REINFORCEMENT DELAY: SOME EFFECTS ON BEHAVIORAL CONTRAST

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Mark Rilling
Major professor

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ABSTRACT

REINFORCEMENT DELAY: SOME EFFECTS ON BEHAVIORAL CONTRAST

By

Ralph William Richards

Interactions among component schedules of a multiple schedule of reinforcement were examined. Specifically, the present study sought to determine if delaying reinforcement during one component of a multiple schedule would increase responding during the other component, i.e., produce behavioral contrast. Also examined was the relationship between the duration of reinforcement delay and the amount of behavioral contrast.

The 35 White Carneaux pigeons were conditioned in one of two standard operant conditioning chambers. Subjects received 20 sessions of nondelayed reinforcement on a two-component multiple schedule that had identical variable interval 1-minute schedules as the components. The training stimuli were a 555 nm. light and a white vertical line superimposed on a 555 nm. surround. For the remaining 15 sessions, subjects were assigned to one of 5 groups, with 7 subjects per group. Four of these groups received reinforcement according to the same multiple schedule as before, but with reinforcement during one component delayed for either 2.5, 5, 10, or 120 seconds. The fifth group was switched to a multiple variable interval 1-minute extinction schedule of reinforcement.

Results showed that the delaying of reinforcement during one component of a multiple schedule does produce behavioral contrast. Groups that received the various durations of reinforcement delay or even extinction during the altered component did not, however, show a statistically significant difference in the amount of behavioral contrast. In terms of theoretical implications, it was suggested that neither a reduction in reinforcement frequency or response rate during the altered component is necessary to the production or maintenance of behavioral contrast.

Approved: Mark Rilling

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REINFORCEMENT DELAY: SOME EFFECTS ON BEHAVIORAL CONTRAST

By

Ralph William Richards

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INTRODUCTION

A multiple schedule requires successive presentation of two or more independent schedules of reinforcement, each in the presence of a different exteroceptive stimulus. Much of the recent research on multiple schedules (e.g., Reynolds, 1961a; 1961b; 1961c; Reynolds & Limpo, 1968; Terrace, 1968; Weisman, 1969; 1970) has examined the frequent interactions that occur between the component schedules. An interaction occurs when an organism's behavior during one component in which reinforcement contingencies are held constant is in some way affected by a change in the reinforcement contingencies associated with _the other component_.

Behavioral contrast has been the most widely studied interaction and has been reviewed extensively by Terrace (1966a; 1971a) and Dunham (1968). Behavioral contrast occurs when the response rate during the unaltered component _increases_ and moves in a _direction away from_ the response rate during the altered component. For example, the changing of a multiple variable interval 1-min. variable interval 1-min. (multiple VI 1-min. VI 1-min.) schedule to a multiple variable interval 1-min. extinction schedule has consistently produced behavioral contrast, i.e., the response rate during the first component is higher when it is alternated with an extinction conponent than when it is alternated with another variable interval 1-min. component. Behavioral contrast is not, however, limited to the special multiple schedule that has extinction as one of its components, as it has been demonstrated in many other multiple schedules, such as multiple variable interval 1-min. variable interval 5-min. (Guttman, 1959; Terrace, 1968; Weisman, 1969), multiple fixed interval 1-min. fixed interval 3-min. (Staddon, 1969), multiple variable interval fixed ratio (Reynolds, 1961c; Thompson, 1965; Bloomfield, 1967), multiple variable interval differential reinforcement of low response rates (Bloomfield, 1967; Terrace, 1968; Weisman, 1969), and multiple variable interval differential reinforcement of other behavior (Weisman, 1970). It has also been observed when responses during one of the multiple schedule's components are punished with electric shock (Brethower & Reynolds, 1962; Terrace, 1968).

Recent research has required the rejection or modification of several theories of behavioral contrast (e.g., Reynolds, 1961a; Terrace, 1966a; 1966b; 1968). For example, the demonstration that behavioral contrast can occur without a reduction in reinforcement frequency (Brethower & Reynolds, 1962; Reynolds & Limpo, 1968; Terrace, 1968; Weisman, 1969; 1970) has led to the rejection of Reynolds' relative frequency of reinforcement hypothesis. Similarly, Terrace (1971a) has modified his earlier position following Wilkie's (1970) demonstration that the delivery of reinforcement independently of the organism's behavior during one component does not produce behavioral contrast and following the suggestion that satiation during one component would not produce behavioral contrast, given that different reinforcers were used in the two components (cf. Premack, 1969). While Terrace still, apparently, views behavioral contrast as a by-product of frustration or some other emotional responses, these emotional responses are now seen to be aroused by a reduction in response rate during one component that is produced by an inhibition of responding.

In each of the previous studies, reinforcement was delivered immediately upon completion of the schedule's requirements. Following the suggestion of several investigators (Brown & Farber, 1951; Holder, Marx, Holder, & Collier, 1957; Amsel, 1958; Renner, 1964) that delayed reinforcement elicits frustration, the present experiment examined the effects of delaying reinforcement during one component of a multiple VI 1-min. VI 1-min. schedule. Specifically, the present experiment attempted to determine if delaying reinforcement during one component would produce behavioral contrast. Also examined was the relationship between the duration of reinforcement delay and the amount of behavioral contrast.

METHOD

Subjects

The thirty-five experimentally naive, adult, female White Carneaux pigeons were maintained at approximately 80% of their free-feeding weight.

Apparatus

An Industrial Electronics Engineers in-line display cell (model 10-3723-757-L), mounted behind the right key, illuminated each of the two operant conditioning chambers (Lehigh Valley Electronics, model 1519). A minimum force of approximately 15-g. was required to operate this key; the other keys were covered with masking tape. No houselight was used, but a white pilot light was attached to the rear wall of both chambers.

During reinforcement the key light was extinguished and a light within the food aperture illuminated. Reinforcement was 2.75-sec. access to mixed grain. The timing of this interval began when the subject placed its head through the food aperture, thus, interrupting a light beam focused on a photocell.

Standard programming and recording equipment was housed in an adjacent room.

Procedure

Throughout training the key was illuminated by a 555 nm. light (S_1) or by a white vertical line superimposed on a 555 nm. surround (S_2). These stimuli were not adjusted for equal intensity. The duration of each S_1 and S_2 presentation was 30-sec., excluding reinforcement time and reinforcement delay time. The stimuli were presented in random order with the restriction that neither stimulus occur more than 3 times in succession. A timeout, during which the chamber was dark and responding nonfunctional, separated all stimulus presentations. During session 1 the timeout duration was 1-sec., while during all subsequent sessions it was 5-sec. Reinforcements set up but not collected during one component did not carry over to the next.

The pigeons were conditioned to key peck by the method of successive approximation. The shaping session terminated following 30 consecutive key pecks. Sessions 2 and 3 also terminated after 30 continuous reinforcements. During sessions 4 and 5, 30 reinforcements were delivered according to fixed ratio 10 and 20 schedules, respectively. All subjects, then, received 20 sessions (60 stimulus presentations per session) of reinforcement according to a multiple VI 1-min. VI 1-min. schedule. During all of the above sessions, there was no delay of reinforcement.

