STIMULUS-REINFORCER CONTINGENCIES AND LOCAL BEHAVIORAL CONTRAST[1]

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Four pigeons were exposed to a series of multiple schedules of variable-interval reinforcement in which pecks were required on one key (operant key) and components were signalled on a second key (signal key). Four additional pigeons experienced identical conditions, except that a yoking procedure delivered food on variable-time schedules, with no key pecks required. One of the components of the multiple schedule was constant throughout the experiment as a variable-interval (or variable-time) 30-second schedule. Operant-key responding during the constant component was uniform throughout the component, uninfluenced by changes in the duration of the variable component, and only slightly influenced by changes in reinforcement frequency correlated with the variable component. By comparison, signal-key response rate during the constant component was highest at the onset of the component, was higher when the variable component was 60-sec long than when it was 1-sec long, and was higher when no reinforcement occurred in the variable component than when reinforcement was scheduled in the variable component. These characteristics of signal-key pecking matched characteristics of local positive behavioral contrast. These data are taken to support the "additivity theory" of behavioral contrast and to suggest that Pavlovian stimulus-reinforcer relations contribute primarily to the phenomenon of local positive contrast.

Key words: behavioral contrast, local contrast, additivity theory, stimulus-reinforcer relations, multiple schedules, key pecking, pigeons

A number of investigators (e.g., Gamzu and Schwartz, 1973; Hearst and Jenkins, 1974; Rachlin, 1973) have suggested that the phenomenon of positive behavioral contrast in pigeons may be accounted for as a summation of Pavlovian conditioned key pecks and operant key pecks. The prototypic demonstration of positive contrast (Reynolds, 1961) involves first exposing pigeons to a multiple variable-interval variable-interval (mult VI VI) schedule, and when response rate has stabilized, changing the schedule to multiple variable-interval extinction (mult VI EXT). As response rate decreases in the EXT component of the multiple schedule, response rate concomitantly increases in the unchanged VI component. Since the change from mult VI VI to mult VI EXT introduces a differential, predictive relation between the VI signal and food, and since the presence of such a differential relation is both necessary and sufficient to engender pecks at the signal (e.g., Gamzu and Schwartz, 1973; Gamzu and Williams, 1971, 1973), contrast can be viewed as a summation of these newly engendered pecks with already maintained operant pecks. A number of predictions derived from this "additivity" theory of contrast have been supported empirically, clearly indicating that summation of operant and reflexive pecks provides at least a partial account of contrast (see Schwartz and Gamzu, 1977, for a review.)

However, contrast has occasionally been observed under conditions in which it would not be predicted on the basis of the additivity theory. For example, additivity theory predicts that contrast will not be observed unless the differential signal for food and the operant manipulandum share the same location. If they do not, then while Pavlovian and operant responses may both occur, they will not be directed at the same place, and thus will not sum. Yet, Beninger and Kendall (1975) and Gutman, Sutterer, and Brush (1975) observed positive behavioral contrast with rats as subjects with procedures in which the differential signal for food was located away from the ma-

nipulandum. Hemmes (1973) reported similar results for pigeons. And Bouzas and Baum (1976) observed contrast in pigeons when the differential signal for food was diffuse overhead illumination and the recorded operant was time spent in one or another part of the chamber. These contradictory data have led to suggestions that behavioral contrast is not a unitary phenomenon (Hearst and Gormley, 1976), and to efforts to explain exactly how response additivity contributes to behavioral contrast.

In one such effort, Schwartz, Hamilton, and Silberberg (1975) suggested that response additivity might account only for *local* positive behavioral contrast. The designation "local positive contrast" refers to the observation that responding during the VI component of a *mult* VI EXT schedule may be substantially higher at the beginning of the component than subsequently. Local contrast has not been studied extensively, but much available evidence is consistent with the additivity theory of contrast (see Schwartz and Gamzu, 1977, for a discussion). First, there is evidence that the magnitude of local contrast increases as a function of the duration of the immediately preceding EXT component (Staddon, 1969). This finding is consistent with observed effects of intertrial interval (ITI) duration on Pavlovian conditioned key pecking (Terrace, Gibbon, Farrell, and Baldock, 1975). Second, Schwartz *et al.* (1975) observed, with a procedure designed to separate spatially operant and Pavlovian key pecks on multiple schedules, that Pavlovian pecks tended to occur exclusively in the first 10 sec of each 2-min VI component. Spealman (1976) also observed that Pavlovian key pecks occurred at a higher rate at the beginning of a component than subsequently. Though some aspects of local contrast—its sensitivity to the particular discriminative stimuli used and to the degree to which a discrimination is mastered (Malone, 1976)—are not obviously compatible with additivity theory, the data relating additivity theory to local contrast (Schwartz *et al.,* 1975; Spealman, 1976) seem to suggest that the contribution of Pavlovian contingencies to behavioral contrast may in fact be largely restricted to local contrast.

