

## BEHAVIORAL CONTRAST OF TIME ALLOCATION<sup>1</sup>

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Pigeons' standing on a platform produced food reinforcement according to two-component multiple schedules in which either both components consisted of the same variable-interval schedule or one of these was replaced with a component without reinforcement (extinction). The components of the multiple schedule alternated every 30 sec, and were signalled by changes in the color of diffuse overhead illumination. Changing the schedule of one of the components to extinction increased the percentage of time spent on the platform during the unchanged component (behavioral contrast). This result casts doubt on accounts that attribute behavioral contrast to variations in the rate of noninstrumental elicited responses.

*Key words:* behavioral contrast, time allocation, elicited responding, response definition, changeover, multiple schedules, pigeons

Behavior during one of the components of a multiple schedule has often been found to depend not only on the schedule of reinforcement associated with that component but also on the schedule of reinforcement associated with the other component. Behavioral contrast is an inverse relation between response frequency in an unchanged component and reinforcement value in the other component (Herrnstein, 1970; Reynolds, 1961). The strength of this relation appears to depend on a number of factors, including the duration of the components (Shimp and Wheatley, 1971; Todorov, 1972), the nature of the response (Westbrook, 1973), and the species under study (Rachlin, 1973). Herrnstein (1970) argued that interactions in concurrent and in multiple schedules result from the same process: sensitivity of responding to the relative, rather than absolute rate of reinforcement. He proposed the following equation as a description of these interactions:

$$P_A = \frac{KR_A}{R_A + mR_B + R_0} \quad (1)$$

where  $P_A$  is rate of responding in component A,  $R_A$  and  $R_B$  are rates of reinforcement in

components A and B,  $R_0$  is rate of reinforcement from all unprogrammed sources,  $K$  is a parameter that depends on the units of measurement, and  $m$  is a parameter representing the degree of interaction between components. In concurrent schedules, where the two alternative sources of reinforcement are simultaneously available,  $m$  equals 1; the relative rate of responding matches the relative rate of reinforcement. In multiple schedules, where the two alternative sources of reinforcement are successively available,  $m$  can have any value within the range of 0.0 to 1.0. Since at the moment of transition between components the effect of the previous source of reinforcement is larger than at any other moment (*e.g.*, Nevin and Shettleworth, 1966), Herrnstein predicts that, other factors being equal, the shorter the components, the stronger the interaction and the closer will the relative rate of responding match relative rate of reinforcement. Shimp and Wheatley (1971) and Todorov (1972) confirmed this prediction. Aside from this prediction, however, Herrnstein's formulation specifies none of the conditions that produce interaction in multiple schedules. It specifies

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only that once a particular value of  $m$  has been set, interaction will follow Equation 1.

Rachlin (1973) presented an alternative account of the relation of multiple to concurrent schedules of reinforcement. He proposed that the interactions produced by the two types of schedule, although superficially similar, arise from different underlying processes. Interaction in multiple schedules, according to Rachlin, results from responses elicited by the transition from a stimulus associated with a low reinforcement value to one associated with a higher reinforcement value. If these elicited responses have a topography similar to the responses producing reinforcement, response rate will increase (behavioral contrast). If, on the other hand, the responses differ in topography, the instrumental response will decrease (induction). Interaction in concurrent schedules, according to Rachlin, results from allocation of time spent at each alternative in such a way that the reinforcement values associated with them become equal. For example, if two concurrent components differ in rate of reinforcement, spending time at them in the same ratio as the ratio of the rates of reinforcement equates the rates of reinforcement per time spent.

Rachlin supports his position with two observations. First, interactions in concurrent schedules have been replicated under a great variety of conditions (de Villiers, *in press*), whereas interactions in multiple schedules appear less general. Second, only those combinations of stimulus and response that produce autoshaping with response-independent food reliably produced behavioral contrast with response-independent food (*e.g.*, Keller, 1974; Schwartz, 1975).

There are two possible ways to test this view of behavioral contrast. One can study interactions in multiple schedules with discriminative stimuli known to elicit no response topographically similar to the instrumental response. Alternatively, one can study time allocation, instead of discrete responses, to avoid possible interaction or summation of discrete responses. The present study combined these two strategies. Standing on a platform was reinforced in multiple schedules with components signalled by changes in diffuse overhead illumination. The use of changes in diffuse illumination makes it unlikely that any contrast observed could be at-

tributed to directed autoshaped pecks. A non-specific instrumental response like standing on a platform should escape summation with specific elicited responses.

## METHOD

### *Subjects*

Three White Carneaux pigeons with previous experimental experience in a variety of procedures involving key pecking were kept at approximately 80% of their free-feeding body weights.

