of choice responses did not match proportions of reinforcements. In addition, matching was not obtained when entry into the terminal links was controlled by unequal variable-interval schedules. A formulation consistent with extant data states that choice behavior is dependent upon the amount of reduction in the expected time to primary reinforcement, as signified by entry into one terminal link, relative to the amount of reduction in expected time to reinforcement signified by entry into the other terminal link.

Many of the variables controlling an organism's choice behavior have been studied with concurrent chain schedules of reinforcement (*e.g.*, Autor, 1960; Herrnstein, 1964*a, b*; Fantino, 1967, 1968; Fantino and Herrnstein, 1968; Pliskoff and Hawkins, 1967; Rachlin, 1967; Reynolds, 1963). In this procedure, the organism responds on two concurrently available keys, each of which is illuminated by the stimulus associated with the initial link of one of the chains. Responses on each key occasionally produce the stimulus for the terminal link of the chain on that key. Responses in the presence of either of the mutually exclusive terminal-link stimuli are reinforced with food. The independent variable has generally involved some difference in the conditions arranged during the terminal links. The dependent variable is the measurement of choice: the distribution of responses in the initial, concurrently presented links of the chain.

One of the more interesting findings in the literature on choice is that of Autor (1960) and

Herrnstein (1964*a*), who showed that the organism distributes its responses during the initial links in the same proportion as reinforcements are distributed in the terminal links; *i.e.*, the organism matches proportions of responses to proportions of reinforcements. For example, the rate (in reinforcements per minute) at which reinforcement is obtained in the terminal link of the chain associated with the left key may be three times greater than the rate of reinforcement in the terminal link of the chain associated with the right key. In this case, the organism emits three times as many responses on the left key as on the right key during the concurrently presented initial links of the two chains.

This formulation may be represented by a simple mathematical equation. Let R_L and R_R represent the number of responses emitted during the initial links of the left and right keys respectively; let t_L and t_R represent the expected time, in minutes, required to obtain reinforcement, as calculated from the onset of the terminal links of the left and right keys respectively. This model states that

$$\frac{R_L}{R_L + R_R} = \frac{\frac{1}{t_L}}{\frac{1}{t_L} + \frac{1}{t_R}} \quad (1)$$

¹This paper is dedicated to B. F. Skinner in his sixty-fifth year.

²This research was supported by NSF Grant GB-6659 to the University of California, San Diego. Reprints may be obtained from the author, Department of Psychology, University of California, San Diego, P.O. Box 109, La Jolla, California 92037.

An implication of equation (1) is that choice, *i.e.*, the distribution of responses in the initial links represented by the left side of the equation, is independent of the expected time required to reach the terminal links. Intuitively, this does not seem plausible: a constant difference between t_L and t_R should be less influential in affecting choice, the greater the time required to reach the terminal links. For example, if the first response on either key produces the stimulus of the associated terminal link, a stimulus associated with a t_L of 10 sec should be strongly preferred to one associated with a t_R of 20 sec; preference should be negligible, however, if an hour's responding is required before these stimuli may be obtained.

Despite this possible shortcoming, equation (1) has been successful in providing reasonably close approximations to all of the relevant published data. This may be due to the widespread use of variable-interval (VI) 1-min schedules in the initial links. With much larger or smaller VIs, however, equation (1) may not hold. In other words, the generality of equation (1) has not been examined. There is, however, an alternative model that has different properties, is consistent with the earlier work, and is empirically distinguishable from equation (1). This formulation stipulates that the critical variable determining choice is the amount of reduction in expected time to primary reinforcement signified by entry into one terminal link relative to the reduction in expected time to reinforcement signified by entry into the other terminal link. For example, if the reduction of expected time to reinforcement is twice as great for the left terminal link as for the right, then the organism should distribute two-thirds of its choice responses to the left key. To express this more generally, one additional term is needed: T , the average time to reinforcement calculated from the onset of the initial links. This new formulation and the calculation of T can be made clearer with an example based on an experiment reported below. Responses during each of the concurrently presented initial links produce entry into the terminal links after a mean interval of 600 sec for each key. Thus, the expected time required to reach a terminal link is 300 sec. The expected times to reinforcement for the left and right terminal links (t_L and t_R) are 30 sec and 90 sec, respectively. Since the left and right terminal links are equiprobable, in this ex-