Each of the subjects was, then, assigned to one of 5 groups, with 7 subjects per group. Four of these groups received 15 additional sessions of multiple VI 1-min. VI 1-min. reinforcement; but with reinforcement during S_2 delayed for either 2.5, 5, 10, or 120-sec. During the delay period, the key light was extinguished and the pilot light on the chamber's back wall was illuminated. At the end of the delay period the pilot light was extinguished and the food magazine raised. The fifth group received 15 sessions of multiple VI 1-min. extinction training; responding to S_2 extinguished the key light for 120-sec. (according to the same VI 1-min. schedule), but no reinforcement was delivered. All subjects were reinforced for responding to S_1 as before, VI 1-min. with no reinforcement delay. Four of the subjects in each group were run in one of the conditioning chambers and the remaining subjects were run in the other chamber.

RESULTS

Figures 1-5 show the response rates to S_1 (denoted by the X's) and S_2 (denoted by the closed circles) during the last 25 sessions of training. Each figure represents one experimental group and contains the data for the 7 individual subjects as well as the group mean. To the left of the dashed vertical line are the final 10 sessions under the multiple VI 1-min. VI 1-min. schedule with no delay of reinforcement. During the 15 sessions to the right of the dashed vertical line the contingencies for S_2 responding were altered as indicated by the caption above each figure. That is, the subjects represented in Figures 1-4 continued to be reinforced on the same multiple schedule as before, but with reinforcement during S_2 delayed for either 2.5, 5, 10, or 120-sec. The subjects in Figure 5 were not reinforced for responding to S_2 during these last 15 sessions.

As shown in Figure 1 delaying reinforcement for 2.5-sec. during S_2 produced different effects on the S_2

response rates of the individual subjects. The S_2 response rates were either temporarily increased and then permanently reduced (bird 38), permanently reduced (birds 609 and 30), temporarily reduced (birds 199 and 206), or not affected (birds 2751 and 4304). The group mean evidences a temporary reduction in S_2 response rate. While the 2.5-sec. delay during S_2 was inconsistent in its effect on the S_2 rate of response, such was not the case for its effect on the S_1 rate of response. The delaying of reinforcement for 2.5-sec. during S_2 produced an increase in the S_1 response rate for all subjects and, hence, the group mean.

As with the 2.5-sec. delay, Figure 2 shows that the 5-sec. delay had not consistent effect on the S_2 response rates. The S_2 response rates either showed no change (bird (2655), a permanent increase (bird 622), a temporary decrease (birds 435 and 389), or a permanent decrease (birds 32, 2955, and 2549). In terms of S_1 responding, five subjects (birds 32, 435, 2655, 389, and 622) showed an increase in response rate. While two of the subjects (birds 2955 and 2549) showed no apparent increase in S_1 response rate, it should be noted that neither of these subjects responded at a stable rate prior to the introduction of the reinforcement delay, i.e., to the left of the dashed vertical line. The mean curve shows a temporary decrease in the S_2 response rate and a permanent increase in the S_1 response rate.

Figure 3 shows that the 10-sec. delay of reinforcement produced either a temporary (birds 466, 40, 2032, 1702, and 1794) or a permanent (birds 263 and 990) reduction in S_2 responding. Six subjects (birds 466, 2631, 2032, 1702, 990, and 1794) showed a clear increase in S_1 response rate; the remaining subject's (bird 40) S_1 response rate curve is only suggestive of an increase in the last 3 sessions (sessions 38-40). The mean S_1 and S_2 response rate curves for the 10-sec. delay group are similar to those of the 2.5 and 5-sec. delay groups as the former shows a permanent increase and the latter a temporary decrease.

From Figures 4 and 5 it is apparent that delaying reinforcement for 120-sec. is similar to nonreinforcement in that both procedures reduce S_2 responding to a near zero level. In terms of S_1 response rates, six subjects (birds 1314, 238, 35, 2518, 889, and 2748) in the 120-sec. delay group showed an increase, and all subjects in the extinction group showed an increase. Mean curves show a reduction in S_2 rate to near zero and an increase in S_1 rate.

In order to determine if the 5 groups differed in the amount of increase in S_1 response rates, the final 10 sessions were collapsed into six 3-day blocks (Table 1). Thus, the first block is the mean S_1 response rate during the last 3 sessions of the multiple VI VI without reinforcement delay. The remaining five blocks represent mean S_1 rates during the sessions where reinforcement during S_2 was either delayed or discontinued. The results of a two-way (trials by groups) analysis of variance with repeated measures on one of the factors (trials) are presented in Table 2. From this table it is quite clear that the only significant effect was the increase in S_1 response rate over sessions due to the changes in the S_2 contingencies. The groups did not differ significantly in the magnitude of the S_1 response rate increase.

Several Pearson product-moment correlations were computed to determine if the magnitude of the increase in S_1 responding could be predicted by the magnitude of the decrease in S_2 responding. The magnitude of the S_1 response rate increase was taken as: (the mean S_1 response rate calculated from sessions 23-25)--(the highest daily

S_1 response rate during sessions 26-40). The magnitude of the S_2 response rate decrease was taken as: (the mean S_2 response rate calculated from sessions 23-25)--(the lowest daily S_2 response rate during sessions 26-40). The obtained correlations for each group, as well as the overall correlation, are presented in Table 3. These correlations are small and show no consistency in even their sign.

Figures 6-8 show the rate of reinforcement during S_1 (denoted by the X's) and S_2 (denoted by the closed circles) for the subjects in the 2.5, 5, and 10-sec. reinforcement delay groups. The rate of reinforcement was computed by dividing the number of reinforcements obtained during S_1 (or S_2) by the total time that the key was illuminated by S_1 (or S_2). In these figures 3 sessions were combined to form each block. The 3 blocks of sessions to the left of the dashed vertical line were computed from the last 9 sessions of the multiple VI VI with no reinforcement delay (sessions 17-25). The 5 blocks to the right of the dashed vertical line were computed from the 15 sessions of the multiple VI VI where reinforcemnt during S_2 was delayed (sessions 26-40). As can be seen in these figures, most subjects showed little change in S_2

reinforcement rate as a result of either the 2.5, 5, or 10-sec. delay contingency. Any reductions, such as shown by birds 4304, 2955, 389, 2631, and 990, were of small magnitude. The reinforcement rates for the 120-sec. delay group are not presented since all of these subjects, except for bird 1129, showed a reduction in S_2 reinforcement frequency to almost zero.

Fig. 1.--Response rates to S_1 (x's) and S_2 (circles) over sessions. During the 10 sessions to the left of the dashed vertical line, the schedule of reinforcement was a multiple VI 1-min. VI 1-min. with no reinforcement delay. During the 15 sessions to the right of the dashed vertical line, subjects continued to be reinforced on the same multiple VI 1-min. VI 1-min. schedule, but with reinforcement during S_2 delayed for 2.5-sec.

