A MOLECULAR ANALYSIS OF MULTIPLE SCHEDULE INTERACTIONS: NEGATIVE CONTRAST¹

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The present experiments investigated the relationship between changes in the relative reinforced interresponse-time distributions and the occurrence of positive and negative contrast in multiple variable-interval—variable-interval and multiple variable-interval—extinction schedules of reinforcement. Experiment I demonstrated that changes in the interresponse-time distributions were consistently correlated with response-rate changes referred to as positive and negative contrast. Corresponding changes in the reinforced interresponse-time distributions suggested that negative contrast resulted as an inductive effect of selectively reinforcing long interresponse times in the altered component at the moment the baseline schedule was reintroduced. Experiment II demonstrated that the magnitude of the negative-contrast effect could be significantly decreased if the altered component schedule was modified in order to prevent the reinforcement of these interresponse times during the first few sessions of baseline recovery. The results supported a proposal that interresponse time—reinforcer relations may act as amplifiers or attenuators of negative contrast.

Key words: interresponse times, negative contrast, multiple schedules, pacing, key peck, pigeons

The increase in the response rate of one component (constant) of a multiple schedule of reinforcement that occurs when the schedule associated with the other component (variable) is changed to extinction (EXT) is referred to as positive behavioral contrast (Reynolds, 1961a). The subsequent decrease in the constant-component rate that is observed when the variable-component baseline schedule is reintroduced is considered an instance of negative behavioral contrast. The many interpretations of these effects (Bloomfield, 1969; Gamzu and Schwartz, 1973; Reynolds, 1961a; Terrace, 1972) all seem to view positive and negative contrast as causally related phenomena, *i.e.*, the occurrence of negative contrast in the

above situation is a result of the reversal of the manipulation responsible for the occurrence of positive contrast in the same situation. However, viewing these schedule interactions as equal but opposite reactions may be oversimplified. First, the occurrence or nonoccurrence of positive contrast does not perfectly predict the occurrence or nonoccurrence of negative contrast (Bloomfield, 1967; Pear and Wilkie, 1971; Reynolds, 1963; Reynolds and Limpo, 1968). Second, when negative contrast does occur, its magnitude is occasionally less than that of positive contrast (Reynolds, 1961b). Third, Reynolds and Limpo (1968) demonstrated that negative contrast occurred during the transition from multiple variable interval—extinction (*mult VI EXT*) to multiple variable interval—variable interval (*mult VI VI*), even though discrimination training on *mult VI EXT* was continued until positive contrast had dissipated.

This lack of symmetry suggests the presence of additional variables that may influence the maintenance or magnitude of positive and negative contrast. For example, gross schedule manipulations (VI to EXT, EXT to VI) may have indirect effects on response rates by influencing the relationship existing between the relative frequency of specific interresponse

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times (IRTs) and their relative frequency of reinforcement within each component. Because there is considerable evidence that changes in these microcontingencies of reinforcement influence response rate, an analysis of such changes may provide a clearer understanding of multiple schedule interactions. For example, both Anger (1956) and Shimp (1973) have demonstrated that, in simple schedules of reinforcement, the particular rate of responding maintained by a schedule is at least partly determined by the relative frequency of reinforcement for particular interresponse times. However, since the relative frequency of reinforced IRTs is not specified by most reinforcement schedules, those IRTs that are reinforced depend on which IRTs are emitted by the organism. This, in turn, influences the probability of occurrence of a particular IRT. This dynamic interaction between the relative frequency of particular IRTs and their relative frequency of reinforcement usually continues until some metastable equilibrium is reached (Anger, 1956; Weiss, 1970).

The introduction of a gross schedule manipulation, *e.g.*, EXT in one component of a multiple schedule, may have strong, although indirect effects on the response rate in both components by virtue of its impact on this metastable equilibrium. Thus, an examination of the changes in the relationship between overall and reinforced IRT distributions during transitional phases of schedule manipulations may be informative.

Although two studies have examined the changes that occur in the interresponse-time distributions of multiple schedules when some aspect of the variable component is altered (Arnett, 1973; Spealman and Gollub, 1974), no study has yet examined the changes that occur in the overall and reinforced IRT distributions of both components during the transitional phases following introduction of the positive contrast producing manipulation and the reversal of this manipulation (*i.e.*, returning to the baseline contingencies).

