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ON SOME CAUSES OF BEHAVIORAL CONTRAST[1]

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Responding at low rates was differentially reinforced in each of two components of a multiple schedule. In order to study the relative contributions to behavioral contrast in one component of the rates of responding, and of reinforcement in a second component, a series of visual stimuli correlated with the duration of each interresponse time was added to one component. The added stimuli resulted in a decreased rate of responding and hence an increased rate of reinforcement in that component. Despite the increase in the rate of reinforcement, the rate of responding without added stimuli in the other component increased (contrast), even though the increase resulted in less frequent reinforcement.

Responding during one component of a multiple schedule of reinforcement is influenced by responding and the consequences of responding during other components. In behavioral contrast (Reynolds, 1961*a*, 1961*b*) responding on a single schedule of reinforcement in component B increases when responding in component A decreases as the result of a change in schedule; the rates of responding change in opposite directions.

It is not clear what conditions in one component are necessary for producing contrast in another. It is known (Reynolds, 1961*a;* Reynolds and Catania, 1961) that contrast in component B can be produced by manipulating the frequency of reinforcement in component A. For example, if component A of a multiple schedule is changed to extinction or to less frequent reinforcement, the rate of responding in that component declines to a lower level, and the rate of responding in component B increases (contrast). Moreover, contrast does not occur in component B if reinforcement continues to occur in component A, even though the rate of responding in component A is reduced nearly to zero. This condition was arranged by presenting the reinforcer frequently during component A but only when no responses had occurred for 50 sec (a differential reinforcement of other behavior [DRO] schedule). It thus appeared that contrast in component B was dependent upon the decrease in the frequency of reinforcement during component A.

The present study attempted to clarify the relationship between contrast and rate of reinforcement by studying the effects on responding in component B of a decreasing rate of responding and an increasing frequency of reinforcement in component A.

METHOD

Subjects

Four adult White Carneaux pigeons were maintained at 80% of their free-feeding weights.

Apparatus

A standard experimental chamber for operant conditioning contained a transilluminated response key mounted 10.5 in. above the floor and operated by an effective force of 15 g, a magazine for presenting the reinforcer (3.5-sec access to grain), and a ventilating fan which also served to mask extraneous sounds. In addition, a vertical array of eight amber neon lamps in the right-front corner of the chamber (5.5 in. to the side of the response key) could be illuminated, one at a time, for 5 sec each, in consecutive order from top to bottom. Each lamp was 0.5-in. in diameter, and the eight were evenly spaced over a total distance of 10.5 in. A different lamp was lighted for each of seven successive 5-sec class intervals of time

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following each response. The eighth lamp remained lighted from 35 sec until a response occurred.

Procedure

The key-pecking of each pigeon was reinforced daily for 28 sessions on a two-component multiple schedule. Each component provided for differential reinforcement of low rates of responding (DRL schedule) by reinforcing only those responses that followed the preceding response by at least 35 sec. Each 90-min session consisted of three 15-min periods of DRL 35-sec with a green key alternated with three 15-min periods of DRL 35-sec with a red key. The color of the key was the only difference between the two components. During the next 16 sessions, the neon lamps were lighted sequentially during the interresponse time (IRT) following each response when the key was red, but not when the key was green. Each response when the key was red reset the IRT clock to its first position. The interresponse times were distributed into 5-sec class intervals for the 45 min of each component.

The performances for Sessions 24 to 28 (the last five sessions before adding the timing stimuli) have been grouped together as period 0. Sessions 29-33, 34-38, and 39-43 (Sessions 1-5, 6-10, and 11-15 after adding the clock) were similarly combined into periods 1, 2, and 3, respectively.

RESULTS

The performance of each bird in each component of the multiple schedule had been stable for at least 10 sessions when the IRT clock was added to the DRL during presentations of the red key. There was no immediate effect on the responding in either of the components of the multiple DRL schedule. Performances during the first one or two sessions with the clock did not differ systematically from previous performances without the clock. By the fifth session, however, responding in the component with the clock had begun to change gradually, and by the sixteenth session there were both a low rate of responding and many reinforcements.

Accompanying this decrease in responding in the DRL with the clock was a consistent increase in the rate of responding in the other DRL component—behavioral contrast. Figure 1 illustrates how the overall levels of responding in the two DRL components changed after the IRT clock was added when the key was red. The data for period 0 represent the level of the stable performance without the clock. The total responses in both DRL components in all periods have been normalized with respect to the totals for the two components in period 0. The average values across the two identical components of the schedule for the two periods of stable performance preceding period 0 were, for Birds D-1 to D-4 respectively: 0.94 and 0.96; 1.02 and 0.97; 0.97 and 0.98; and 1.04 and 1.01.