### *Apparatus*

The experimental space measured 152 cm long and wide by 49.5 cm high. It was enclosed in a plywood box lined with white composition board (Celotex). The floor consisted of sheet aluminum with holes punched in it. A 23-cm by 23-cm platform was located adjacent to the center of one wall at floor level. The platform was composed of a wire grid. When depressed, it operated microswitches that allowed recording of time spent on it. An aluminum panel the same width as the platform and 29 cm high, mounted on the wall in front of it, contained a round hole, 5 cm in diameter, its center 11 cm from the floor and in line with the center of the platform. Through this hole, a magazine (Lehigh Valley Electronics) containing mixed grain could be made available. Two 28-V dc light bulbs were mounted above the hole, 27 cm from the floor. Two 25-W ac light bulbs, one red and one green, were mounted on the ceiling, each 7.5 cm (center distance) from the midline and 15 cm (center distance) from the wall containing the grain magazine. Their ends were 39 cm from the floor. A loudspeaker on the ceiling provided white noise for masking extraneous sounds.

Events were arranged and recorded with electromechanical equipment located in the same room as the experimental chamber.

### *Procedure*

Initial training consisted in frequent presentation of grain, at first independent of behavior, and then only when the pigeon was standing on the platform. Neither the red nor the green stimulus light was on. After the pigeons were eating regularly from the magazine and standing on the platform most of the

time, they were switched to the first condition shown in Table 1: a multiple variable-interval variable-interval schedule, in which the red light was on during one component and the green light was on during the other. As long as the bird stood on the platform, the two small lights above the food magazine were lit, and reinforcement—3-sec access to grain—if available, was delivered according to the variable-interval (VI) schedule. During preliminary training, a schedule was selected for each animal that was lean enough to allow contrast to occur (*i.e.*, to avoid a “ceiling” effect), but rich enough to maintain stable performance. For Birds 44 and 60, the schedule was VI 8-min; for Bird 127, it was VI 4-min. The intervals were drawn from the progression suggested by Fleshler and Hoffman (1962).

The pigeons were exposed to the sequence of multiple schedules shown in Table 1. When the VI schedule operated in both components, the same programmer scheduled reinforcement in both components. If extinction was in force in a component, the programmer stopped during that component, and reinforcement was prevented. When operating, the programmer advanced until reinforcement was scheduled, regardless of whether the pigeon was on the platform or not. Once a reinforcement was scheduled, the programmer stopped until it had been delivered. A changeover delay (COD) prevented reinforcement for 1.5 sec after the bird stepped onto the platform.

The components alternated every 30 sec. A session ended after 120 components had been presented. Sessions were run daily.

## RESULTS

Figure 1 shows for each pigeon the percentage of time spent on the platform for each component. For all birds, the percentage of time spent on the platform during the unchanged component of the multiple schedule increased when the schedule associated with the other component was changed to extinction. This result was replicated with both the red and the green lights as the signals associated with the unchanged component. The magnitude of the positive behavioral contrast varied within a range of 20% to 30% absolute increase in the percentage of time on the platform, and was of about the same magnitude as the decrease in the percentage of time

Table 1

Order of conditions and number of sessions each condition lasted.

Multiple Schedule Components		Sessions		
Red	Green	Bird 127	Bird 44	Bird 60
VI*	VI*	28	82	82
EXT	VI*	35	34	35
VI*	VI*	67	44	63
VI*	EXT	40	40	40

\*VI 4-min for Bird 127; VI 8-min for Birds 44 and 60.

on the platform during the component associated with extinction.

The left panels of Figure 2 show for each pigeon the mean rate of platform depression for each component during the last five sessions of each condition. It was calculated by dividing the number of depressions by the total time that the pigeon was off the platform. The reciprocal of this measure represents the latency of the platform depressions. The right panels show for the same sessions and for each component the mean time in minutes spent on the platform each time it was depressed.

These two measures were related to behavioral contrast in a different way for each pigeon. For Bird 127, behavioral contrast was a consequence of an increase in the time on the platform associated with each depression, whereas for Bird 44 it resulted from an increase in the rate of platform depression. A combination of these two patterns accounts for the behavioral contrast observed in Bird 60.

## DISCUSSION

These results indicate that time allocation can follow the same pattern of behavioral contrast in multiple schedules as does the rate of key pecking. Just as behavioral contrast with pecking can be compared to distribution of pecking between concurrent VI schedules (Herrnstein, 1970), the behavioral contrast of time allocation here can be compared to time allocation between concurrent VI schedules (Baum and Rachlin, 1969). In both comparisons, both behavioral contrast and reinforcement matching can be attributed to the same sensitivity to relative rate of reinforcement (Equation 1).