The present experiments investigated the role of the interactions between the reinforced and overall IRT distributions on the development of negative contrast. Experiment I demonstrated that one effect of reintroducing the baseline variable-interval schedule following extended exposure to EXT was selectively to reinforce many very long IRTs. These data

suggested that negative contrast was partly an inductive effect of selectively reinforcing long variable-component IRTs. Experiment II demonstrated that the occurrence of negative contrast was a function of whether or not these long IRTs were reinforced.

EXPERIMENT I

METHOD

Subjects

Two naive male Silver King pigeons were maintained at 80% of their free-feeding weights. Water was available only in the home cage.

Apparatus

The experimental apparatus was a standard pigeon test chamber (Gerbrands Model #G5610) containing two clear response keys. Only the left key, transilluminated by an Industrial Electronics Engineers in-line projector, was used in the present experiment. Pecks, of at least 0.15 N on this key, were recorded and operated a feedback relay mounted behind the front panel. The reinforcer was 4-sec access to mixed grain delivered by a food hopper located below and between the two keys. The houselight remained off during the session. During the reinforcement cycle, the keylight was turned off and a 7-W lamp illuminated the food hopper. Masking noise was provided by a white-noise generator and an exhaust fan. Solid state programming was located in an adjacent room.

Procedure

Key pecks were first reinforced in the presence of red and green stimuli on a two-ply multiple schedule with identical random-interval (RI) 1-min schedules ($T = 4$ sec) associated with each component. Both components were of 1-min duration and were presented in strict alternation with no blackout between components. Since uncollected scheduled reinforcers were cancelled at completion of a component, responses during the first 4 sec of any component were not reinforced. Each session was terminated after 60 reinforcers had been delivered.

After 60 sessions of baseline RI 1-min RI 1-min, the schedule associated with the variable component (green) was changed to EXT

Fig. 1. Response rates per minute for each component for both birds for the last five sessions of baseline, *mult* RI 1-min RI 1-min, 15 sessions of *mult* RI 1-min EXT, and the first 15 sessions of return to *mult* RI 1-min RI 1-min. Open circles represent variable-component rates and closed circles represent constant-component rates.

for 15 sessions and then returned to baseline RI 1-min. During *mult* RI 1-min EXT, daily sessions were terminated after the delivery of 30 reinforcers.

In addition to response rates, reinforced and unreinforced IRTs were recorded during each session for both constant and variable components during all phases of the experiment. All responses were recorded sequentially by means of a BCI Model 100 30 channel multiplexer and a standard stereo tape deck (described by Mostofsky, Cohen, and Babish, 1973).

RESULTS

Figure 1 shows response rates per minute for each component for the last five sessions of baseline *mult* RI 1-min RI 1-min, for all 15 sessions of RI 1-min EXT, and for the first 15 sessions after the schedule was returned to *mult* RI 1-min RI 1-min. The open circles represent variable-component response rates, closed circles represent constant-component rates. Both positive and negative contrast were obtained for both subjects.

Figure 2 shows both the overall IRT distributions (closed circles) and the reinforced IRT distributions (open circles) for each component for Bird W23 (left half) and for Bird 459 (right half). For each bird, the data from the constant component are presented on the left and those from the variable component are on the right. For the sake of clarity, only nine sessions are shown for each subject. The data of the omitted sessions are consistent with the trends represented in Figure 2. IRTs were grouped into 0.09-sec class intervals with all IRTs ≥ 1.98 sec placed into the twenty-third class interval. The number of IRTs, the mean IRT, and the standard deviation of the total and reinforced distributions, for both constant and variable components, are presented in Appendix A. Due to equipment failure, IRT data were not available for all sessions.

Consider first the changes occurring in IRT distributions when the variable-component RI 1-min schedule was changed to EXT. The mean IRT of both the overall and reinforced IRT distribution of the constant component shifted to shorter durations, as would be expected (Reynolds and McLeod, 1970). The shape of these distributions corresponded fairly well with changes in the overall response rates. For example, the overall rate decrease from Session 7 to Session 15 (Figure 1) was correlated with a shift of both the reinforced and total IRT distributions for that session to longer IRT values.