The present experiment was designed to explore further the relation between Pavlovian contingencies and local behavioral con-

trast. One group of pigeons (variable-interval or VI group) was exposed to a series of multiple schedules in which pecks were required for reinforcement on one key (operant key) while the components of the schedules were signalled on a different key (signal key). Procedures like this have successfully separated operant and Pavlovian contributions to positive contrast (Keller, 1974; Schwartz, 1975; Schwartz, Hamilton, and Silberberg, 1975; Spealman, 1976). While one component of the multiple schedule was held constant throughout the experiment, the second component varied, either in duration or in reinforcement frequency. To the extent that contrast is the result of Pavlovian conditioning, these variations in reinforcement frequency and component duration —known to affect behavioral contrast—were expected to affect predominantly signal-key responding. And to the extent that Pavlovian conditioning contributes to *local* contrast, it was expected that local-contrast-like effects would be restricted to the signal key. Specifically, it was expected that operant-key pecking during the constant component would be maintained at a uniform rate throughout the component, and would be uninfluenced by different durations of the variable component, and by different reinforcement frequencies correlated with the variable component. By comparison, it was expected that signal-key pecking in the constant component would be highest at the onset of the component (local positive contrast), and would decrease as the duration of the variable component decreased and as the reinforcement frequency in the variable component increased.

While the spatial separation of Pavlovian and operant contingencies has seemed successfully to separate Pavlovian and operant contributions to behavioral contrast, the possibility exists that responding on the signal key is in some way influenced by concomitant responding on the operant key. Thus, a second group of pigeons (variable time or VT group) was included in the experiment. This group was yoked to the first group so that conditions were identical to those of the first group, except that food was always delivered independent of responses. It was expected that this group would peck only at the signal key, and that the pattern and frequency of signal-key responses observed would match those observed in the VI group.

METHOD

Subjects

Eight White Carneaux pigeons, aged 3 to 5 yr, with varied and extensive experimental histories, were maintained at 80% of free-feeding weights.

Apparatus

Four identical Gerbrands pigeon chambers (G 7313), contained three-key pigeon panels. The keys were Gerbrands normally-closed keys, requiring a force of 0.1 N to operate. They were spaced 7.5 cm apart, center-to-center, and were located 21 cm above the grid floor. A grain hopper was located directly below the center key, 5.5 cm above the grid floor, and a pair of houselights was located in the center of the ceiling of the chamber. The houselights were illuminated throughout experimental sessions, except during feeder operation when a light in the feeder was illuminated. Scheduling of experimental events, data collection, and data analysis were accomplished with a Digital Equipment Corporation PDP 8/E digital computer using SKED software (State Systems Incorporated, Kalamazoo, Michigan).

Procedure

The pigeons in the variable-interval (VI) group (P1 to P4) were exposed to a series of procedures (described below) in which key pecks were reinforced on a VI schedule with the interreinforcement intervals randomly distributed. The pigeons in the variable-time (VT) group (P1Y to P4Y) were yoked to the pigeons in the first group so that whenever a pigeon in the VI group produced food with a key peck, food was also delivered to its yoked, VT partner. In all respects, aside from the presence or absence of a dependency between key pecks and food, conditions for the two groups of pigeons were identical.

Throughout each daily session (except during feeder operations), the center key was illuminated with white light. For the VI pigeons, pecks on the center key (operant key) were required to produce food. Periods of food availability were signalled by the color of the left key (signal key), which alternated between red and green. Reinforcement consisted of 4-sec access to mixed grain. Each session consisted of 50 cycles of red and green left-key illumination and their correlated reinforcement conditions.

The pigeons were exposed to a series of procedures that differed only in the conditions correlated with the green left key. Through all procedures, the red left key was correlated with a VI 30-sec reinforcement schedule for responding on the white center key (or VT 30-sec for pigeons in the VT group), and periods of red-key illumination were fixed at 20 sec.

The series of conditions correlated with green left key for pigeons in the VI group is presented in Table 1. Conditions were identical for the VT group, except that food delivery was independent of responding. During Conditions 1 to 5, the duration of the variable component was manipulated while the frequency of food delivery was constant. In Conditions 6 to 11, the frequency of food delivery was manipulated while component duration was constant. In the first five conditions, food was not available when the left key was green (extinction). Thus, the procedures were *mult* VI 30-sec EXT for the VI group and *mult* VT 30-sec EXT for the VT group. The duration of the green-key component of the multiple schedule was either 60 sec or 1 sec. During Conditions 1 and 3, when the duration of green-key components was 60 sec, the duration of individual components was variable. Component durations of 20, 40, 60, 80, or 100 sec were ordered semirandomly, but occurred with equal frequency. The purpose of these procedures was to explore whether response rate during the constant (red key) component was affected by the duration of the immediately preceding variable (green key) component, as has been

Table 1

Sequence of conditions signalled by green left key for pigeons in the VI group.

	Schedule	Component Duration	Fixed or Variable
1	Extinction	60 sec	Variable
2	Extinction	1 sec	Fixed
3	Extinction	60 sec	Variable
4	Extinction	1 sec	Fixed
5	Extinction	60 sec	Fixed
6	Extinction	20 sec	Fixed
7	VI 60-sec	20 sec	Fixed
8	VI 30-sec	20 sec	Fixed
9	VI 15-sec	20 sec	Fixed
10	VI 30-sec	20 sec	Fixed
11	Extinction	20 sec	Fixed

observed in other studies of multiple schedule performance (Staddon, 1969). At all other times, the duration of the green component was fixed.

In Conditions 6 to 11, the duration of the green component was held constant at a fixed, 20-sec value (identical to red-component duration), and what varied from condition to condition was the schedule of reinforcement correlated with green.