ample, T , the expected time to reinforcement, is: $300 \text{ sec} + [(1/2) \cdot (30 \text{ sec}) + (1/2) \cdot (90 \text{ sec})] = 360 \text{ sec}$. Thus, when the left terminal link is obtained, the organism is $360 - 30 = 330 \text{ sec}$ closer to reinforcement than it had been at the outset; when the right terminal link is obtained, the organism is only $360 - 90 = 270 \text{ sec}$ closer. This new formulation predicts that the organism will distribute the following proportion of its choice responses to the left: $330 / (330 + 270) = 0.55$. Thus, formulation (2) states (by definition):

$$\frac{R_L}{R_L + R_R} \begin{cases} = \frac{T - t_L}{(T - t_L) + (T - t_R)} & \text{when } t_L < T, t_R < T \\ = 1 & \text{when } t_L < T, t_R > T \\ = 0 & \text{when } t_L > T, t_R < T \end{cases} \quad (2)$$

Of course, the case in which *both* t_L and t_R are greater than T is impossible.

In the example discussed above, formulation (1) predicts that the organism will distribute the following proportion of its choice responses to the left: $1/30 / (1/30 + 1/90) = 0.75$. Indeed, equation (1) predicts 0.75 regardless of the time required to enter the terminal links. These times help determine T , which affects equation (2) only. Thus, one test that would allow a choice between these formulations is one that varied T while holding t_L and t_R constant. If the organism's choice were unaffected by this manipulation, formulation (1) would be supported. Formulation (2) would be supported if choice varied in the predicted direction. In a second test of the two models, the mean times required to enter the terminal links of the two keys are unequal. In previous studies, these times have been equal; when they are unequal, formulations (1) and (2) generally make different predictions.

The predictions made by these formulations are shown in Fig. 1 for the terminal-link values used in the present study (VI 30-sec and VI 90-sec). Formulation (1) always predicts a choice proportion of 0.75; it should be added, however, that neither Autor (1960) nor Herrnstein (1964a) stated whether or not formulation (1) applies when the initial link schedules are different. Figure 1 suggests values of the initial-link VIs that would permit straightforward experimental tests to determine whether formulation (1) or (2) provides a better description of choice. The present study examined this question.