Changing the variable-component schedule to EXT increased the frequency of IRTs ≥ 1.98 sec in the variable component. Although the overall frequency of variable-component responding was decreasing, there appeared to be a slight increase in the relative frequency of shorter IRTs as well. This increase was primarily due to the animals responding near the end of the extinction component just before onset of the constant-component stimulus. Because this responding did not develop until after the animals were exposed to several sessions of *mult* RI 1-min EXT, it is unlikely that the occurrence of these responses was related to the initial occurrence of positive contrast.

An examination of the changes after the baseline RI 1-min schedule was reintroduced reveals the presence of many long IRTs in the variable component. The mean IRTs of the variable-component reinforced IRT distributions for the first session after return to base-

line were significantly greater than the mean IRTs in this component during the last baseline RI 1-min session (Appendix A). A similar increase occurred in the standard deviations. The shift in the mean IRT for Bird 459 was from 1.5 sec to 4.3 sec, and for Bird W23 from 1.8 sec to 5.2 sec. The standard deviation for Bird 459 increased from 0.78 to 4.92 and for Bird W23 from 1.39 to 9.39. These effects were primarily due to the presence of many extremely long IRTs in the variable component (Figure 2). Although the mode of both reinforced and overall distributions gradually shifted toward shorter IRT durations, the large increase in the relative frequency of long IRTs was maintained over several sessions.

In the constant component, the relative frequency of both overall and reinforced IRTs ≥ 1.98 sec also increased over baseline levels immediately after return to the baseline condition. This increase in the longest reinforced IRTs preceded the gradual shift in the rest of the distribution, which revealed an increasing mode as sessions progressed.

DISCUSSION

Mackintosh (1975) suggested that changes in the microcontingencies of reinforcement, produced by a gross schedule manipulation, may play an important role in maintaining positive contrast. Experiment I demonstrated, as would be predicted (Reynolds and MacLeod, 1970), that an increased probability of short IRTs in the constant component was accompanied by an increased probability of reinforced short IRTs. Although this association is logically necessary, it is also likely that the new reinforcement distribution maintained the shifted IRT distribution (Anger, 1956).

If the response rate in the constant component can be maintained by the changes in the contingencies of reinforcement for specific IRTs, then the reintroduction of reinforcement for responding in the variable component should not decrease the constant-component rate, unless a change occurs in the reinforcement contingencies for constant-component IRTs. The data indicate the possibility

of such an effect. Experiment I demonstrated that reintroduction of the variable-component RI 1-min schedule following extinction resulted in the selective reinforcement of relatively long IRTs (≥ 1.98 sec). Through induction, long IRTs may also have begun to occur in the constant component. Once they began, these long constant-component IRTs could have contributed to the constant-component rate decrease (negative contrast).

Experiment II examined this possibility by controlling IRT reinforcement contingencies in the variable component. The schedule was selected to meet two requirements. First, it prevented the reinforcement of very long IRTs in the variable component without disrupting the reinforced IRT distribution in effect in the constant component. Second, it did not require a variable-component response rate at or above the rate in the constant component. On the basis of the data from Experiment I, a pacing contingency was chosen that allowed only IRTs ≤ 1.50 sec to be reinforced. Figure 2 indicates that only three of 60 constant-component reinforced IRTs during the last session of *mult* RI EXT were greater than 1.50 sec. Therefore, limiting the reinforced IRTs in the variable component to ≤ 1.50 sec should not significantly alter the constant-component reinforced IRT distribution. Second, this pacing value (1.50 sec) can be satisfied by a response rate of just over 40 responses per minute (the inverse of the 1.50-sec IRT limitation). Figure 1 reveals that this rate is approximately one-third the rate in the constant component during the last session of RI 1-min EXT.

EXPERIMENT II

METHOD

Subjects

Three male Silver King pigeons were maintained at 80% of their free-feeding weights. Two (W23 and 459) were used in Experiment I. Bird 2656 was naive. Water was available only in the home cage.

Fig. 2. Total IRT distributions (closed circles) and reinforced IRT distributions (open circles) for each component for Birds W23 and 459. Class interval width is equal to 0.09 sec with all IRTs ≥ 1.98 sec placed into the twenty-third class interval. IRT data of selected sessions from each condition are presented. The number in parentheses is the session number corresponding to each condition.

Apparatus

A second standard three-key pigeon chamber (Gerbrands Model #G5610) was used in addition to that used in Experiment I. Only the center key (transilluminated by an Industrial Electronics Engineers in-line projector) was used. Pecks at least 0.15 N on this key were recorded and operated a feedback relay mounted behind the front panel.