Throughout the experiment, pecks on both the white operant key and the green or red signal key were recorded separately for each quarter of the component (5-sec periods in red and either 5- or 15-sec periods in green). Each condition was planned to last for 21 sessions, as long as overall response rate in the last five sessions on both signal and operant keys during each multiple schedule component did not deviate from the mean of the last five sessions by more than 10%. This stability criterion was met without exception through all experimental conditions.

RESULTS

Figure 1 presents response rates during Conditions 1 to 5 for pigeons in the VI group during the constant component (red signal key) as a function of the duration of the variable component (green signal key), which was either 60 sec or 1 sec (designated in the figure as the ITI or intertrial interval). Rates on the signal and operant keys are presented separately for each quarter of the constant component (5 sec). Virtually no responding on either key occurred during the variable component, which was correlated with extinction, so those data are not presented.

Operant-key responding did not vary systematically as a function of the duration of the variable component. There was occasional variation in the rate of operant-key responding within the component (panels 1 and 3 for Pigeon 1; panel 3 for Pigeon 3; panel 1 for Pigeon 4). However, for the most part, operant-key responding was as constant within components as it was across conditions.

In contrast, signal-key responding displayed definite within-component patterning, and was markedly affected by the duration of the variable component. Only Pigeon 3 pecked the signal key during the constant component when the variable component was 1 sec in

duration. All four pigeons pecked the signal key when the variable component was 60 sec in duration. Under these conditions (first, third, and fifth panels), signal-key pecking generally was highest in the first quarter of the component and decreased precipitously (often aproaching zero) as the component continued. Only Pigeon 3 (first and third panels) deviated from this pattern, with increased rate as the component continued.

Table 2 presents overall response rates during the constant, red signal-key component, summed over operant and signal keys, for each of Conditions 1 to 5. While Conditions 1, 3, and 5 are conventional multiple schedule procedures, Conditions 2 and 4 are more like simple VI procedures, since the green signal key, extinction component was only 1 sec in duration. Table 2 indicates that total responding during the red component was substantially higher during Conditions 1, 3, and 5. This result is analogous to demonstrations of positive behavioral contrast in which the schedules compared are simple VI and *mult* VI EXT. It is clear from Table 2 and Figure 1 that the contrast effect results entirely from changes in signal-key responding across conditions. Moreover, the distribution of signal-key responding depicted in Figure 1 clearly indicates that the contrast effect is largely a local one. Thus, all four pigeons in this group displayed a contrast effect produced by signal-key responding, and for three of the four, it was a local contrast effect.

Data similar to those in Figure 1 are presented for the VT pigeons in Figure 2. These pigeons virtually never pecked the operant key, nor did they peck the signal key when it was green (signalling the variable component, extinction), so these data are not presented. Generally, the pattern of signal-key respond-

Table 2

Responses per minute during the constant component (red signal key), summed across operant and signal keys, for Conditions 1 to 5. Data are averaged across the last five sessions of each condition.

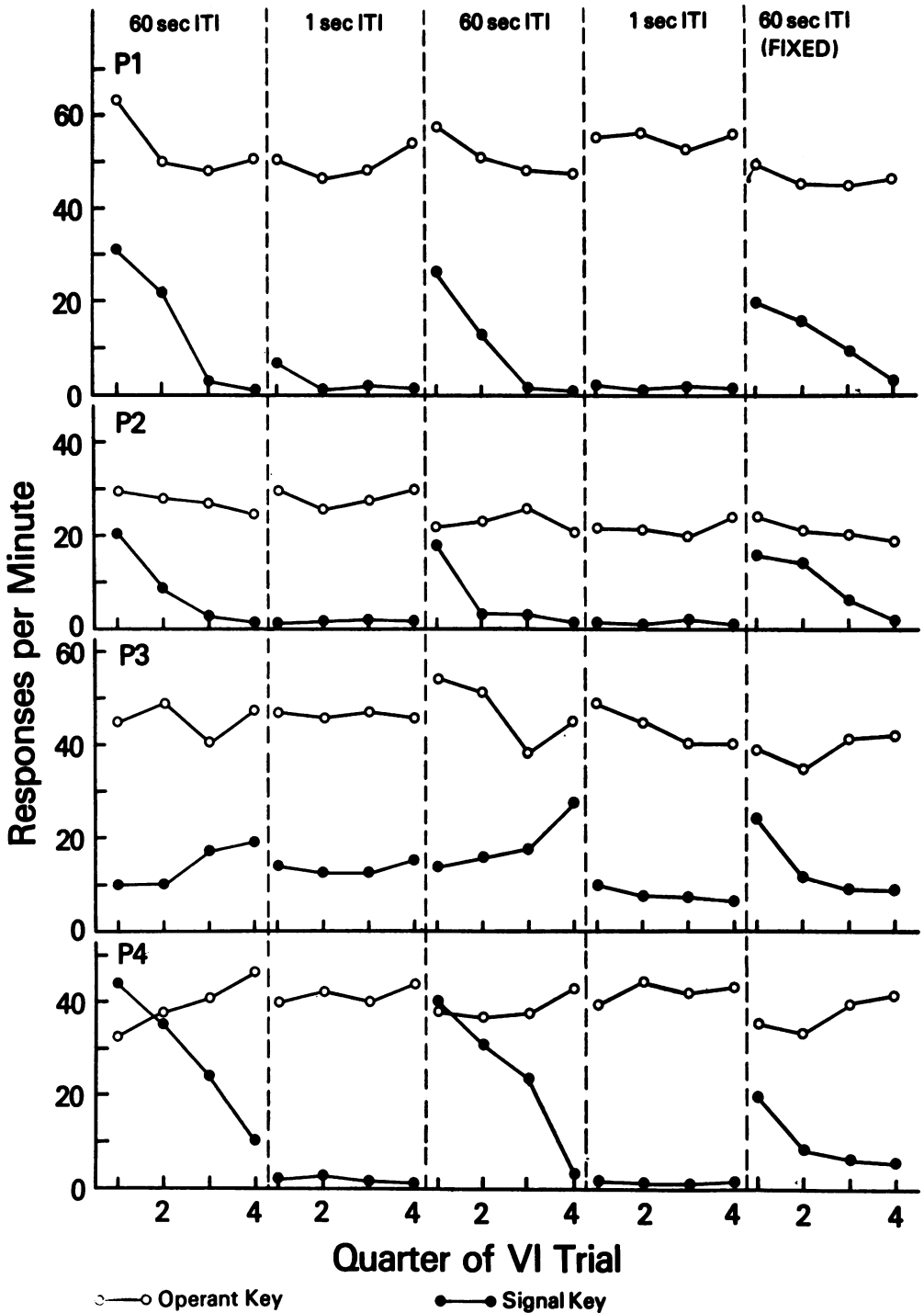| Condition	Pigeon			
	1	*2*	*3*	*4*
1	65.7	36.6	62.0	68.7
2	51.9	30.6	59.4	42.1
3	64.9	33.5	62.9	64.1
4	57.5	22.2	55.2	39.1
5	61.8	34.1	55.8	50.6