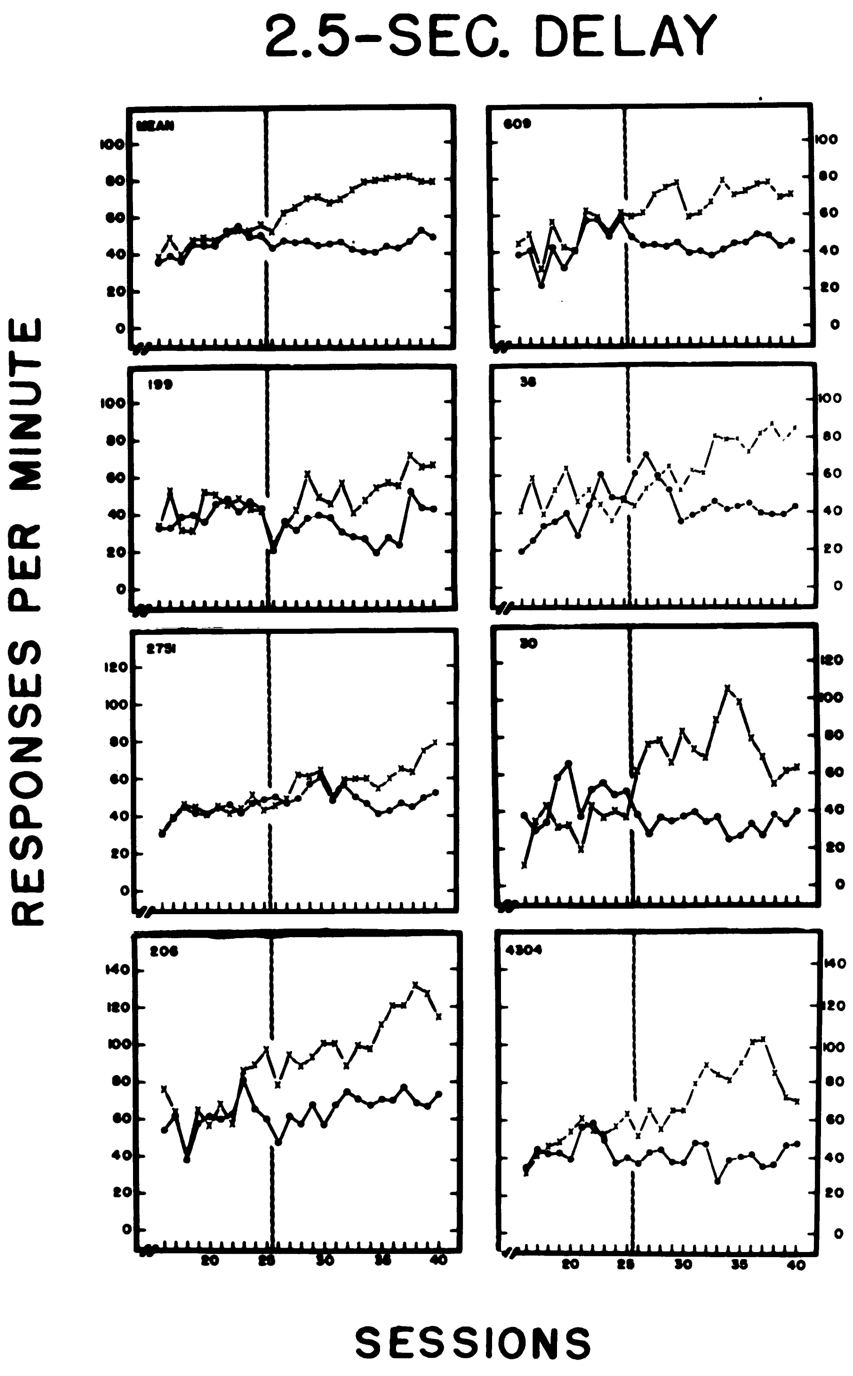
2.5-SEC. DELAY
RESPONSES PER MINUTE
SESSIONS
MEAN
609
199
38
2731
30
206
4304
0
20
40
60
80
100
120
140
20
25
30
35
40

Fig. 1

Fig. 2.--Response rates to S_1 (x's) and S_2 (circles) over sessions. During the 10 sessions to the left of the dashed vertical line, the schedule of reinforcement was a multiple VI 1-min. VI 1-min. with no reinforcement delay. During the 15 sessions to the right of the dashed vertical line, subjects continued to be reinforced on the same multiple VI 1-min. VI 1-min. schedule, but with reinforcement during S_2 delayed for 5-sec.

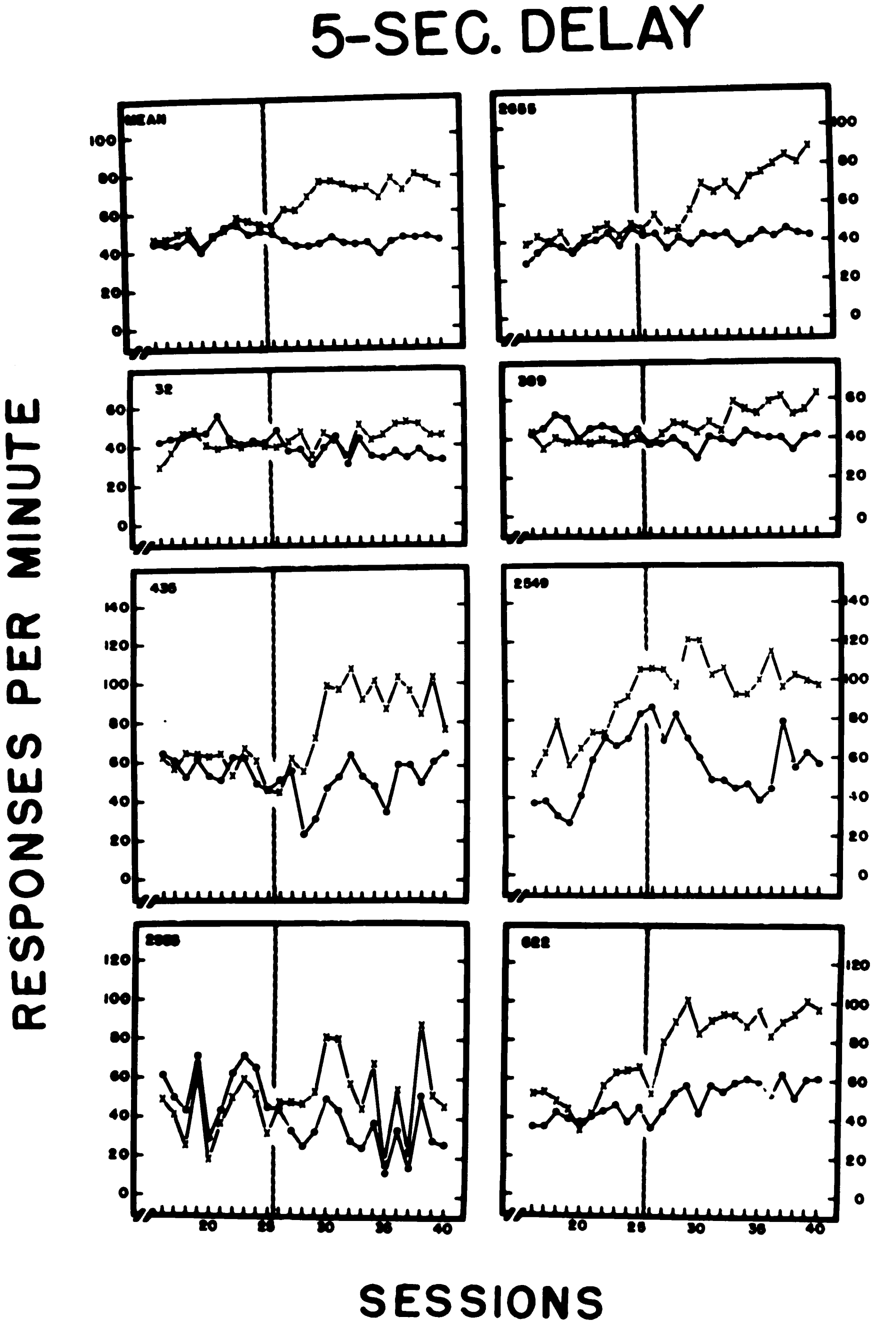
5-SEC. DELAY
RESPONSES PER MINUTE
SESSIONS
MEAN
2655
32
369
436
2549
622
0
20
40
60
80
100
120
140
25
30
35
40

Fig. 2

Fig. 3.--Response rates to S_1 (x's) and S_2 (circles) over sessions. During the 10 sessions to the left of the dashed vertical line, the schedule of reinforcement was a multiple VI 1-min. VI 1-min. with no reinforcement delay. During the 15 sessions to the right of the dashed vertical line, subjects continued to be reinforced on the same multiple VI 1-min. VI 1-min. schedule, but with reinforcement during S_2 delayed for 10-sec.