Procedure

The responses of the three pigeons were first reinforced in the presence of two different wavelengths (green and red) on a two-ply multiple schedule with identical constant-probability VI 1-min schedules associated with each component. The values of the 20 intervals used were derived from Catania and Reynolds (1968). Variable-interval instead of random-interval schedules were used in Experiment II to control more precisely the average interreinforcement interval.

Both components were of 1-min duration and, with two exceptions, were presented in semirandom fashion. Since Bird W23 failed to exhibit positive contrast during condition 2 and W23 and 459 during condition 5, the alternation of the components was changed from a semirandom to a fixed sequence for the last eight sessions of condition 6 and the first 10 sessions of condition 7. Beginning with Session 11 of condition 7, the sequence was returned to semirandom for the remainder of the experiment. This temporary change to a fixed sequence was attempted because preliminary data from our laboratory have suggested that the strict alternation of components sometimes facilitated development of positive contrast.

Uncollected scheduled reinforcers (4-sec access to mixed grain) were cancelled at the completion of a component. The reinforcement schedule associated with the variable component was at various times changed to extinction and then returned to either VI 1-min paced 0, 1.50 sec, or VI 1-min (unpaced). All three subjects were exposed at various times to both the paced and the unpaced conditions (Table 1).

Paced variable interval. For each bird, during at least one of the conditions in which the variable-component schedule was returned from EXT to VI 1 min, a pacing contingency was also in effect (VI 1-min paced 0, 1.50 sec);

that is, when a variable interval had elapsed, a response initiated an IRT that was reinforced only if a second response terminated the IRT between 0 and 1.50 sec. Responses terminating an IRT greater than 1.50 sec were not reinforced, but initiated a new IRT. Reinforcement was held available until the IRT criterion was met. The effect of the pacing procedure was to prevent the first response emitted in the variable component, the first response after the reinforcer had become available, and any other response terminating an IRT longer than 1.50 sec from being reinforced. The pacing contingency was in effect only in the variable component and was removed after a maximum of 13 sessions.

Control. The 1.50-sec pacing value was selected to eliminate reinforcement for variable-component IRTs longer than 1.50 sec without producing high response rates in the constant component. Two additional pigeons, 5498 and 5598, were tested to examine the possibility that selectively reinforcing IRTs ≤ 1.50 sec in the variable component actually increased constant component rates by increasing reinforcement for short IRTs. Responses were first reinforced on a *mult* VI 1-min VI 1-min schedule. When stable behavior was obtained, the 1.50-sec pacing contingency was added to one component of the schedule. The *mult* VI 1-min schedules were identical to those previously used, except that horizontal and vertical lines, projected on the response key, served as the discriminative stimuli. Line tilt was used to increase the possibility that rate changes in the paced component would, by induction, produce rate changes in the unpaced component.

RESULTS

Table 1 shows the sequence of conditions for each pigeon, the number of sessions at each condition, and, for the last five sessions of each condition, the mean response rate, and the mean reinforcement rate (reinforcers per minute) in both the constant and variable components. Analogous data for Birds 459 and W23 for each condition of Experiment I are also included in Table 1 (Conditions A, B, and C). The data in Table 1 show that the obtained mean reinforcement rate for the last five sessions of each pacing condition was approximately equal to the mean obtained reinforcement rate for the last five sessions of the preceding *mult* VI 1-min VI 1-min condition,

Table 1

The sequence of conditions for each pigeon, the number of sessions at each condition, the mean response rate, and the mean reinforcement rate in both constant and variable components for the last five sessions of each condition. Similar data for Birds W23 and 459 for each condition of Experiment I are also included (A, B, and C).