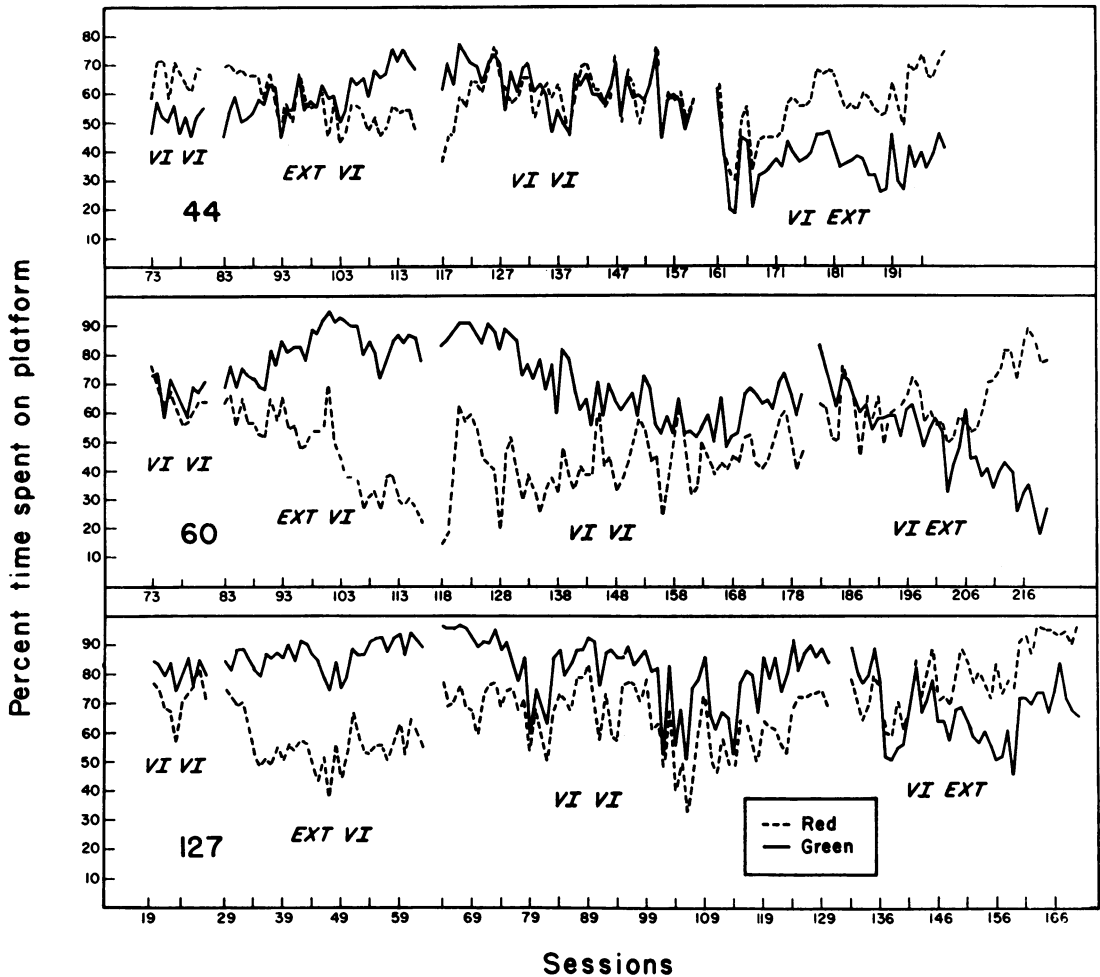


Fig. 1. Day-by-day percentage of time spent on the platform in each component of the various multiple schedules. Each row shows data for one pigeon. The internal labels always give the schedule prevailing in red first; e.g., "EXT VI" means that extinction was in force in red, variable interval in green.

Taken at face value, the results disconfirm Rachlin's (1973) notion that relative reinforcement affects behavior in concurrent and multiple schedules through two different mechanisms. One could postulate unobserved pecking at the stimulus lights or something in their vicinity. The behavioral contrast obtained would result from the birds' stepping onto the platform in order to peck. Occasional observation produced no evidence that the pigeons were pecking at the stimulus lights. Some other response, however, could be substituted for the sake of argument. Although such reasoning might explain the results, it extends Rachlin's hypothesis to the point where it approaches irrefutability.