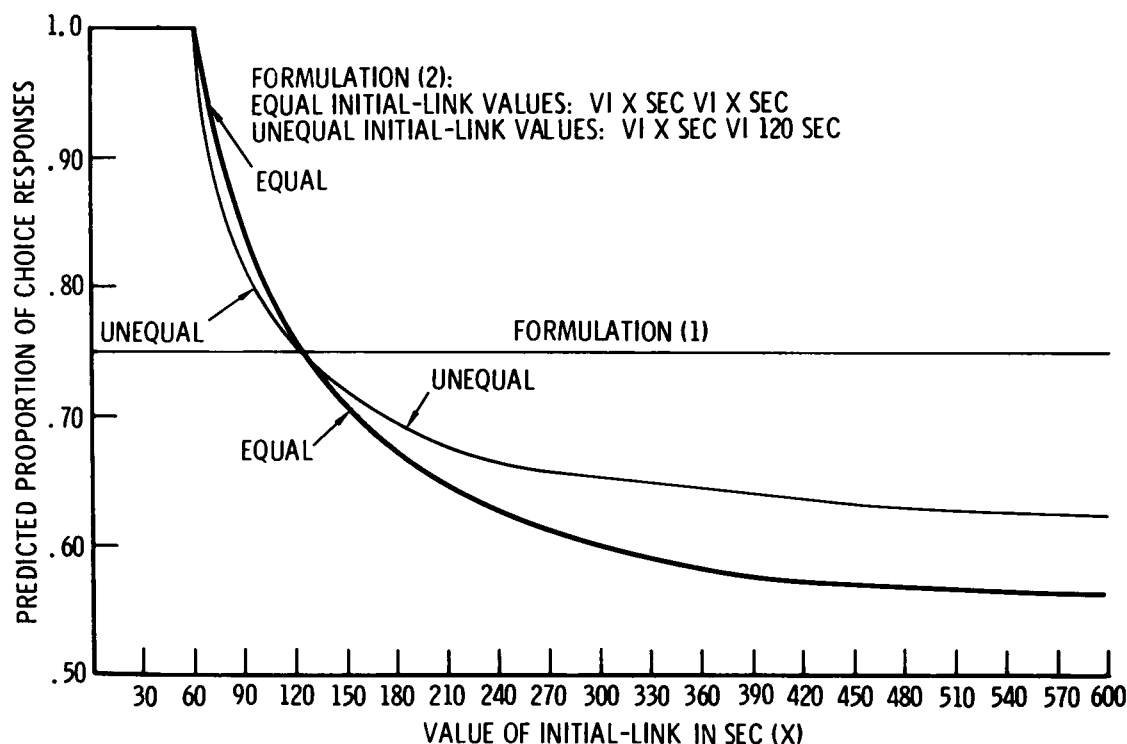


Fig. 1. The predictions made by formulations (1) and (2) for the terminal-link values used in the present study (VI 30-sec and VI 90-sec). The required proportions of choice responses to the key with VI 30-sec in the terminal link are plotted against different initial-link values. In the case of unequal initial-link values, the VI of the initial link leading to the VI 30-sec is varied (VI X-sec) along the abscissa while the VI of the initial link leading to the VI 90-sec is always VI 120-sec. In the case of equal initial links, of course, the VI values covary.

METHOD

Subjects

Six adult male White Carneaux pigeons were maintained at approximately 80% of their body weights measured while they had free access to grain. They were experimentally naive at the start of the experiment.

Apparatus

The experimental chamber was a modified picnic icebox (Ferster and Skinner, 1957) containing a solenoid-operated grain hopper, two 6-w lamps for general illumination and two translucent response keys 3 in. (7.6 cm) apart, mounted 9 in. (22.9 cm) above the floor. The right key was transilluminated by either a white or red light, the left key by either a white or green light. Transillumination was accomplished by stimulus lights mounted behind the response keys (Westinghouse D18, C-7-1/2 Christmas bulbs). A minimum force of 10 g (0.01 N) was required to operate each response

key. Each response produced auditory feedback by operating a 110-v ac relay. Standard scheduling and recording equipment was located in an adjacent room.

Procedure

The concurrent chains procedure is schematized in Fig. 2. As indicated, VI schedules³ controlled access to the stimuli of the terminal links. When such access was scheduled by

³The nominal interreinforcement intervals (in sec) for each of the VI tapes used in the present study are listed below. The intervals occurred in the order listed for half of the sessions and in the reverse order during other sessions. VI 600-sec: 957, 120, 273, 785, 710, 752; VI 120-sec: 24, 113, 54, 56, 66, 80, 264, 195, 205, 83, 8, 146, 230, 40, 238; VI 40-sec: 38, 30, 10, 34, 12, 29, 112, 108, 25, 10, 121, 60, 22, 20, 25, 20, 9, 17, 55, 30, 33, 49, 20, 113, 8, 44, 9, 20, 7, 37, 10, 70, 63, 10, 9, 16, 38, 83, 8, 20, 25, 14, 150, 32, 78; VI 90-sec: 60, 85, 143, 45, 200, 95, 57, 16, 143, 90, 51, 149, 107, 22, 326, 30, 31, 56, 12, 65; VI 30-sec: 38, 32, 9, 22, 30, 5, 62, 7, 24, 24, 15, 16, 12, 65, 8, 48, 17, 34, 44, 6, 24, 91, 84, 72, 32, 20, 8, 9, 12, 22.