Subject	Condi- tion	Schedule		Session	Responses per Minute		S ² Rate	
		Constant	Variable		Con- stant	Variable	Con- stant	Variable
W23	A	RI 1-min	RI 1-min	60	82.7	76.6	1.06	0.95
	B	RI 1-min	EXT	15	107.8	17.6	1.11	0.00
	C	RI 1-min	RI 1-min	32	84.7	80.6	1.00	0.96
	1	VI 1-min	VI 1-min	22	78.9	75.7	1.14	0.95
	2	VI 1-min	EXT	28	74.8	15.0	1.11	0.00
	3	VI 1-min	VI 1-min paced 0, 1.50 sec	10	85.0	74.4	1.14	0.93
	4	VI 1-min	VI 1-min	5	75.9	65.6	0.97	1.02
	5	VI 1-min	EXT	15	58.7	5.9	1.00	0.00
	6	VI 1-min	VI 1-min	30	75.3	72.8	1.05	0.98
	7	VI 1-min	EXT	22	88.2	7.0	1.01	0.00
459	8	VI 1-min	VI 1-min	14	73.1	69.9	1.02	1.03
	9	VI 1-min	EXT	26	100.1	22.9	1.00	0.00
	10	VI 1-min	VI 1-min paced 0, 1.50 sec	8	103.7	102.8	1.01	1.02
	11	VI 1-min	VI 1-min	18	95.1	98.2	1.00	1.00
	A	RI 1-min	RI 1-min	60	57.5	62.5	1.06	1.09
	B	RI 1-min	EXT	15	126.9	9.0	0.99	0.00
	C	RI 1-min	RI 1-min	31	73.7	70.1	1.00	0.94
	1	VI 1-min	VI 1-min	22	72.1	59.1	1.09	1.05
	2	VI 1-min	EXT	26	100.6	4.9	1.08	0.00
	3	VI 1-min	VI 1-min paced 0, 1.50 sec	13	107.8	81.2	1.00	1.02
2596	4	VI 1-min	VI 1-min	5	89.4	69.3	1.04	0.99
	5	VI 1-min	EXT	17	86.7	6.6	0.99	0.00
	6	VI 1-min	VI 1-min	33	89.2	92.4	0.97	1.04
	7	VI 1-min	EXT	18	109.7	11.8	0.99	0.00
	8	VI 1-min	VI 1-min	15	77.3	60.0	1.04	0.94
	1	VI 1-min	VI 1-min	22	67.9	61.8	0.95	1.01
	2	VI 1-min	EXT	20	137.8	10.9	1.02	0.00
	3	VI 1-min	VI 1-min paced 0, 1.50 sec	12	110.0	104.7	0.96	1.04
	4	VI 1-min	VI 1-min	10	109.7	98.1	0.95	0.99
	5	VI 1-min	EXT	20	136.0	5.7	0.97	0.00
	6	VI 1-min	VI 1-min	16	82.1	72.1	1.01	0.93

and that the constant-component rate did not significantly decrease when the pacing contingency was in effect. That is, even though both the variable-component response rate and reinforcement rate increased to a level equal to (reinforcement rate) or above (response rate) that of the previous baseline *mult* VI 1-min VI 1-min condition, there was no corresponding decrease in the constant-component response rate.

Figure 3 shows both the variable (open circles) and the constant (closed circles) component rates per session during *mult* VI 1-min VI 1-min, *mult* VI 1-min EXT, and either *mult*

VI 1-min VI 1-min or *mult* VI 1-min paced 0, 1.50 sec. The data for those conditions in which the pacing contingency was added to the VI 1-min schedule of the variable component, following exposure to EXT, are presented in rows 1 and 3 (paced); the data during those conditions when the pacing contingency was not added to the variable-component VI schedule following exposure to EXT, are presented in row 2 (unpaced). Bird W23 was exposed to a second pacing condition because positive contrast was not obtained during those *mult* VI EXT sessions that preceded the first pacing condition (Column 1). The response-rate data

Fig. 3. Variable (open circles) and constant (closed circles) component response rates (per minute) during *mult* VI 1-min VI 1-min, *mult* VI 1-min EXT, and return to either *mult* VI 1-min VI 1-min (row 2) or *mult* VI 1-min VI 1-min paced 0, 1.50 sec (rows 1 and 3).

of Birds W23 and 459 for the last five sessions of condition 4, all sessions of condition 5, and the first several sessions of condition 6 have not been included in Figure 1 because negative induction, rather than positive contrast, was obtained in Condition 5. The reason for this result is not clear at the present time. The vertical arrows, in Figure 3, indicate the session in which the pacing contingency was removed.

Figure 3 shows that selectively reinforcing variable-component IRTs between 0 and 1.50 sec during return to *mult* VI 1-min VI 1-min following exposure to *mult* VI EXT eliminated the occurrence of negative contrast. When the pacing contingency was in effect in the variable-component schedule, after the re-

introduction of the VI schedule (rows 1 and 3, Figure 3), the constant-component rate did not return to the baseline rate as the variable-component response rate increased; in fact, with one exception, the constant-component rate remained unchanged.