The results presented in Figure 2 indicate

that the contingencies of the present experiment produced different response patterns for the three pigeons. Only Bird 44 produced a constant average duration of pressing the platform that could be construed as a discrete response like a lever press or key peck. As in other experiments on multiple schedules with discrete responses, contrast for Bird 44 resulted from an increase in response rate. Bird 127, on the other hand, produced a pattern consistent with characterizing standing on a platform as a continuous activity: contrast resulted from an increase in average duration of standing on the platform, with no effect on rate of platform pressing. That the two birds' disparate activity patterns both produced behavioral contrast further reduces the proba-

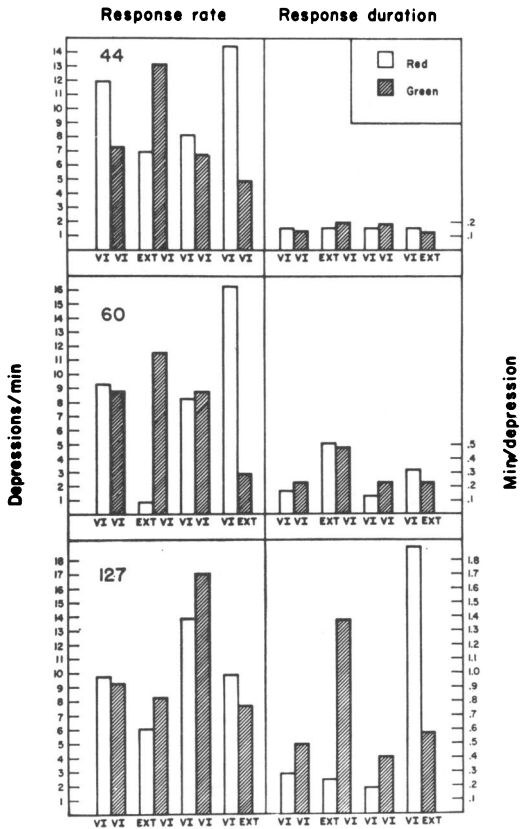


Fig. 2. Rate of platform depression (left panel) and average time in minutes spent on the platform each time it was depressed (right panel), averaged over the last five days of each condition. Each panel shows data for one pigeon.

bility that the increase in the time standing on the platform was only a byproduct of elicited responding.

There is at least one difference between the results presented in Figure 1 and those obtained when key pecking is reinforced according to a *mult* VI EXT schedule and the discriminative stimuli are displayed on the instrumental key. In the latter experiments, key pecking virtually vanishes during the component associated with extinction, whereas in the present experiment, the time spent on the platform decreased only slightly. It may be more difficult to establish stimulus control with diffuse stimuli than with localized stimuli. Alternatively, the failure to eliminate responding may have been due to the low cost of standing on the platform. The leanness of the VI schedules needed to reduce the percentage of time spent standing on the platform be-

low 100% supports this view. Finally, in the absence of a timeout between components, it was possible for standing on the platform during the extinction component to be accidentally reinforced by a reinforcer presented at the beginning of the unchanged component.

The present results are at odds with the failure to find contrast when treadle pressing replaced key pecking (Hemmes, 1973; Westbrook, 1973). In view of the report by Spearman and Gollub (1974) that there is a larger contrast in key pecking when a small, rather than a larger, reinforcement density is associated with the multiple schedule, it is possible that the discrepancy may have resulted from our use of very lean schedules instead of the relatively rich schedules (VI 1-min) used by Hemmes and by Westbrook. If so, this would imply that the reinforcement density critical to produce contrast depends on the topography of the response. This conclusion remains uncertain, however, due to the ambiguity of the results presented by Hemmes and by Westbrook. In Westbrook's experiment, there was little evidence that the pigeons discriminated between the two components of the multiple schedule; in Hemmes's experiment, the phase associated with a *mult* VI EXT schedule was studied for only 10 days. In the present experiment, more than 20 sessions were required before contrast was observed. Topographical changes in the response under study render Westbrook's (1973) results still more ambiguous. He recorded the duration of each treadle press in addition to its frequency, and found for all pigeons an increase in response duration after the transition to extinction. The increase in response duration was larger during the unchanged than the extinction component, suggesting that response duration was a more sensitive index of the changes in the relative rate of reinforcement. The change in the topography of the response makes it impossible to evaluate the failure to obtain contrast in the count of microswitch closures.

In a related experiment, Scull and Westbrook (1973) also failed to obtain contrast in pigeons on a two-component multiple schedule with a different instrumental response—key pecking or lever pressing—associated with each component. Neither of the two responses increased in frequency during the extinction of the other. On the other hand, contrast appeared when the same response was associated

with both components. Equation 1 can accommodate these findings if it is assumed that the constant  $m$  (degree of component interaction) varies along a dimension of response similarity. These findings are damaging for the elicitation theory of contrast, because they suggest that a keylight associated with reinforcement in alternation with a period of extinction is not a sufficient condition for behavioral contrast of pecking.

In conclusion, the present results suggest that interactions in multiple schedules are not due to elicited responding, but rather are due to the influence of relative value on responding.

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