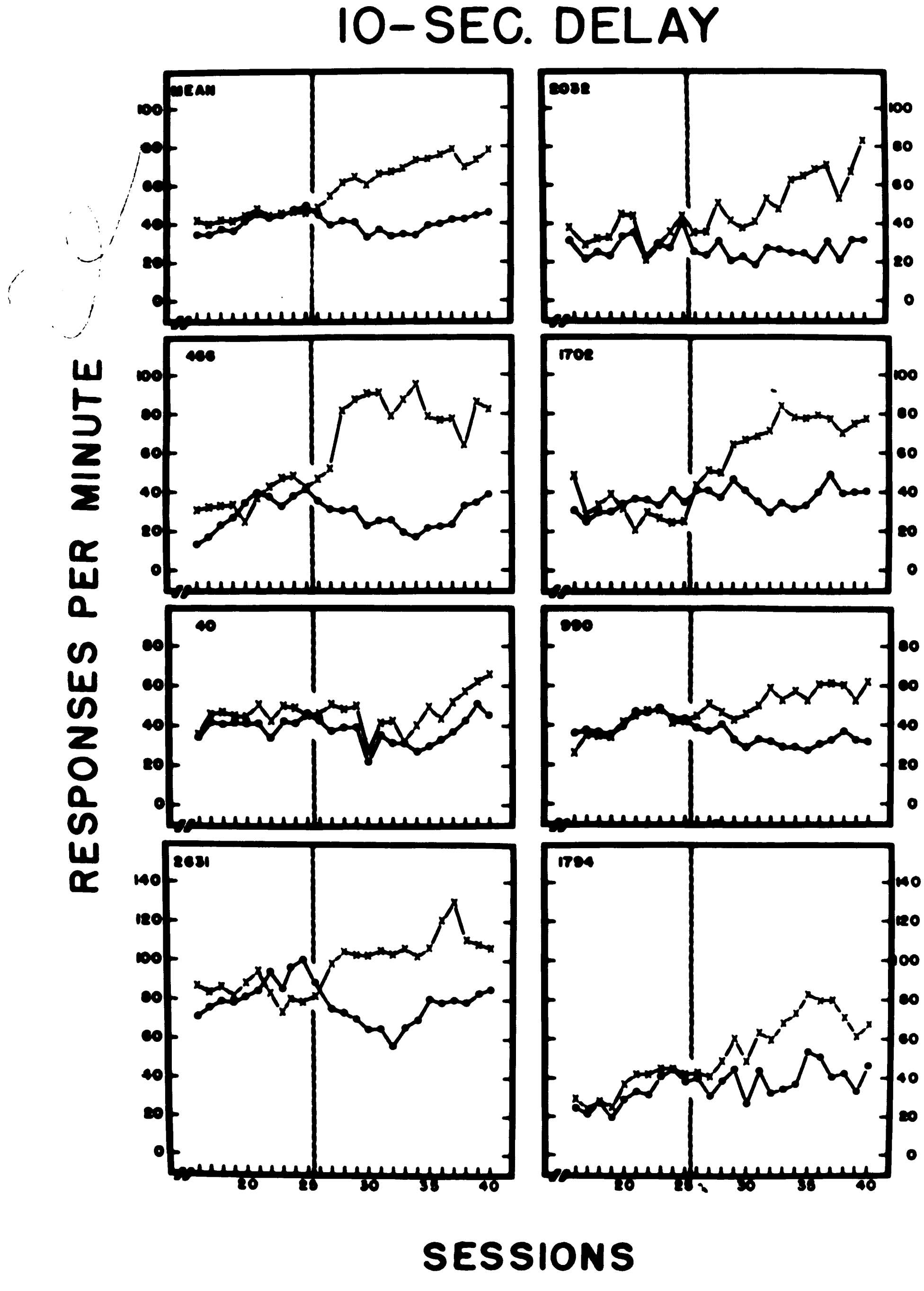
10-SEC. DELAY
MEAN
2032
466
1702
40
990
2631
1794
0
20
40
60
80
100
120
140
20
25
30
35
40
RESPONSES PER MINUTE
SESSIONS

Fig. 3

Fig. 4.--Response rates to S_1 (x's) and S_2 (circles) over sessions. During the 10 sessions to the left of the dashed vertical line, the schedule of reinforcement was a multiple VI 1-min. VI 1-min. with no reinforcement delay. During the 15 sessions to the right of the dashed vertical line, subjects continued to be reinforced on the same multiple VI 1-min. VI 1-min. schedule, but with reinforcement during S_2 delayed for 120-sec.

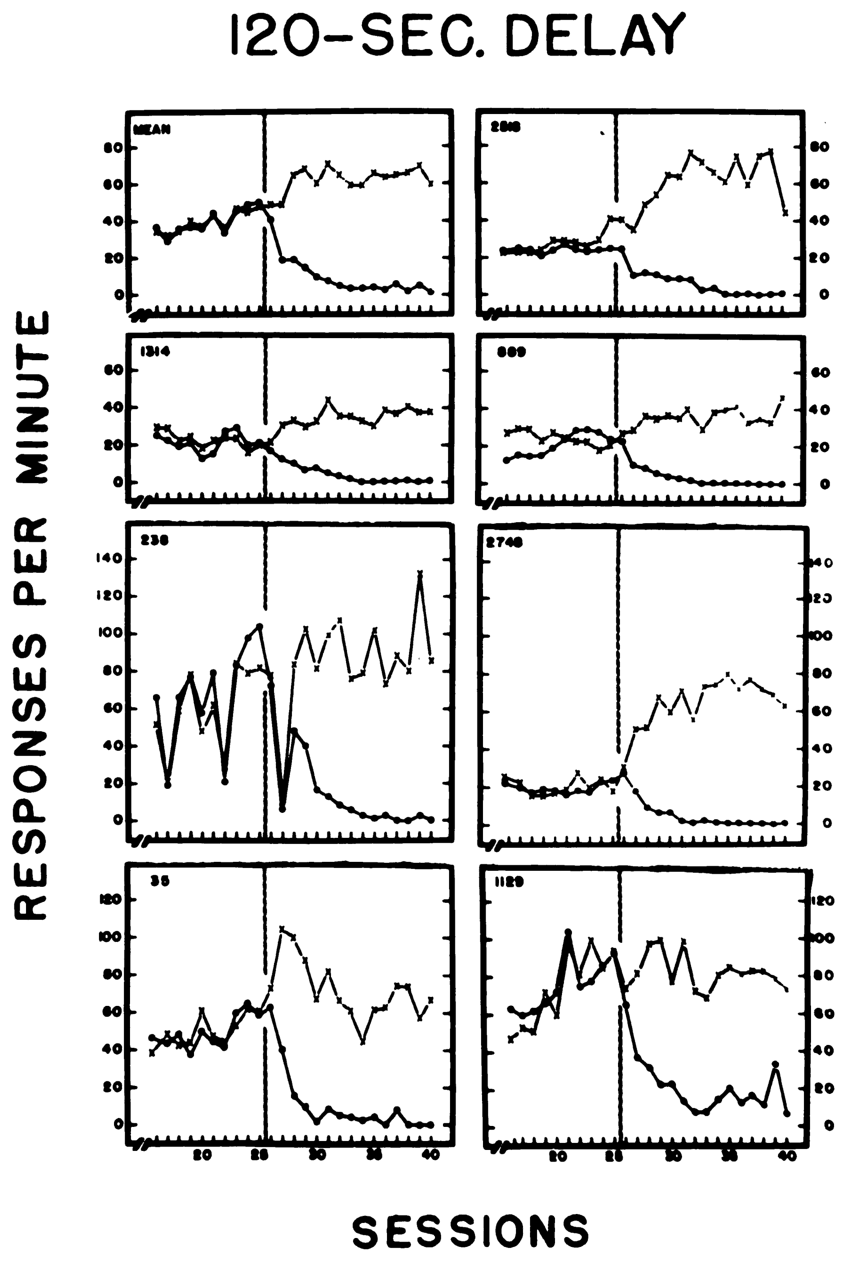
120-SEC. DELAY
RESPONSES PER MINUTE
SESSIONS
MEAN
2818
1314
889
238
2748
35
1129
0
20
40
60
80
100
120
140
20
25
30
35
40