Fig. 1. Responses per minute, averaged across the last five sessions of each procedure, on the operant and signal keys during the constant VI 30-sec component of the multiple schedules. Response rate is plotted separately for each 5-sec quarter of the 20-sec component. The other multiple schedule component was always correlated with extinction, and what varied from one procedure to the next was its duration (identified at the top of each panel as an intertrial interval, or ITI).
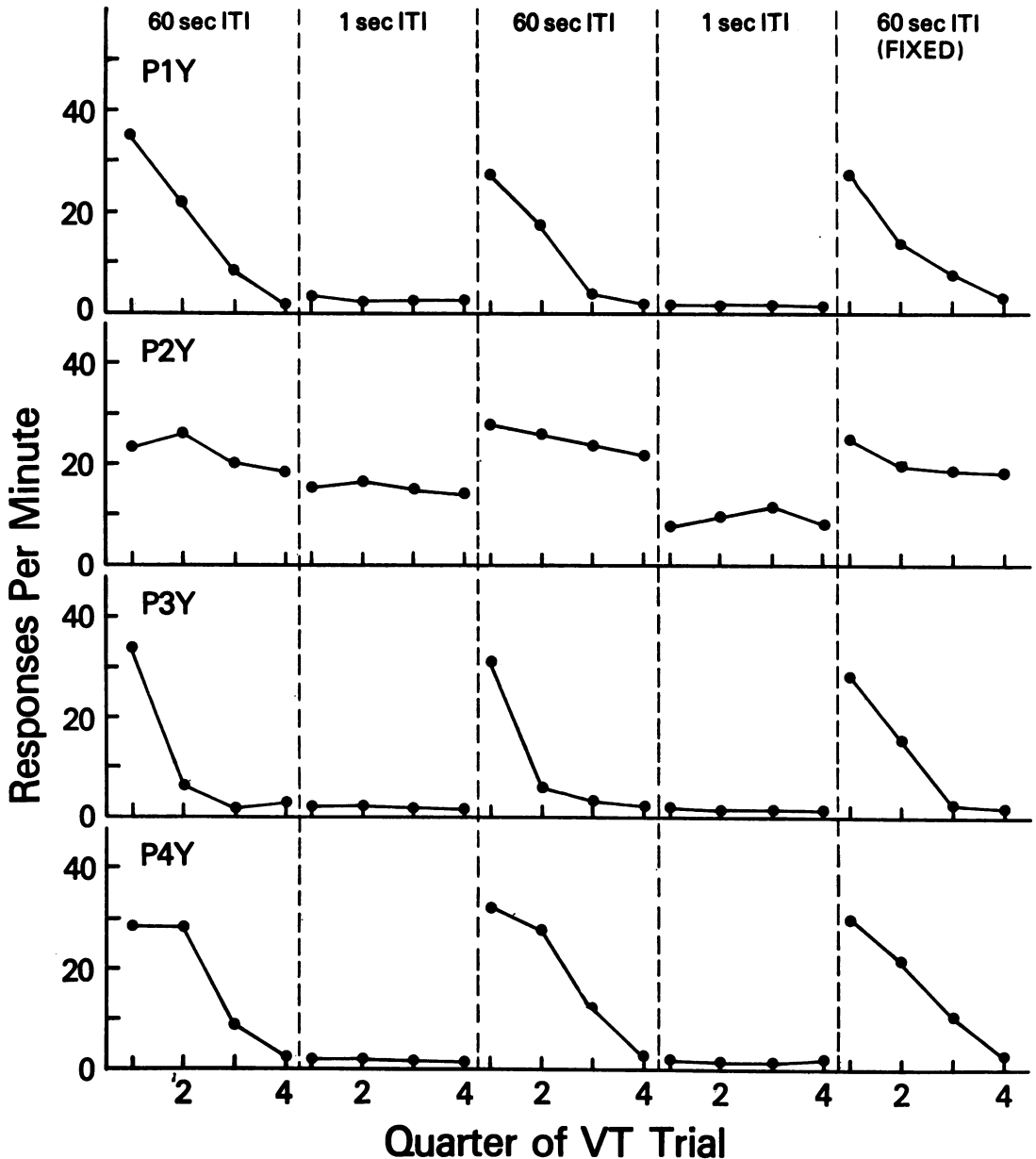
Fig. 2. Responses per minute, averaged across the last five sessions of each procedure, on the signal key during the constant VT 30-sec component of multiple schedules. Response rate is plotted separately for each 5-sec quarter of the 20-sec component. The other multiple schedule component was always correlated with extinction, and what varied from one procedure to the next was its duration (identified at the top of each panel as an intertrial interval, or ITI).