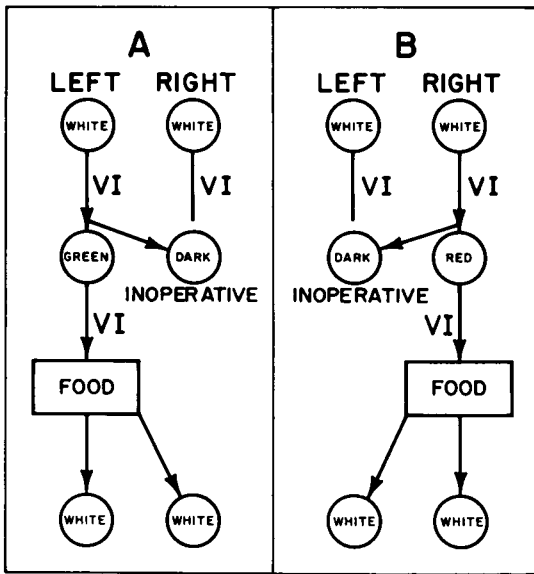


Fig. 2. Pictorial representation of the experimental procedure. Figure IIA indicates the sequence of events when responses on the left key were reinforced. Figure IIB represents the analogous sequence on the right key.

either VI programmer, it stopped operating, but the other VI programmer continued to operate. The next response on the appropriate key produced the terminal stimulus associated with that key and two additional events: (1) the VI programmer associated with the other key stopped operating; (2) illumination was removed from the other key, which became inoperative. Pecks in the presence of the terminal stimuli produced food according to different VI schedules. After food reinforcement, the initial links were reinstated. Pigeons 1 to 4 were first studied with a *chain* VI 30-sec VI 90-sec schedule on the left key and a *chain* VI 90-sec VI 30-sec schedule on the right key. After this phase, each of the six pigeons was studied with equal-valued VI schedules associated with the initial links. Three pairs of VI values were selected: *concurrent* VI 40-sec VI 40-sec, *concurrent* VI 120-sec VI 120-sec, and *concurrent* VI 600-sec VI 600-sec. These values were selected so that equation (2) would predict choice proportions greater than those predicted by equation (1) for one condition (VI 40-sec VI 40-sec), less than (1) for another condition (VI 600-sec VI 600-sec), and the same as (1) for the third condition (VI 120-sec VI 120-sec). Since there were six possible orders of exposure to these three conditions, each of the six pigeons was studied with a different order.

The schedules for the terminal links were again VI 30-sec and VI 90-sec; for each successive condition, however, these values were reversed. Thus, for the first and third conditions with equal initial links the VI 30-sec was associated with the left key; for the second condition, the VI 30-sec was associated with the right key as it had been in the first phase of the experiment, when the initial links were unequal.

Each experimental session terminated after 40 reinforcements of 4-sec access to grain. Each condition remained in effect until responding satisfied a visual stability criterion from day to day; this required about 28 daily sessions.

RESULTS

All data are averages taken from the last four sessions in each procedure. The absolute rate of responding for each pigeon on each key during the initial and terminal links is shown in Table I. These rates of responding are simply the total number of responses made on a key during the initial or terminal link, divided by the total duration of that link.

The proportion of choice responses (or the proportion of the absolute *rates* of responding that are presented in Table I, since durations of the two initial links are identical) to a key is the number of responses during the initial link of one key divided by the total number of responses during both initial links [or $\left(\frac{R_L}{R_L + R_R}\right)$ in equations (1) and (2)]. The choice proportions required by each formulation for each of the data points may be readily calculated from equations (1) and (2). For example, in the first phase of the experiment, equation (1) requires that the proportion of choice responses on the right key equal $\frac{1}{30} \text{ sec} / (\frac{1}{30} \text{ sec} + \frac{1}{90} \text{ sec}) = 0.75$, while equation (2) requires that this proportion equal $67.5 \text{ sec} / (67.5 \text{ sec} + 7.5 \text{ sec}) = 0.90$. The predictions for each of the four conditions, the actual choice proportions obtained, and the deviations of the predicted values from the obtained values are presented in Table II.

DISCUSSION

The large deviations between the choice proportions obtained in this study and those required by formulation (1) demonstrate that

Table I

Absolute rates of responding (response/min) during the initial and terminal links for each key and for each pigeon in each of the four conditions. All VI values listed are in seconds. The sub headings "VI 30 key" and "VI 90 key" indicate the schedules of the *terminal* links. The notation (L) or (R) next to each entry indicates whether the data are from the left or right key, respectively.