Fig. 4

Fig. 5.--Response rates to S_1 (x's) and S_2 (circles) over sessions. During 10 sessions to the left of the dashed vertical line, the schedule of reinforcement was a multiple VI 1-min. VI 1-min. with no reinforcement delay. During the 15 sessions to the right of the dahsed vertical line, subjects were reinforced on a multiple VI 1-min. extinction schedule.

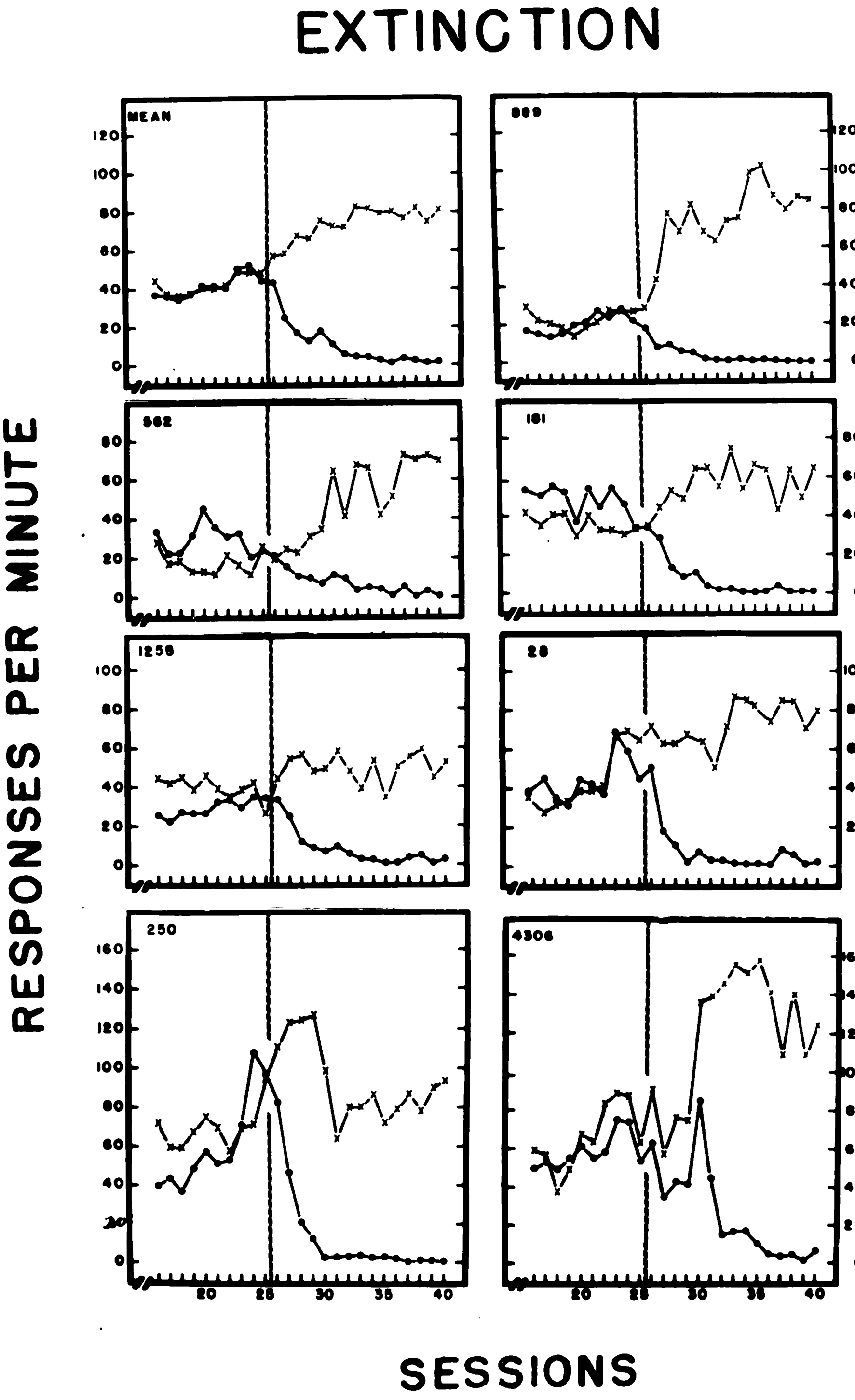
EXTINCTION
MEAN
889
562
181
1258
28
250
4306
RESPONSES PER MINUTE
0
20
40
60
80
100
120
140
160
20
25
30
35
40
SESSIONS

Fig. 5

TABLE 1

RESPONSES PER MINUTE DURING S_1 OVER THE SIX 3-DAY BLOCKS (SESSIONS 23-40) FOR THE GROUPS WHICH RECEIVED EITHER NO REINFORCEMENT OR REINFORCEMENT THAT WAS DELAYED FOR 2.5, 5, 10, OR 120-SEC. DURING S_2

	Bird	3-day blocks computed from sessions					
		23-25	26-28	29-31	32-34	35-37	38-40
2.5-sec. delay	199	44.5	33.6	52.3	48.4	55.4	67.7
	30	37.9	71.7	74.0	87.6	81.9	59.7
	2751	46.4	52.2	59.0	59.8	59.9	72.3
	609	57.3	64.0	70.6	69.0	73.1	72.7
	206	90.9	87.1	98.2	95.3	117.3	124.6
	38	42.3	51.6	59.8	73.5	77.6	83.1
	4304	57.6	57.7	70.1	84.6	97.7	75.4
	mean	53.8	59.7	69.1	74.0	80.4	79.4
5-sec. delay	2655	47.4	48.8	57.7	66.3	76.3	84.7
	622	65.0	74.3	92.2	91.9	89.6	97.2
	32	40.5	43.1	41.8	43.2	49.7	47.3
	2955	47.8	47.6	71.5	56.9	31.4	61.9
	2549	95.0	102.8	114.6	97.2	104.1	99.9
	389	38.1	42.6	46.3	52.6	57.9	56.7
	435	58.0	54.1	89.4	103.6	95.7	87.8
	mean	56.0	59.0	73.4	73.1	72.1	76.5
10-sec. delay	990	43.8	47.6	46.2	56.4	58.4	57.7
	466	46.0	60.2	89.4	87.2	77.7	71.6
	2032	36.1	40.4	40.2	54.2	67.7	67.7
	2631	77.8	95.1	103.9	104.2	119.4	108.9
	1702	25.6	48.3	66.7	78.0	78.3	74.3
	40	48.2	48.6	39.8	38.6	48.6	61.9
	1794	44.2	44.5	57.6	67.2	80.9	66.2
	mean	46.0	55.0	63.4	69.4	75.9	72.6
120-sec. delay	1314	19.6	28.2	35.4	34.6	35.3	39.4
	889	20.5	30.7	35.6	35.9	38.2	38.2
	2518	32.3	41.3	60.7	71.4	65.0	65.6
	1129	91.8	83.8	91.4	73.4	82.6	77.9
	2748	20.5	44.2	65.7	67.6	76.1	67.8
	35	58.5	92.3	79.1	57.5	66.5	66.2
	238	81.8	57.4	94.6	87.6	88.0	99.3
	mean	46.4	54.0	66.1	61.1	64.5	64.9
Extinction	562	18.2	22.6	43.4	58.2	55.4	71.2
	28	67.1	66.1	61.0	81.3	80.5	78.3
	181	32.4	44.1	59.2	61.5	57.8	59.1
	889	26.9	49.7	72.8	70.9	96.2	83.4
	1258	35.8	51.8	52.1	47.0	46.8	52.4
	2520	79.0	119.3	96.4	82.2	79.2	87.2
	4306	80.0	74.9	116.8	150.9	136.3	124.4
	mean	48.5	61.2	71.7	78.9	78.9	79.4