The unchanged constant-component response rate is in contrast to the performance of the same birds during return to *mult* VI 1-min VI 1-min when the pacing contingency was not in effect. Within a similar number of sessions, the constant-component response rates of all pigeons during the unpaced conditions decreased to a level at or below that of the prior baseline *mult* VI 1-min VI 1-min response rates. The results cannot be attributed to prior

exposure to the pacing contingency, since Birds W23 and 459 were first exposed to the unpaced condition (Experiment I), and Bird 2656 to the paced condition. Also, a greater response-rate decrease was obtained during unpaced conditions, following exposure to the paced condition, (459, 2656) than *vice versa*. This may have occurred because the baseline *mult* VI 1-min VI 1-min rates were considerably higher following paced conditions (Table 1).

Figure 3 also shows that the removal of the pacing contingency did not significantly affect response rates in either component.

Figure 4 shows response rates per minute for control subjects, for both constant (closed circles) and variable (open circles) components for the last five sessions of *mult* VI 1-min VI 1-min, for all sessions of *mult* VI 1-min VI 1-min paced 0, 1.50 sec, and the first few sessions of return to VI 1-min VI 1-min. The data for Bird 5493 are presented in the top half of Figure 4 and those for Bird 5598 in the bottom half. Introduction of the 1.50-sec pacing contingency in the variable component did not increase the constant-component (unpaced) rates of either pigeon. The 1.50-sec pacing contingency increased the variable (paced) component rate of one subject. However, this increase did not occur until after four sessions of exposure to the pacing contingency. In addition, the increase in the paced component response rate that eventually occurred for Bird 5598 was due to change in the unusual response pattern in that component and did not appear to be correlated with an increase in the modal IRT. During the baseline sessions, the variable-component response pattern was characterized by response bursts followed by a long pause. The animal responded at an equal rate throughout the constant component. Introduction of the pacing contingency disrupted the response pattern in the variable component; *i.e.*, the pause disappeared and the animal responded at a constant rate throughout the component. As a result the overall rate increased, but there was no associated rate increase in the constant (unpaced) component.

DISCUSSION

The results of Experiment II demonstrated that, following exposure to *mult* VI EXT, selectively reinforcing variable-component IRTs between 0 and 1.50 sec prevented the constant-component responding from decreasing to the

Fig. 4. Variable (open circles) and constant (closed circles) component response rates (per minute) for the last 10 sessions of *mult* VI 1-min VI 1-min and all sessions of *mult* VI 1-min VI 1-min paced 0, 1.50 sec. The pacing contingency was in effect only in the variable component.

baseline response rate. Nonetheless, the response rate in the variable component increased to a level above its prior *mult* VI VI baseline and the reinforcement frequency increased to baseline levels.

One possible interpretation of these results is that the pacing contingency reinforced short IRTs in the variable component, thus producing a high rate in the variable component. In turn, this high rate occurred in the constant component by induction. Some support for this view is provided by the results of Hemmes and Eckerman (1972). They found that reinforcing short IRTs in the variable component of a *mult* VI VI schedule would significantly increase the rate in the variable component and to a lesser degree in the constant component. However, at introduction of the pacing procedure, Hemmes and Eckerman required a response rate in the variable component between two to six times the ongoing response rate for reinforcement; the present experiment required between one-half to one-third the on-

going response rate for reinforcement. Thus, the Hemmes and Eckerman conditions favored induction to the constant component, but the present ones did not. The data of Figure 4 show that introducing the pacing procedure did not increase the constant (unpaced) response rates, and, in fact, its removal resulted in a slight decrease in the unpaced response rates. In the present study, then, the pacing contingency did not appear to induce a high rate in the unpaced component, but rather appeared to prevent the decrease seen during negative contrast.

The many current interpretations of contrast effects in multiple schedules of reinforcement (Bloomfield, 1969; Gamzu and Schwartz, 1973; Reynolds, 1961a; Terrace, 1972) all seem to view the occurrence of negative contrast as a direct result of reversing the manipulation that was responsible for both the initiation and maintenance of positive contrast in the same experimental situation. Experiment II demonstrated that the occurrence of negative contrast upon return to *mult* VI VI from *mult* VI EXT cannot easily be attributed to (1) the increase in either the variable-component response rate (Terrace, 1972) or reinforcement rate (Reynolds, 1961a) or to (2) the removal of the differential stimulus reinforcer relation that had previously existed between the component stimuli during the *mult* VI EXT condition (Gamzu and Schwartz, 1973). Instead, the data of Experiment II support Schwartz's (1975) suggestion that positive and negative contrast may be unrelated phenomena that are controlled by different variables.