Pigeon	(i) Chain VI 90 VI 30 vs. Chain VI 30 VI 90				(ii) Chain VI 600 VI 30 vs. Chain VI 600 VI 90			
	Initial Link Rates		Terminal Link Rates		Initial Link Rates		Terminal Link Rates	
	VI 30 Key	VI 90 Key	VI 30 Key	VI 90 Key	VI 30 Key	VI 90 Key	VI 30 Key	VI 90 Key
1	42.4 (R)	1.4 (L)	142.2 (R)	54.5 (L)	27.6 (R)	14.1 (L)	93.2 (R)	96.8 (L)
2	44.8 (R)	0.1 (L)	59.4 (R)	45.4 (L)	31.4 (L)	24.5 (R)	76.8 (L)	59.4 (R)
3	41.5 (R)	8.5 (L)	67.5 (R)	69.0 (L)	36.1 (L)	20.8 (R)	102.3 (L)	98.3 (R)
4	36.0 (R)	0.6 (L)	57.5 (R)	56.1 (L)	27.3 (R)	15.9 (L)	78.2 (R)	61.5 (L)
5	—	—	—	—	44.7 (L)	33.4 (R)	110.8 (L)	69.3 (R)
6	—	—	—	—	36.6 (L)	32.6 (R)	79.3 (L)	96.2 (R)

Pigeon	(iii) Chain VI 120 VI 30 vs. Chain VI 120 VI 90				(iv) Chain VI 40 VI 30 vs. Chain VI 40 VI 90			
	Initial Link Rates		Terminal Link Rates		Initial Link Rates		Terminal Link Rates	
	VI 30 Key	VI 90 Key	VI 30 Key	VI 90 Key	VI 30 Key	VI 90 Key	VI 30 Key	VI 90 Key
1	37.1 (L)	12.9 (R)	95.9 (L)	85.8 (R)	45.3 (L)	3.7 (R)	95.1 (L)	124.7 (R)
2	46.9 (L)	13.6 (R)	46.3 (L)	59.1 (R)	54.3 (R)	0.1 (L)	50.8 (R)	85.9 (L)
3	53.2 (L)	8.0 (R)	96.9 (L)	83.4 (R)	74.1 (R)	0.1 (L)	89.6 (R)	87.6 (L)
4	35.1 (L)	14.5 (R)	64.4 (L)	59.5 (R)	57.2 (L)	6.8 (R)	42.1 (L)	64.8 (R)
5	67.2 (R)	2.2 (L)	70.6 (R)	88.3 (L)	76.3 (L)	3.0 (R)	68.4 (L)	87.3 (R)
6	62.4 (R)	13.6 (L)	77.0 (R)	81.5 (L)	57.3 (L)	4.9 (R)	86.3 (L)	53.0 (R)

this formulation is generally inadequate. It provides a fair approximation to the data only within an intermediate range of values. Since previous workers have found it convenient to work within this range of values, however, formulation (1) has, until now, provided a good description of choice.

A better description of choice is provided by formulation (2). In 15 of the 16 cases for which formulations (1) and (2) describe different choice proportions, (2) provides a closer fit to the obtained data. Perhaps more significant is the finding that for each of these 16 points, equation (2) accounts for the direction of the deviations from equation (1). For example, in each of the 10 cases for which formulation (2) requires a higher choice proportion than formulation (1), cols (i) and (iv) in Table IIB show that (1) underestimates these proportions; for each of the six cases in which (2) requires a lower choice proportion than (1), col (ii) in Table IIB shows that (1) overestimates these proportions. Table IIB indicates also that only for the condition described in col (iii) does formulation (1) provide even a rough approximation to the data; but this is the condition in which the choice proportions re-

quired by formulations (1) and (2) coincide precisely.

The absolute rates of responding shown in Table I reveal an additional finding of interest. The sum of the initial-link response rates on the two keys (*i.e.*, the overall rate of responding in the initial links) does not vary in a very orderly manner with the size of the VIs in the initial links. Considering the data from the conditions with equal initial links (cols ii-iv), only that for two of the six pigeons (Pigeons 3 and 4) shows a monotonic relation between absolute rate of responding and the length of the VIs. Thus, the dramatic changes in the distribution of choice responses on the two keys are not accompanied by commensurate changes in the overall rate of choice responding.