TABLE 2

SUMMARY TABLE OF THE ANALYSIS OF VARIANCE ON THE S_1 RESPONSE RATES OVER THE SIX 3-DAY BLOCKS (SESSIONS 23-40) FOR THE GROUPS WHICH RECEIVED EITHER NO REINFORCEMENT OR REINFORCEMENT THAT WAS DELAYED FOR 2.5, 5, 10, OR 120-SEC. DURING S_2.

Source of Variance	SS	df	MS	F
Between Ss				
A (groups)	3299.706	4	824.926	<1
Ss within groups	78633.622	30	2621.120	
Within Ss				
B (blocks of sessions)	17424.125	5	3484.825	27.641*
AB	1389.556	20	69.477	<1
B x Ss within groups	18911.152	150	126.074	

*p < .001

TABLE 3

PEARSON PRODUCT-MOMENT CORRELATIONS BETWEEN THE MAGNITUDE OF THE INCREASE IN S_1 RESPONDING AND THE MAGNITUDE OF THE DECREASE IN S_2 RESPONDING

2.5-sec.	5-sec.	10-sec.	120-sec.	Extinction	overall
+.37	+.26	-.02	-.11	-.03	+.09

Fig. 6.--Reinforcement rates during S_1 (x's) and S_2 (circles) over blocks of sessions (3 sessions per block). During the 3 blocks of sessions to the left of the dashed vertical line, the schedule of reinforcement was a multiple VI 1-min. VI 1-min. with no reinforcement delay. During the 5 blocks of sessions to the right of the dashed vertical line, subjects continued to be reinforced on the same multiple VI 1-min. VI 1-min. schedule, but with reinforcement during S_2 delayed for 2.5-sec.

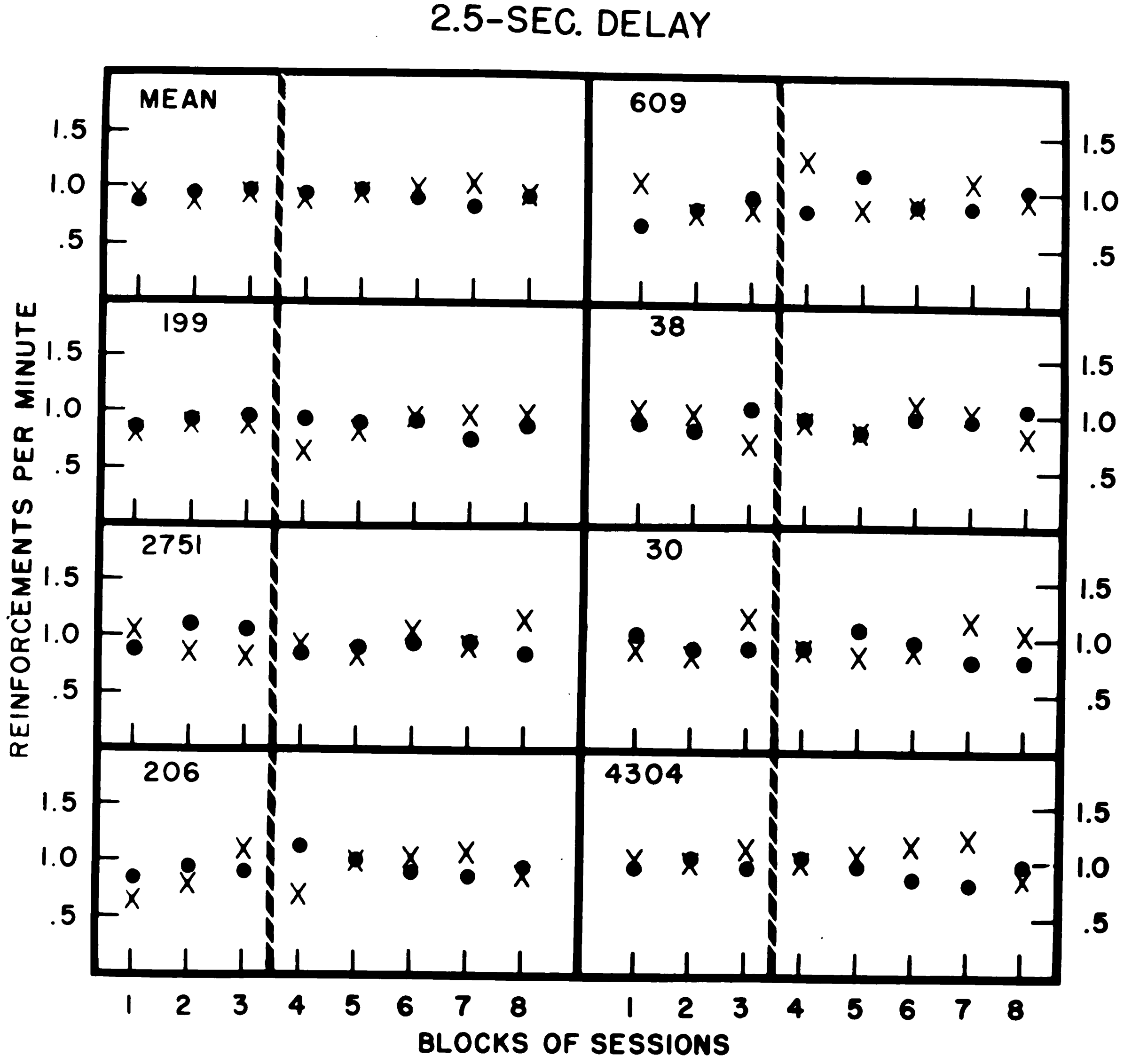
2.5-SEC. DELAY
MEAN
609
199
38
2751
30
206
4304
1.5
1.0
.5
REINFORCEMENTS PER MINUTE
1 2 3 4 5 6 7 8
BLOCKS OF SESSIONS

Fig. 6

Fig. 7.--Reinforcement rates during S_1 (x's) and S_2 (circles) over blocks of sessions (3 sessions per block). During the 3 blocks of sessions to the left of the dashed vertical line, the schedule of reinforcement was a multiple VI 1-min. VI 1-min. with no reinforcement delay. During the 5 blocks of sessions to the right of the dashed vertical line, subjects continued to be reinforced on the same multiple VI 1-min. VI 1-min. schedule but with reinforcement during S_2 delayed for 5-sec.