The development of the new performances is apparent in the distribution of interresponse times per opportunity (IRT/op). IRT/op is the conditional probability that a response will occur in a specific IRT interval, given that it may occur in that interval or any later interval. IRT/op is calculated by dividing the number of IRTs in a given class interval of IRT duration by the total number of IRTs of that duration and all longer durations. The IRT/op distributions for the IRT-clock DRL and normal DRL are shown in

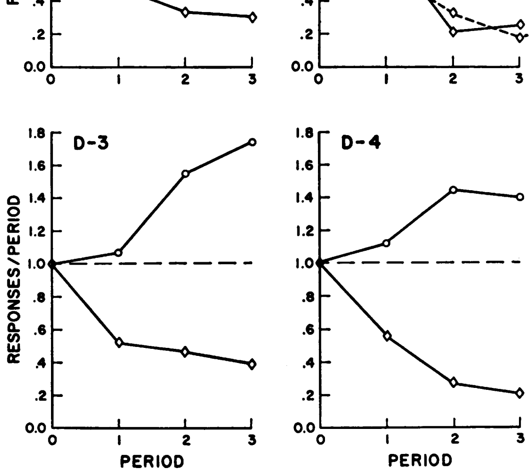

Fig. 1. The total number of responses per period of five sessions for each of four pigeons in each of two components of a multiple schedule.

Fig. 2, using the average of the data for all four pigeons. The IRT/op distributions for the individual pigeons did not differ systematically from the average.

Before the addition of the IRT clock (period 0), both DRL components had stable distributions characterized by an IRT/op of just below 0.50 for all class intervals except the last (35 sec), which, by definition, is always 1.0. Figure 2A shows the progressive development of the DRL performance in the DRL with the IRT clock in periods 1, 2, and 3. By period 3, the probability of responding before completion of the 35-sec DRL interval was small, so that there were few short IRTs and many long ones, and thus a lowering of the overall rate of responding.

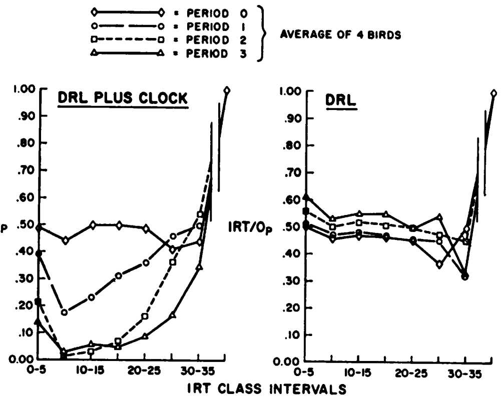

Fig. 2. The number of interresponse times per opportunity as a function of class intervals of IRT duration in each of two components of a multiple schedule.

The IRT/op distribution for the DRL without the clock (Fig. 2B) changed only slightly in shape, but the IRT/op for most of the shorter class intervals was consistently increased from period 0 to period 3. This small increase in IRT/op in the shorter IRT intervals corresponds to the increase in the overall rate of responding—the behavioral contrast effect.

As was expected with a DRL schedule, the changes in the rates of responding altered the numbers of reinforcements per session. Table I shows the reinforcements per period for the DRL components with added clock. The reinforcement frequency increased without exception and by factors that ranged from 3.9 for Bird D3 to 18.9 for Bird D4. At the same time, the reinforcements in the normal DRL component decreased consistently and by factors that ranged from 0.81 for Bird D1 to 0.36 for Bird D2. Thus, behavioral contrast occurred under conditions in which the contrast effect of increased responding in the normal DRL component resulted in a decreased frequency of reinforcement. Furthermore, the contrast occurred despite an increase in the frequency of reinforcement in the DRL with the clock.

REINFORCEMENTS PER PERIOD

		PERIOD			
SUBJECT	COMPONENT	0	1	2	3
D-1	DRL-CLOCK	16	49	61	165
	DRL	21	23	17	17
D-2	DRL-CLOCK	13	31	74	106
	DRL	14	21	9	5
D-3	DRL-CLOCK	58	109	132	225
	DRL	50	63	38	28
D-4	DRL-CLOCK	12	16	107	227
	DRL	17	13	10	13
AVERAGE	DRL-CLOCK	25	51	95	181
	DRL	25	30	18	16

DISCUSSION

The present data show that positive behavioral contrast may occur during one component of a multiple schedule (the normal DRL) even though the rate of reinforcement increases in the second component (the DRL with clock). This finding forces a reconsideration of a previous suggestion by Reynolds (1961*a*, *b*) that a decrease in the frequency of reinforcement in the second component, and hence an increase in the relative frequency of reinforcement in the first component, was a primary cause of behavioral contrast in the first component. It would be possible to rescue that speculation by appealing to the status of the separate stimuli composing the IRT clock as stimuli associated with non-reinforcement. It might be that contrast in the DRL component of the schedule was produced by the lack of reinforcement in the presence of a few or all of the seven negative stimuli. One consequence of such an appeal would be to point to the number of distinct negative stimuli as a possible cause of contrast regardless of their duration, and it may in fact prove proper to do so. Pavlov (1927) found an increasing magnitude of the respondent analog of contrast (what he called positive induction) as the number of preceding negative stimuli increased. On the other hand, such an account would ignore the fact that the frequency of reinforcement did increase in the presence of the stimulus on the key during which the IRT clock operated.