GENERAL DISCUSSION

The present authors suggest that a complete account of multiple schedule interactions should include an assessment of the contribution of differential reinforcement of IRTs to the magnitude of both positive and negative contrast. Changes in the relationships existing between the relative frequency of specific interresponse times and their relative frequency of reinforcement may act as either magnifiers or attenuators of both positive contrast and negative contrast effects.

Positive Contrast

For whatever reason additional responses are first emitted in the constant component

when some feature of the variable component is manipulated (Bloomfield, 1969; Gamzu and Schwartz, 1973; Reynolds, 1961a, b; Terrace, 1972), these responses may interact with the existing contingencies of reinforcement to produce further rate changes. The magnitude of the contrast effects typically obtained then may be a function of both (1) the schedule in effect in the constant component and (2) the variable component manipulation. Although this question is not addressed in the present experiments, the use of synthetic VI schedules (Shimp, 1973) may allow these effects to be separated experimentally. With synthetic VI schedules, the relative frequency of reinforcement for each IRT can be specified and held constant throughout the experiment. Thus, any change in the constant-component rate could be attributed solely to the variable-component manipulation and not to its indirect effects on the relative frequency of reinforcement for constant-component IRTs.

Viewing the magnitude of positive and negative contrast usually obtained as the sum of these two influences may also help account for the conflicting evidence for the transience of positive contrast. Terrace (1966) and Pear and Wilkie (1971) reported that the magnitude of positive contrast decreases considerably if discrimination training is extended, whereas Hearst (1971), Selekman (1973), and Dukhayyil and Lyons (1973) reported that this is not the case. The present analysis suggests that the transience of contrast is primarily the result of the noncontingent relationship existing between the overall and reinforced IRT distributions of the constant component. Once short IRTs are occurring, they are more likely to be reinforced and increase in frequency. Yet, the continued occurrence of short IRTs is not specified by the schedule of reinforcement, and like other superstitious behavior may eventually drift out.

Negative Contrast

The reported failures reliably to obtain a symmetrical negative contrast effect (Bloomfield, 1967; Pear and Wilkie, 1971; Reynolds, 1961b, 1963; Reynolds and Limpo, 1968) are also consistent with the present proposal that changes in IRT relationships may serve as amplifiers or attenuators of contrast effects. If the magnitude of the observed positive contrast effect represents the sum of the influences of

both the variable-component schedule change and changes in the IRT-reinforcer relationship, then it is reasonable to assume that the removal of only one of these influences (*i.e.*, the variable-component schedule change) would not necessarily result in a negative contrast effect that was equal in magnitude but opposite in direction to the original positive contrast effect.

Instead, the magnitude of negative contrast should also depend on the pattern of responding controlled by the variable component stimulus at the time of the schedule change. For example, the removal of an extinction procedure that decreases responding by nonreinforcement should produce a greater negative contrast effect than the removal of a blackout procedure that decreases variable-component responding by removing the opportunity to respond in the presence of the variable-component stimulus. Unfortunately, the differential effect of these two procedures has yet to be examined. Those studies that have used a blackout procedure to reduce variable-component responding either did not attempt to recover the baseline *mult VI VI* performance (Sadowsky, 1973; Vieth and Rilling, 1972) or did not expose pigeons to the blackout procedure long enough for stable IRT relationships to develop (Reynolds, 1961b).

In summary, the present authors suggest that changes in the relationships existing between the relative frequency of specific IRTs and their relative frequency of reinforcement may influence the magnitude of positive and negative contrast. That is, although these schedule factors may not be responsible for the initial occurrence of contrast, they may, under certain conditions, act either to amplify or to attenuate contrast.

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APPENDIX A

The number of IRTs, the mean IRT, and the standard deviation of the total and reinforced IRT distributions for both constant and variable components for each session of each of the conditions for which data were available in Experiment I.