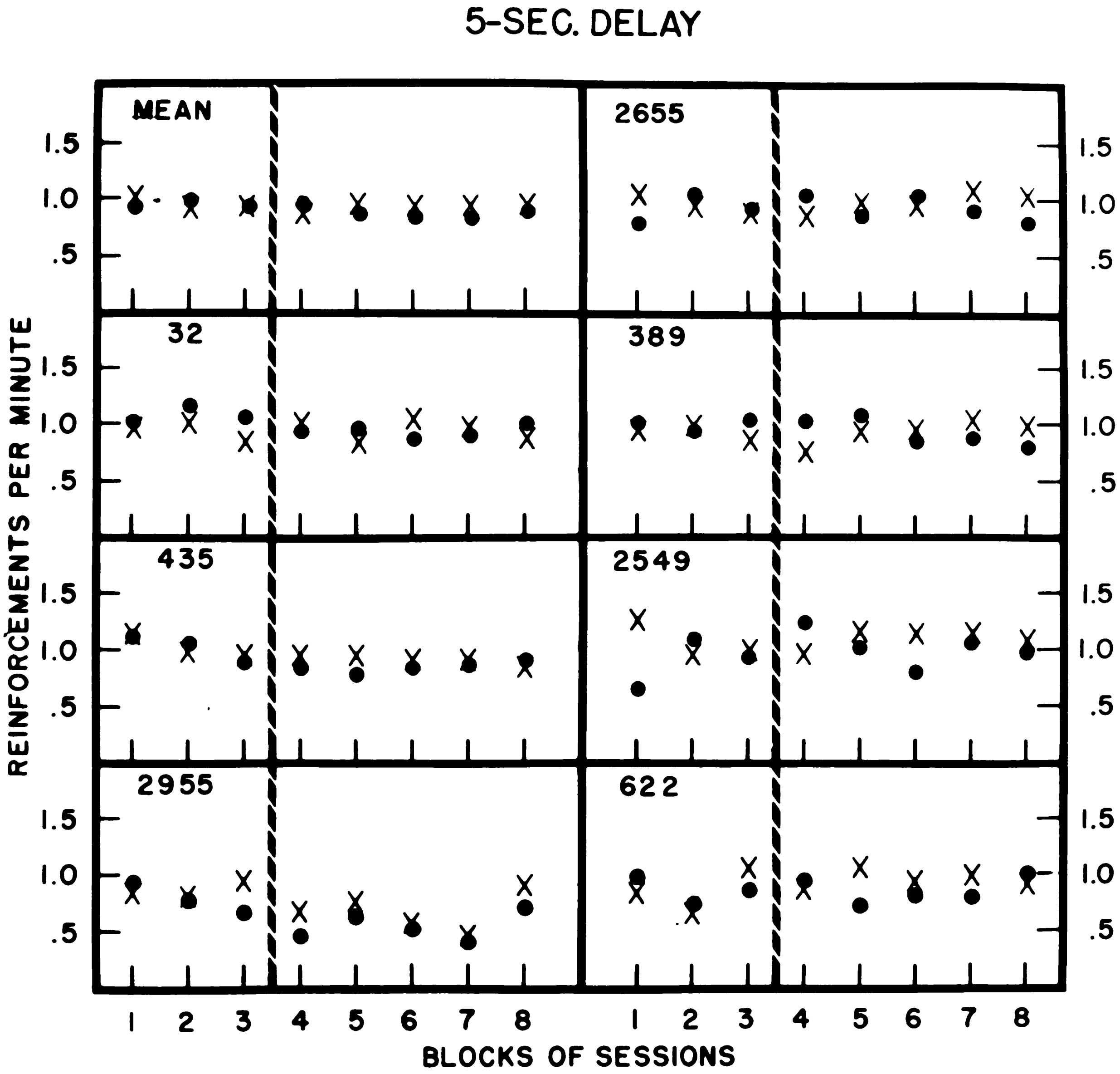
5-SEC. DELAY
MEAN
2655
32
389
435
2549
2955
622
1.5
1.0
.5
REINFORCEMENTS PER MINUTE
1 2 3 4 5 6 7 8
BLOCKS OF SESSIONS

Fig. 7

Fig. 8.--Reinforcement rates during S_1 (x's) and S_2 (circles) over blocks of sessions (3 sessions per block). During the 3 blocks of sessions to the left of the dashed vertical line, the schedule of reinforcement was a multiple VI 1-min. VI 1-min. with no reinforcement delay. During the 5 blocks of sessions to the right of the dashed vertical line, subjects continued to be reinforced on the same multiple VI 1-min. VI 1-min. schedule, but with reinforcement during S_2 delayed for 10-sec.

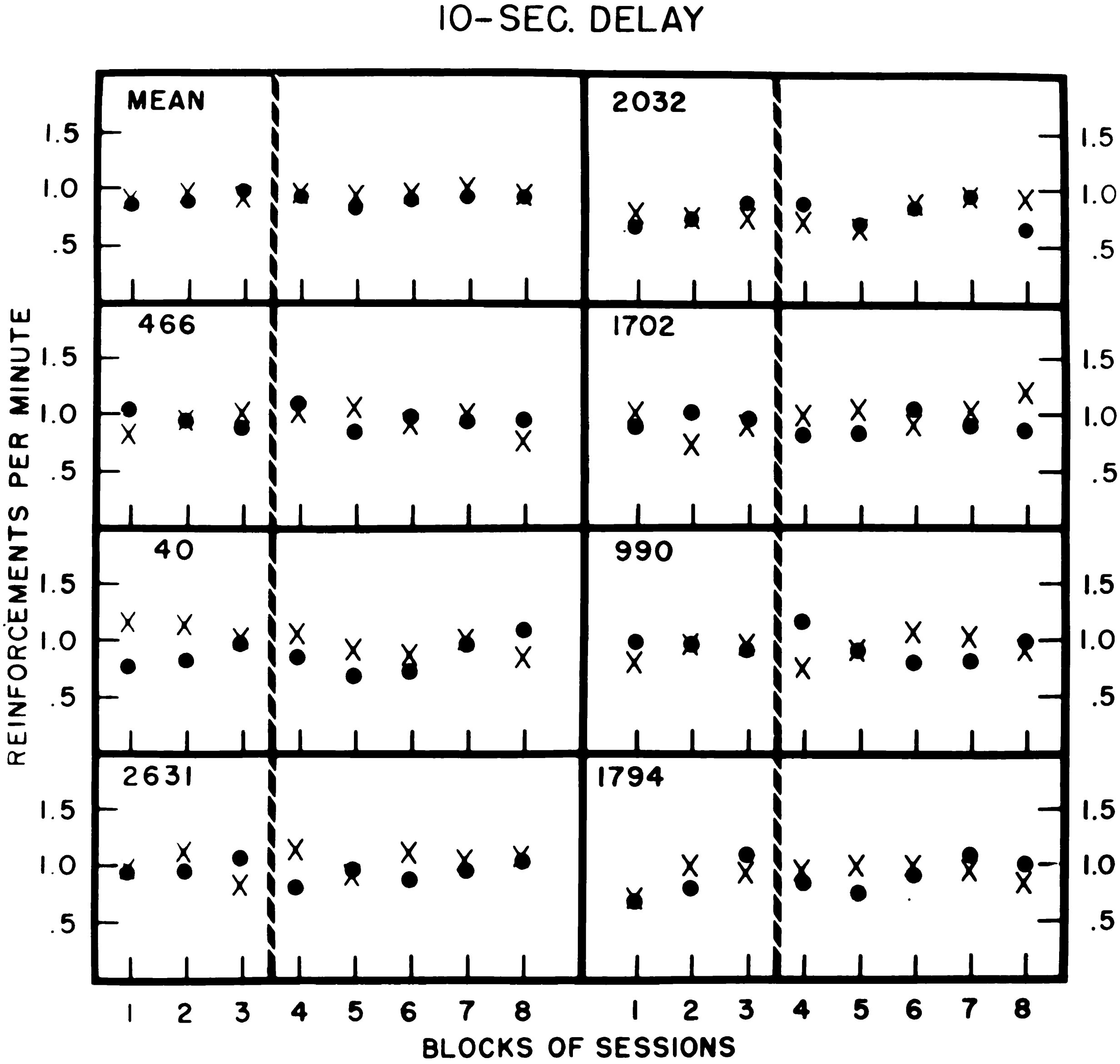
10-SEC. DELAY
MEAN
2032
466
1702
40
990
2631
1794
1.5
1.0
.5
REINFORCEMENTS PER MINUTE
1 2 3 4 5 6 7 8
BLOCKS OF SESSIONS