Although equation (2) provides a reasonable description of choice for every condition studied in the present experiment, some other formulation might provide an even better description, *e.g.*, with a significantly lower (absolute) mean deviation than the 0.06 associated with (2). Alternatively, it should be possible to improve the predictive accuracy of formulation (2). For example, at least one aspect of

Table II

IIA Proportion of choice responses to key providing higher rate of reinforcement in terminal link for each pigeon in each of four conditions. The average proportion for each condition and the proportions required by formulations (1) and (2) are listed below the line. All VI values listed are in seconds.

Pigeon	(i)	(ii)	(iii)	(iv)
	Chain VI 90 VI 30 vs. Chain VI 30 VI 90	Chain VI 600 VI 30 vs. Chain VI 600 VI 90	Chain VI 120 VI 30 vs. Chain VI 120 VI 90	Chain VI 40 VI 30 vs. Chain VI 40 VI 90
1	0.97	0.66	0.74	0.93
2	1.00	0.56	0.77	1.00
3	0.83	0.63	0.87	1.00
4	0.98	0.63	0.70	0.89
5	—	0.57	0.97	0.96
6	—	0.53	0.82	0.92
Av. Proportion	0.94	0.60	0.81	0.95
Model I	0.75	0.75	0.75	0.75
Model II	0.90	0.55	0.75	1.00

IIB The deviations of the choice proportions above from the proportions required by formulation (1) and (2) for each pigeon for conditions (i)-(iv). For each of the 16 points in which (1) and (2) make different predictions, the smaller deviation is shown in italics. Col (v) on each side gives the mean of the *absolute* deviations for each pigeon. The means of the absolute deviations for each condition are listed below the line.

Pigeon	Formulation (1)					Formulation (2)				
	(i)	(ii)	(iii)	(iv)	(v)	(i)	(ii)	(iii)	(iv)	(v)
1	+0.22	-0.09	-0.01	+0.18	0.12	+0.07	+0.11	-0.01	-0.07	0.06
2	+0.25	-0.19	+0.02	+0.25	0.18	+0.10	+0.01	+0.02	0	0.03
3	+0.08	-0.12	+0.12	+0.25	0.14	-0.07	+0.08	+0.12	0	0.07
4	+0.23	-0.12	-0.05	+0.14	0.14	+0.08	+0.08	-0.05	-0.11	0.08
5	—	-0.18	+0.22	+0.21	0.20	—	+0.02	+0.22	-0.04	0.09
6	—	-0.22	+0.07	+0.17	0.15	—	-0.02	+0.07	-0.08	0.06
Mean of absolute deviations	0.20	0.15	0.08	0.20	0.16	0.08	0.05	0.08	0.05	0.06

formulation (2) may help account for the present deviations and it points to a potentially desirable refinement of this model. This is the method of computing T, which is calculated from the onset of the initial links. In fact, the longer the organism responds in the initial links in any given cycle the smaller is the expected time to achieve primary reinforcement. For example, when the schedules are *chain* VI 600-sec VI 30-sec on the left and *chain* VI 600-sec VI 90-sec on the right, T, as presently calculated, is 6 min. As the elapsed time in the initial link increases, however, the real expected time to primary reinforcement progressively decreases from 6 min, and occasionally approaches 1 min. The latter extreme case occurs whenever the elapsed time since the onset of the initial links approaches the value of the longest interreinforcement interval on the VI 600-sec tapes. In other words, the VIs become effectively smaller the more time that has passed since the onset of the initial links. It is

conceivable that the organism's choice behavior reflects these changes in the expected time to primary reinforcement. If so, its choice proportions *within* an exposure to the initial links should show the same effects as occur when smaller VIs are used, namely, more responding in the initial link of the key with the higher rate of reinforcement in the terminal link. Alternatively, the organism's choice behavior may not reflect these more molecular dynamics of the reinforcement parameters. Although an additional experiment would be required to decide this question adequately, the analysis has a clear implication for the deviations obtained in the present experiment. In particular, it requires that the organism's choice proportions should be somewhat greater than those predicted by formulation (2). In other words, the deviations from (2), in Table IIB, should be positive. This is impossible, of course, for the six data points in col (iv) because for these points formulation (2) requires

a proportion of 1.00. For 12 of the remaining 16 data points the deviations are indeed positive. This support for the analysis is sufficiently suggestive to warrant further experimentation.