ing during the constant component was similar for these pigeons as for the pigeons in the VI group. Only Pigeon 2Y pecked the signal key at appreciable rates when the variable component was 1 sec in duration. All pigeons but Pigeon 2Y pecked the signal key appreciably more in the first quarter of the constant

component than in subsequent quarters, and response rate decreased in an orderly fashion as the component continued. For all pigeons but Pigeon 2Y, this temporal patterning of responding within the component was dramatic. Thus, signal-key pecking was very similar for VI and VT pigeons. In both groups,

signal-key pecking resembled typical demonstrations of local positive behavioral contrast.

In the first and third conditions, the duration of the *variable* component differed from one component to the next. Though the average duration was 60 sec, individual components were either 20, 40, 60, 80, or 100 sec. The duration of the immediately preceding component had no effect on responding on either the signal key or the operant key, for either the VI or the VT pigeons.

The effects of variations in reinforcement frequency in the variable component, with component duration held at 20 sec, are shown in Figure 3 for the VI group, averaged across the last five sessions of each procedure. Responses per minute, on both operant and signal keys, in each quarter of both constant and variable components are presented. Operant- and signal-key responding during green are omitted from the first panel, since very few responses occurred in this condition. Each panel is identified by the reinforcement schedule in effect in the variable component. Consider first responding in the constant component (red signal key). Operant-key rate (open circles) was uniform within the component. There was no sign of local contrast in the first quarter of the component. Across conditions, response rate on the operant key was only moderately (though consistently) influenced by the reinforcement schedule in the variable component.

The first four panels of Figure 3 indicate that responses on the operant key decreased somewhat as the reinforcement rate in the variable component was increased. These changes generally were of small magnitude, although they were consistent both within and between subjects. For example, in the case of Pigeon 3 (which showed the largest decrease) the following average rates occurred as the schedule in the variable component was changed from extinction to VI 15-sec (panels 1 to 4, respectively): 45, 42, 38, and 34 responses per minute.

By comparison with operant-key responding, signal-key responding in the constant component (filled circles) was extremely sensitive to the schedule in force during the variable component. The pigeons pecked the red signal key at substantial rates when extinction was scheduled in the variable component. They pecked the key somewhat less when a VI 60-sec sched-

ule was in force in the variable component. They pecked very little, if at all, when a VI 30-sec schedule was in effect in the variable component, and somewhat more when a VI 15-sec schedule was in effect in the variable component. With the exception of Pigeon 3, at all times when appreciable pecking at the red signal key occurred, its distribution within the component was analogous to local positive contrast, and similar to the pattern depicted in Figure 1. Thus, signal-key responding occurred only when red and green signalled different reinforcement frequencies, *i.e.*, when red was a differential predictor of food.

The conditions in this experiment that most closely correspond to standard demonstrations of positive behavioral contrast are Conditions 10 and 11, the last two panels of Figure 3. These conditions involved a transition from *mult* VI 30-sec VI 30-sec to *mult* VI 30-sec EXT. Table 3 presents response rates in the constant VI 30-sec component on the operant key alone and summed across operant and signal keys for these two conditions. The data are averaged for each pigeon across the last five sessions of each condition. Contrast effects on the operant key alone were quite small, except for Pigeon 3. On the other hand, contrast effects across both keys were substantial, for all four pigeons.

Figure 4 presents data analogous to those in Figure 3 for the pigeons in the VT group. Only signal-key responding is presented, since virtually no pecks were directed at the operant key, and in the first panel, only red signal-key responding is presented because no green signal-key responses occurred. The pattern of signal-key responding by these pigeons was very much like that observed in the VI pigeons. Signal-key responding in the constant

Table 3

Responses per minute during the constant component (red signal key), on the operant key and summed across the operant and signal keys, for Conditions 10 and 11 (VI 30-sec VI 30-sec and VI 30-sec Extinction). Data are averaged across the last five sessions of each procedure.