Fig. 8

DISCUSSION

Behavioral contrast is said to occur if, following a change in the S_2 reinforcement contingencies the <u>increased</u> S_1 response rate changes in a direction <u>away from</u> that maintained by S_2. The present experiment was conducted to determine whether the delaying of reinforcement during one component of a multiple VI 1-min. VI 1-min. schedule would produce behavioral contrast. The relationship between the duration of reinforcement delay and the amount of behavioral contrast produced, if any, was also examined.

From Figures 1-4 it is quite clear that the delaying of reinforcement during one of the multiple schedule's components did produce behavioral contrast. Of the 28 subjects that received delayed reinforcement during S_2, 24 clearly showed behavioral contrast. Three of the four subjects that failed to show behavioral contrast (Birds 1129, 2955, and 2549) also failed to show stable response rates prior to the introduction of the reinforcement delay. The responding of the remaining subject (Bird 40) was suggestive of behavioral contrast but only during the last 3 sessions of the reinforcement delay contingency.

Using a modified discrete-trial paradigm, where both S_1 and S_2 were associated with different durations of reinforcement delay and where the delay was not associated with a stimulus change, Keller (1970) also demonstrated behavioral contrast. The conclusion that delayed reinforcement produces behavioral contrast, thus, seems to hold across large variations in procedure.

Groups that received reinforcement delays of 2.5, 5, 10, or 120-sec. or even extinction during S_2 did not show a statistically significant difference in the magnitude of behavioral contrast. This failure to find magnitude differences may, however, be due more to the between-subjects design employed than to the absence of a relationship. Most studies concerned with the amount of behavioral contrast (e.g., Reynolds, 1961b; 1963; Thompson, 1965; Bloomfield, 1967) have employed a within-subjects design. There were, however, two related reasons for the present study's between-subjects design. Since behavioral contrast follows a temporal course and even disappears after extended training (Terrace, 1966b), a within-subjects design would require counterbalancing the presentation order of the different delay durations. But, the effect of a particular duration of reinforcement delay has also been shown to depend on the manner in which it is introduced (Ferster, 1953). Thus, a particular reinforcement delay might have different effects depending on whether it was presented at full duration (not preceded by shorter reinforcement delays) or gradually increased over sessions (preceded by shorter reinforcement delays).

So, while there were distinct advantages to using a betwee-subjects design, such a design may not have been the most sensitive to differences in the magnitude of behavioral contrast. It should be noted, however, that a recent between-subjects experiment (Taus & Hearst, 1970) was able to show statistically significant differences in the amount of behavioral contrast.

A second possible reason for the failure to find a relationship between duration of delay and the amount of behavioral contrast concerns the value of the baseline VI schedule. Reynolds (1963) suggests that the reinforcement rate during the unaltered component in part determines the magnitude of behavioral contrast. Perhaps, the use of a VI 3-min. baseline, which Reynolds has shown to be quite sensitive to behavioral contrast, would have been more appropriate. A third possibility is that the function relating delay duration to the amount of behavioral contrast reaches asymptote at or before the minimum delay duration of the present study (2.5-sec.). Indeed, a more positive conclusion might have been possible if some shorter delays had been included.

Results of the present study also have important implications for conditions necessary to the production of behavioral contrast. From Figures 6-8 it is clear that behavioral contrast can be produced without reducing the reinforcement rate during the altered component. This finding is in agreement with several studies that were specifically designed to hold reinforcement rate constant during the altered component (e.g., Terrace, 1968; Weisman, 1969; 1970).

Terrace (1971a) maintains that behavioral contrast is a by-product of some emotional responses that are produced by the subject's reduced and inhibited responding during the altered component. Of the 21 subjects in the 2.5, 5, and 10-sec. delay groups, four showed no reduction in S_2 response rate; however, all of these showed behavioral contrast. Nine subjects showed only a temporary reduction in S_2 responding and eight of these showed behavioral contrast. Of the eight that did permanently reduce S_2 responding, six showed behavioral contrast. Clearly, a permanent reduction in responding during the altered components is not necessary to the production or maintenance of behavioral contrast. The present data further suggest that behavioral contrast may occur regardless of <u>any</u> reduction in responding during the altered component.

While only 4 subjects did show behavioral contrast without a reduction in responding during the altered component, it does seem that Terrace's position needs some modification. Keeping within the rubric of his emotionality theory, it may be that the response rate reduction, like behavioral contrast, was just a frequent by-product of some emotional responses elicited by the reinforcement delay. In support of this interpretation, it should be noted that in many cases the response rate reduction, like behavioral contrast (Terrace, 1966b), disappeared with further training. Extended training (Terrace's subjects received 60 sessions) might have shown the response rate reduction to be temporary in all subjects.

If one accepts the emotionality interpretation of behavioral contrast, there still remains the problem of specifying the necessary and sufficient conditions that produce the frustration or other emotional responses. Guttman's suggestion that the weaker of two reinforcement schedules can become "functionally negative," while intrinsically appealing, is not very useful. There are no specified or readily apparent criteria for classifying one of two schedules of equal reinforcement frequency as the weaker. For example it is unclear why a DRO should be considered weaker than a VI of equal reinforcement frequency, and, yet, it is quite clear that changing a multiple VI VI to a multiple VI DRO does produce behavioral contrast (Weisman, 1970). Premack's (1969) suggestion that

> Contrast results if and only if there is a change in the aversiveness associated with one of the components in the schedule. [p. 136]

may be the most workable hypothesis at present. This hypothesis is, of course, quite similar to Bloomfield's (1969) contention that behavioral contrast is produced by "a worsening of conditions" during one of the components. If behavioral contrast occurs the stimulus associated with the altered component should possess all the properties of other aversive stimuli--subjects should learn a new response to escape from the stimulus and the stimulus should serve as an elicitor of aggression and as a punisher of ongoing behavior. Likewise, if no contrast is observed, these properties should not be present. Although a beginning has been made in studying multiple schedules within these different paradigms (e.g., Rilling, Askew, Ahlskog, & Kramer, 1969; Rilling, Kramer, & Richards, 1971; Terrace, 1971b; Weisman & Premack, 1966), more research will be required before a definitive conclusion can be made.

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