Another effort at rescuing the reinforcement interpretation of contrast may be made by considering pausing (not pecking), rather than pecking, to be the response reinforced by a DRL schedule and hence the response whose frequency should be counted in evaluating the occurrence of contrast. Under this assumption, the phenomenon reported here would be a negative, rather than a positive contrast; as the rates of pausing and reinforcement increase on the DRL with the IRT clock, the rate of pausing decreases in the other component. Such an assumption, while possibly useful, raises issues on which the present data do not bear. Moreover, the present data, in conjunction with other studies of contrast, provoke other considerations.

One common factor of the conditions in one component of a multiple schedule that have been shown to produce contrast in a second component is that they reduce the rate of responding. This occurs in extinction and also when the key is simply not illuminated (Reynolds, 1961*a*). The rate of responding is also decreased by adding punishment to a schedule of reinforcement (Brethower and Reynolds, 1962), as well as by reducing the frequency of reinforcement in the component causing the contrast (Reynolds, 1963). Finally, in the present data, the rate of responding was decreased by the addition of the IRT clock to the DRL schedule. All of these manipulations in one component of a multiple schedule generate behavioral contrast in another component, and all of them decrease the rate of responding. The terminal level to which responding decreases is not the same in all cases: it is near zero for extinction, at zero for an unilluminated key, and merely moderate but less than the formerly prevailing rate for the other cases. It thus seems that a decrease in the rate of responding may be implicated as one generative factor in the production of behavioral contrast.

Terrace (1963) has shown that a negative stimulus in whose presence no responses have ever been emitted does not produce contrast in a second component when employed in a multiple schedule. In the present context, this sort of stimulus does not produce contrast because it has not been an occasion for a decrease in the rate of responding, as has been suggested. It may be, though, that in this and in other cases not producing contrast, despite differences in the frequency of reinforcement between components of a multiple schedule, the organism simply fails to attend to the relevant, contrast-related, aspect of the stimuli.

The rate and relative frequency of reinforcement, however, cannot be neglected, even though the lack of contrast in Terrace's errorless procedure shows that non-reinforcement in one component of a multiple schedule is not always a sufficient condition for the production of contrast. One indication of the importance of the rate of reinforcement comes from the demonstration (Reynolds, 1961*a*) that contrast does not occur if reinforcement is delivered for not responding in the other component. Also, the relative frequency of reinforcement has been shown in a variety of studies to be a powerful predictor of the magnitude of contrast (Bloomfield, 1967; Reynolds, 1961*a*, 1961*b*, 1963).

It is important to note, though, that in Reynolds' (1961*a*) data, the frequency of reinforcement for not responding reached an extremely high level, on the order of four or five times as frequent as the reinforcement of responding in the component of the multiple schedule in which contrast failed to appear. This finding suggests that although rate and relative frequency of reinforcement are important in modulating behavioral contrast, they may be relatively weak variables in the sense that they must assume quite large values in order to be fully effective in eliminating contrast.

Another indication of the importance of frequency of reinforcement is suggested by a comparison of the present data with the behavioral contrast obtained by Reynolds and Catania (1961) by alternating a DRL schedule with simple extinction. The magnitude of the contrast they obtained was larger than the present one, indicating that the increased rate of reinforcement in the component with the IRT clock in these data may have limited the magnitude of contrast in the simple DRL component. Thus, it appears that when contrast is occasioned by a decreasing rate of responding, its magnitude may be limited to various degrees by the frequency of reinforcement.

The rate of responding and the rate of reinforcement are usually positively correlated and are separable only with such procedures as differential reinforcement of not responding, punishment, IRT clocks, and occasionally by adventitious superstitions. The chance initial exploitation of the idiosyncratically high rates of reinforcement afforded by differential reinforcement of not responding may account for the failure to recognize earlier the importance of changes in the rate of responding in the determination of behavioral contrast.

Finally, the lack of data on a potentially fundamental case of contrast should be noted. Because of the difficulty of producing a substantial and monotonic increase in the rate of responding, together with a substantial and monotonic decrease in the rate of reinforcement, it is not known whether this combination in one component of a multiple schedule would produce contrast in a second component.

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