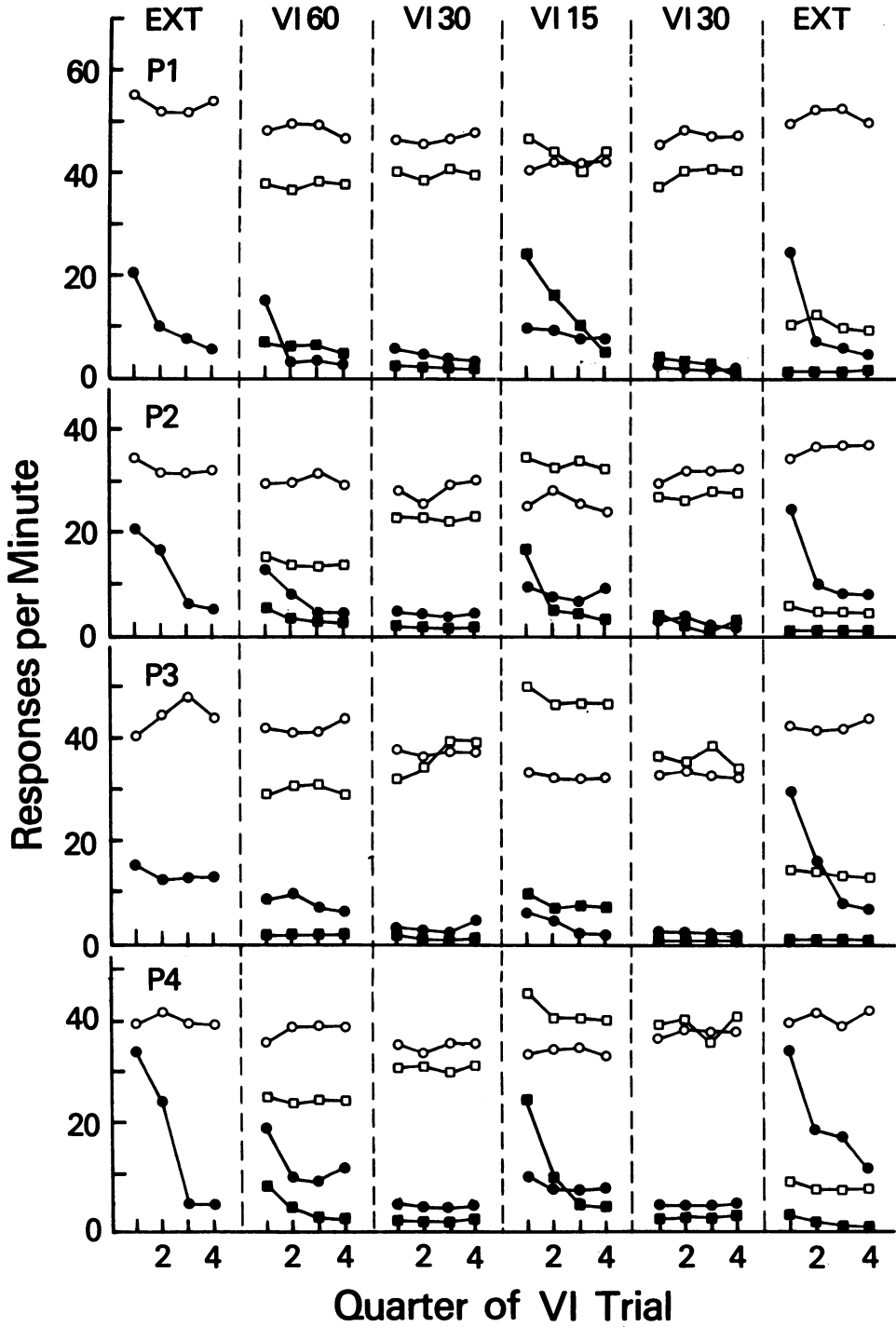| | | Pigeon | | | |
	Schedule	P-1	P-2	P-3	P-4
Operant Key	VI 30 VI 30	47.5	32.0	33.2	38.8
	VI 30 EXT	51.0	37.0	43.0	42.1
Operant Key and	VI 30 VI 30	48.6	34.2	33.2	42.1
Signal Key	VI 30 EXT	61.9	51.3	58.5	63.9