The conditions for which formulations (1) and (2) make identical predictions may be specified more rigorously by setting them equal to one another. Hence, for $t_L < T$ and $t_R < T$:

$$\frac{T - t_L}{(T - t_L) + (T - t_R)} = \frac{1}{\frac{1}{t_L} + \frac{1}{t_R}};$$

$$(T - t_L)(t_R + t_L) = t_R(T - t_L) + t_R(T - t_R);$$

$$T = \frac{t_L^2 - t_R^2}{t_L - t_R};$$

$$0 = (t_L - t_R)(t_L + t_R - T)$$

Thus, there are two solutions:

$$t_L = t_R$$

$$\text{and } T = t_L + t_R$$

When either of these conditions is met, formulations (1) and (2) make identical predictions. For example, whenever the terminal links are equal ($t_L = t_R$) both formulations require choice proportions of 0.50. This implication appears somewhat implausible for the case of unequal initial links. With grossly unequal initial links and small but equal terminal links, for example, a higher rate of responding might be expected in the initial link that provides more frequent access to its terminal link. If this were so, refinement of formulation (2) would be required, at least for the case of unequal initial links. Two qualifications should be noted, however. In the first place, preference for the key with the shorter initial link might be due to the greater number of primary reinforcements it leads to; Fantino and Herrnstein (1968) showed this to be a significant variable affecting choice in concurrent-chain schedules. In the second place, the present experiment is admittedly not an adequate test of the generality of formulation (2) with unequal initial links. Indeed, only one data point in the present experiment employed unequal initial links. The present experiment does show that formulation (1) cannot describe choice when the initial links are unequal, whereas formulation (2) is compatible with the data thus far obtained.

The present results are germane to an important secondary question originally raised by Fantino and Herrnstein (1968). In their

study, the number of primary reinforcements obtained during each cycle of the terminal link was varied, but the rate at which these reinforcements were scheduled in the terminal links was kept constant. The proportion of choice responses in the initial link varied directly (although nonproportionally) with the number of primary reinforcements given in the terminal links. Fantino and Herrnstein noted that, in principle, their results could be explained in terms of rate, rather than number, of reinforcements by calculating rate of reinforcement over total experimental time instead of just over time during the terminal links. Although the authors presented arguments against this interpretation of their results, it remained a logical possibility. Indeed, the possibility remained that in all experiments utilizing concurrent chains the main variable controlling choice behavior was the relative rate of reinforcement integrated over total experimental time and not over the terminal links only. This possibility is clearly refuted by the results from the first condition of the present experiment. In that condition the overall rate of reinforcement was 0.50 rfts/min for each key, since the schedules were *chain* VI 30-sec VI 90-sec and *chain* VI 90-sec VI 30-sec on the left and right keys respectively. Thus, if the variable controlling choice behavior were the rate of reinforcement integrated over total experimental time, the organism should distribute about half of its initial-link responses to each key. Instead, fairly large preferences were manifest for the right terminal link. Moreover, this preference for the right terminal link occurred despite two features of the experimental design that favored the left terminal link in this condition: (1) the greater number of conditioned and primary reinforcements obtained on the left; (2) the fact that, in a choice situation, VI 30-sec schedules maintain higher rates of responding in their presence than do VI 90-sec schedules. Thus, the data strongly reject the hypothesis that rate of reinforcement calculated over total experimental time is the important variable affecting choice.

The present experiment underscores the importance of testing conclusions originally formulated with a certain range of VI schedules for VI values outside this range. This point has been made before; for example, Hearst, Koresko, and Poppen (1964) showed

that the shape of the generalization gradients obtained with VI 3-sec or VI 4-sec schedules was markedly different from the shape of gradients obtained by previous workers using only VI 1-sec schedules.

In summary, previous experiments, particularly those of Autor (1960) and Herrnstein (1964a), indicated that the proportion of responses in the initial links matches the proportion of the rates of reinforcement in the terminal links. The present results show that this is not generally true. The results do support an alternative formulation that is consistent with extant data. This formulation states that choice behavior is determined by the degree of reduction in the expected time to primary reinforcement signified by entry into one terminal link, relative to the degree of reduction signified by entry into the other terminal link.

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