Schedule	Session	Constant						Variable					
		Total			Reinforced			Total			Reinforced		
		X	SD	N	X	SD	N	X	SD	N	X	SD	N
SUBJECT 459													
mult RI RI	60	0.97	0.52	1698	1.29	0.36	33	1.02	0.69	1612	1.49	0.78	27
mult RI EXT	1	0.92	0.52	2387	0.92	0.58	30	1.08	0.78	2151	—	—	—
	2	0.82	0.44	1865	1.23	0.56	34	1.23	0.81	1322	—	—	—
	3	0.79	0.50	2217	1.16	0.44	30	1.47	1.04	1230	—	—	—
	4	0.69	0.46	3201	1.02	0.51	30	1.43	1.04	1556	—	—	—
	5	0.59	0.39	2957	0.91	0.60	30	1.67	1.18	974	—	—	—
	6	0.52	0.36	2828	0.80	0.34	31	1.56	1.17	834	—	—	—
	7	0.52	0.36	2918	0.81	0.38	31	1.61	1.32	770	—	—	—
	8	0.54	0.39	3127	0.95	0.53	30	1.61	1.27	805	—	—	—
	12	0.48	0.30	2641	0.91	0.52	30	1.57	1.63	331	—	—	—
	13	0.49	0.34	2656	—	—	—	1.52	1.47	224	—	—	—
	14	0.54	0.40	2426	0.90	0.57	30	2.10	1.65	124	—	—	—
	15	0.51	0.33	2460	0.93	0.51	30	2.30	1.75	103	—	—	—
mult RI RI	1	0.56	0.39	2771	0.86	0.48	—	1.09	1.22	1353	4.32	4.92	—
	2	0.71	0.51	3681	1.32	0.85	36	1.32	1.31	478	3.94	2.48	24
	3	0.58	0.34	2123	0.80	0.44	—	1.05	0.88	1141	2.34	1.30	—
	5	0.80	0.58	1740	1.22	0.68	33	1.15	0.86	1239	1.92	0.98	27
	10	0.81	0.41	1709	1.10	0.62	29	1.16	0.69	1170	1.72	0.94	31
	11	0.77	0.37	2362	1.03	0.36	34	1.12	0.64	1722	2.04	0.79	26
	12	0.77	0.48	2110	1.08	0.43	32	1.07	0.77	1557	1.77	1.29	28
SUBJECT W23													
mult RI RI	60	0.78	0.58	2034	1.63	1.59	30	0.87	0.62	1995	1.77	1.39	30
mult RI EXT	1	0.65	0.49	2565	1.01	0.70	30	0.86	0.60	2189	—	—	—
	2	0.56	0.39	2625	1.04	0.97	33	0.93	0.70	1713	—	—	—
	3	0.61	0.47	2761	1.26	1.16	31	0.89	0.76	2052	—	—	—
	4	0.61	0.49	2534	1.02	0.94	31	0.91	0.70	1743	—	—	—
	5	0.59	0.43	1763	1.12	0.67	32	0.87	0.72	1301	—	—	—
	6	0.58	0.44	2609	0.83	0.41	30	0.89	0.83	1631	—	—	—
	7	0.58	0.40	3299	0.85	0.56	30	1.09	0.96	1521	—	—	—
	8	0.51	0.26	2535	0.72	0.25	31	1.26	1.20	846	—	—	—
	12	0.59	0.39	1969	0.82	0.28	—	1.39	1.20	464	—	—	—
	13	0.58	0.39	3086	—	—	30	1.79	1.53	598	—	—	—
	14	0.59	0.39	3254	—	—	—	2.11	1.53	485	—	—	—
	15	0.61	0.39	3490	0.87	0.34	30	1.78	1.51	311	—	—	—
mult RI RI	1	0.72	0.55	2308	1.41	1.45	37	1.08	0.85	1417	5.21	9.39	23
	2	0.60	0.36	2172	1.02	0.91	33	0.97	0.73	1383	1.88	1.47	27
	6	0.75	0.50	2135	1.12	0.48	33	0.95	0.67	1730	1.55	0.90	27
	10	0.72	0.54	2454	1.36	1.40	28	0.93	0.64	1861	1.74	1.12	32
	11	0.83	0.64	1964	1.65	1.39	32	0.90	0.62	1747	1.57	1.58	28
	12	0.78	0.54	2018	1.34	1.10	30	0.86	0.54	1756	1.40	0.44	30