Fig. 3. Responses per minute in each quarter of the multiple schedule, on both operant and signal keys. Data are averaged across the last five sessions of each procedure. One multiple schedule component was always corre-lated with a VI 30-sec schedule of reinforcement. Operant-key pecks during this component are indicated by open circles and signal-key pecks by filled circles. The other multiple schedule component was correlated with different reinforcement schedules, identified at the top of each panel. Operant-key pecks during this compo-nent are indicated by open squares, and signal-key pecks by filled squares.
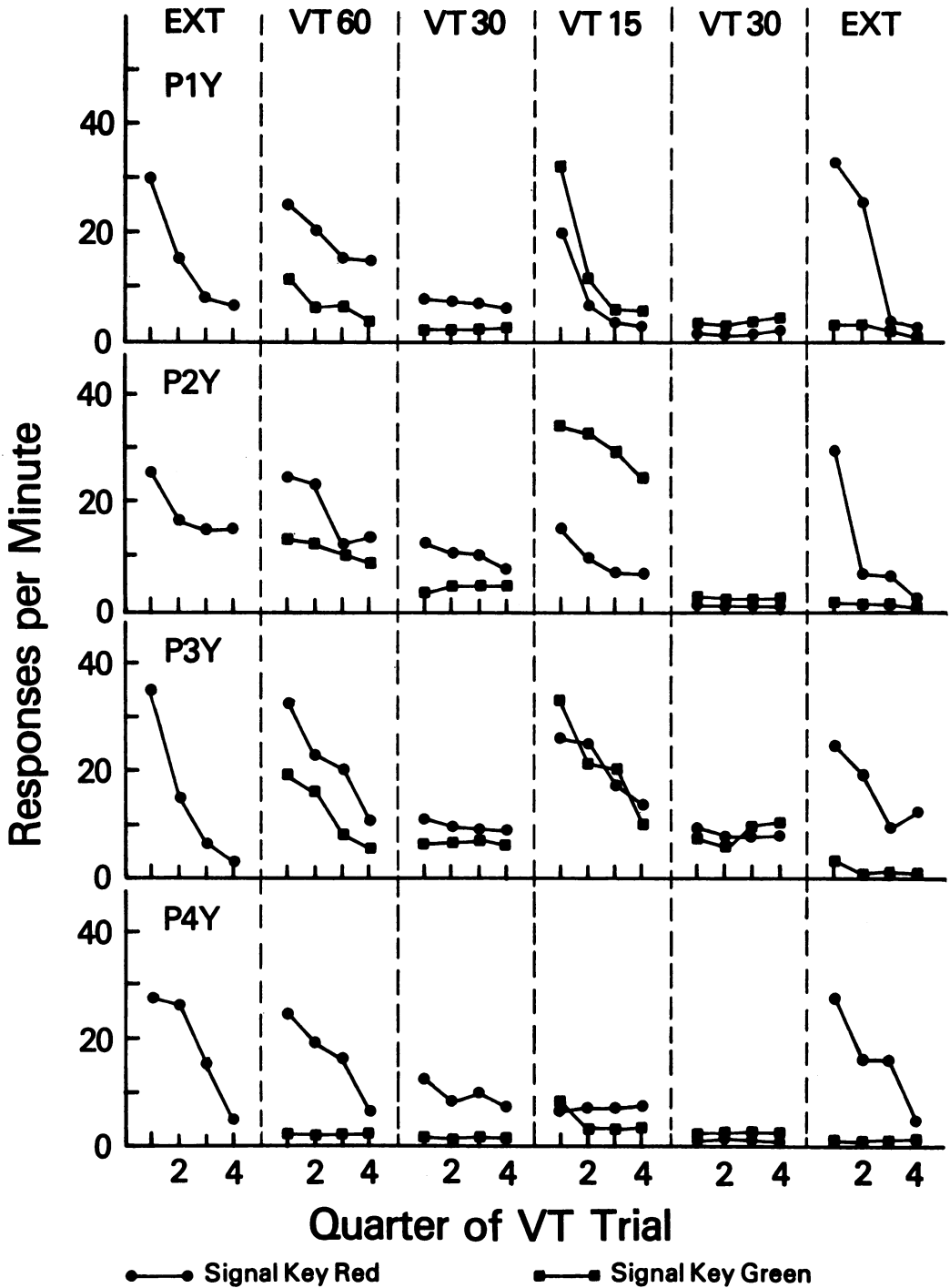
Fig. 4. Responses per minute in each quarter of the 20-sec components of the multiple schedule, on the signal key. Data are averaged across the last five sessions of each procedure. One multiple schedule component was always correlated with a VT 30-sec schedule of reinforcement. Signal-key pecks during this component are indicated by filled circles. The other multiple schedule component was correlated with different schedules, identified at the top of each panel. Signal-key pecks during this component are indicated by filled squares.

component (red key) was appreciable only when red and green signalled different frequencies of food delivery. Pigeon 4Y never pecked the green signal key at substantial rates. The other three pigeons pecked the green signal key at appreciable rates only when the schedule correlated with green was more dense (VT 15-sec) than the schedule correlated with red. Absolute levels of signal-key responding were somewhat higher for the VT group than for the VI group. In all other respects, signal-key responding for VI and VT groups are similar.

DISCUSSION

The present experiment investigated the effects of variations in the duration and reinforcement frequency associated with one component of a multiple schedule on operant-key and signal-key responding during the second, constant component. The major findings may be summarized as follows:

1. Signal-key responding in the constant component was substantial when the variable component was 60 sec long, and almost nonexistent when the variable component was 1 sec long.

2. Signal-key responding in the constant component was substantial when the variable component was correlated with extinction, almost nonexistent when the variable component was correlated with a VI 30-sec schedule, and intermediate between these extremes when the variable component was correlated with either VI 60-sec or VI 15-sec schedules.

3. Signal-key responding, when it was maintained, was almost always highest at the beginning of a component, and decreased rapidly as the component continued.

4. Signal-key responding by pigeons exposed to VT schedules was generally similar to signal-key responding by pigeons on VI schedules.

5. Operant-key responding during the constant component was distributed uniformly throughout the component, was unaffected by the duration of the variable component, and was marginally affected by the frequency of reinforcement correlated with the variable component.

The present data are consistent in most respects with the results of an extensive series of studies by Spealman (1976). Spealman found operant-key responding during the constant component of a multiple schedule to be largely insensitive to the duration of multiple schedule components and to the reinforcement frequency correlated with the variable component. Signal-key responding was sensitive to both variables, decreasing as component duration increased and decreasing as reinforcement frequency in the variable component increased. Finally, Spealman observed higher signal-key rates at the start of a component than later in the component (though less pronounced than in the present experiment); operant-key rate tended to be uniform throughout the component.

One striking difference between Spealman's and the present data is Spealman's finding that signal-key responding decreased as component duration increased. In the present experiment, the opposite result occurred. This discrepancy can be explained in terms of an important procedural difference. In Spealman's experiment, the two components were always of equal duration. Variations in component duration were variations in the duration of *both* components. His finding was consistent with evidence that multiple schedule interaction increases as component duration decreases (Rachlin, 1973; Shimp and Wheatley, 1971). In the present experiment, the duration of only one component was varied. Increasing the duration of one component enhances the signal value of the stimulus correlated with the other component. The result obtained here is analogous to findings in autoshaping studies, in which trial and intertrial intervals are varied (Terrace *et al.*, 1975). The smaller the ratio of trial time to intertrial interval, the greater is responding during the trial. Indeed, other aspects of the present data are similar to findings obtained in autoshaping studies. Wasserman (1973) observed that response rate in an autoshaping procedure was highest at the onset of a trial and decreased as the trial continued.

A second difference between Spealman's data and the present data is revealed in the fourth panels of Figures 3 and 4. The schedule in effect in green here was VI (or VT) 15-sec. When there is a transition on a multiple schedule from a component with relatively high reinforcement density to one with relatively low reinforcement density (as from VI 15-sec to VI 30-sec), response rate is typically

lower at the start of the low-density component than subsequently, a phenomenon referred to as local negative behavioral contrast (*e.g.*, Nevin and Shettleworth, 1966). Spealman observed some instances of local negative contrast in his experiment (Spealman, 1976, Figures 2 and 4). The present data show no sign of local negative contrast. Indeed, Pigeons 1Y, 2Y, and 3Y show clear local positive contrast. In addition, comparison of panels 3 and 4 of Figures 3 and 4 shows no sign of overall negative contrast, such as one might expect when the variable component of a multiple schedule is changed from a reinforcement density equal to that in the constant component to one greater than that in the constant component. For pigeons in the VI group, the differences in operant-key responding during the constant component between panels 3 and 4 of Figure 3 are small, though in the expected direction. However, differences in signal-key responding are in the opposite direction: the pigeons pecked the constant component signal key more when the variable component was correlated with VI 15-sec than when it was correlated with VI 30-sec. This effect was even larger for Pigeons 1Y, 2Y, and 3Y, and similar effects were observed by Gamzu and Schwartz (1973). It seems, therefore, that the present data and analysis cannot be extended to account for negative behavioral contrast, either local or overall. Schwartz (1975) came to a similar conclusion in a study that demonstrated that positive but not negative behavioral contrast was affected by the location relative to the response key of stimuli correlated with multiple schedule components.

The present data strongly suggest that signal-key responding is similar to autoshaped responding, and under the control of the same variables that influence responding in autoshaping situations. The most notable of these variables is the relation between the key stimulus and the reinforcer. Indeed, the procedure to which the pigeons on the VT group were exposed *was* an autoshaping procedure. It differed from standard procedures only in that the "trial" was 20 sec long, rather than 6 or 8 sec. That these pigeons and the pigeons for the VI group were similar, in terms of signal-key responding, strongly suggests that Pavlovian variables are significant in most multiple schedule procedures.

In recent years, substantial evidence has accumulated in support of an account of positive behavioral contrast, in terms of the additive interaction of Pavlovian, stimulus-reinforcer contingencies and operant, response-reinforcer contingencies, and the present data support the account (see Schwartz and Gamzu, 1977, for a review). However, this "additivity" theory of contrast cannot explain all of the data. Contrast has been observed in pigeons and in rats under conditions in which additivity theory would not predict its occurrence, *e.g.*, when the signal for the multiple schedule components is located away from the operant manipulandum (Beninger and Kendall, 1975; Bouzas and Baum, 1976; Gutman, Sutterer, and Brush, 1975; Hemmes, 1973). Contrast is sometimes affected by variables about which additivity theory is silent. For example, contrast is affected by the point at which reinforcement actually occurs in the variable component (Williams, 1974, 1976). Contrast is affected by the degree of similarity of S+ and S−, and by the level of discrimination training involved in the experiment (Malone, 1976). And occasionally, studies of contrast have reported the opposite of local contrast-response rate increases as the contrast component continues (Buck, Rothstein, and Williams, 1975). Findings such as these have led a number of investigators to suggest that contrast is not a unitary phenomenon (*e.g.*, Hearst and Gormley, 1976; Schwartz and Gamzu, 1977; Schwartz, Hamilton, and Silberberg, 1975). Pavlovian, stimulus-reinforcer relations may account for some instances and features of behavioral contrast, but not all of them.

At present, the feature of contrast that is the best candidate for an account in terms of additivity theory is local positive contrast; the increase in responding that occurs just after the transition from one multiple schedule component to the next. The present experiment, and previous research (Schwartz *et al.*, 1975; Spealman, 1976) strongly suggest that signal-key responding occurs predominantly in the beginning of a multiple schedule component. While most studies of behavioral contrast have not investigated possible local contrast effects, it is clear from existing evidence that local contrast is only a part, and not a necessary part, of overall behavioral contrast (*e.g.*, Boneau and Axelrod, 1962; Freeman, 1971; Malone, 1976). Thus, while overall contrast

effects may be the product of variables other than Pavlovian contingencies, local contrast effects, and that portion of overall contrast that can be attributed to local contrast, may be the proper province of additivity theory.

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