and Reynolds (1973). Absolute response rates for the ascending series are presented in Fig. 2. The number of responses was divided by the total session duration. The FR(food) response rates (open circles) have an inverted U shape function whether the concurrent FI responding was reinforced with food or water. Highest FR(food) response rates were reached when FI responding was reinforced with food. Fixed-interval(water) response rates (closed squares) were generally low at the low FR requirements, but gradually increased with the higher FR requirements. Fixed-interval(food) response rates (open squares) were extremely low at the low and intermediate FR requirements, but increased abruptly to some asymtope level at the high FR requirements.

DISCUSSION

The present results indicate that the reinforcers used in conc FR FI schedules substantially influence the effects of the FR requirment on response rates. That FR response rates under conc FI(water) FR(food) conditions were consistently lower than FR rates under conc FI(food) FR(food) conditions probably reflect the deprivation procedures used.

The greatest effect of different reinforcers was seen on FI responding. The relatively stable, gradual increase under conc FI(water) FR(food) conditions (Phase I) differs from those under conc FI(food) FR(food) conditions (LaBounty & Reynolds, 1973; the present experiment Phase II). Fixed-interval response rates in Phase II were consistently lower than those of Phase I for the low and intermediate ratio requirements. When responding on both schedules was reinforced with food, FR reinforcement rate seemed to predict the maintenance of asymtopic FI responding. When water reinforced FI responding, no such reinforcement rate effect was seen. Further studies should consider schedule, stimulus, and schedule value effects in their investigations.

The present data merit systematic replications with other schedules and reinforcers. Catania (1973) pointed out that very little research has been done with concurrent schedules in which the reinforcers were different and that such studies should consider motivational interactions between the reinforcers used. We used rats as Ss and food and water reinforcers because so much is known about about relations between eating and drinking in rats (e.g., Bolles, 1967; Code, 1967). It is possible that the present finding on conc FI(water) FR(food) depend on the levels of concurrent deprivations of food and water. Effects of varying deprivation levels might differ from effects of changing schedule parameters. Alternatively, the effects could be complementary. Substantial data will be needed to resolve these important issues.

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NOTE

1. Raw data from Experiment I may be obtained by requesting a copy of "The effects of varying the ratio requirement on a concurrent fixed-ratio: food, fixed-interval: water schedule of reinforcement"—M. A. Thesis, March, 1973, by Keith A. Wood, from the Librarian, University of Florida.

The role of local interactions in behavioral contrast

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Typical behavioral contrast effects were obtained using a multiple variable-interval extinction schedule of reinforcement. Response rate was higher, however, during VI components preceded by a VI component than during a VI component preceded by extinction. This effect, contrary to previous findings concerning sequential effects, challenges recent interpretations of behavioral contrast derived from the literature on autoshaping.

Gamzu and Schwartz (1973) have advanced an account of contrast effects in multiple schedules derived

from the literature on autoshaping. According to this view, contrast results from the excitation of particular responses, determined by the biology of the organism, simply by virtue of a signal of the transition from periods of low reinforcement probability to periods of

Table 1
Schedule for Training for All Subjects

Condition	Number of Sessions
VI 15-sec	1
VI 30-sec	1
Mult VI 30-sec EXT	2
Mult VI 2-min EXT	20
VI 2-min	20
Mult VI 2-min EXT	20
VI 2-min	10
Mult VI 2-min EXT	20
VI 2-min	10
Mult VI 2-min BO/TO	10

high reinforcement probability. Thus, the rate increase seen in the typical contrast experiment, transition from a variable-interval schedule to a multiple variable-interval extinction, is due to the addition of "elicited" pecks to those regularly maintained by the VI schedule.

Rachlin (1973) has elaborated this view, arguing that contrast effects are temporally bound to the moment of stimulus transition. Local rate is highest just after entry into the high reinforcement component because the excitatory signal value of the positive stimulus is then maximal. As time into the component increases the local rate correspondingly decreases, since the stimulus no longer differentially signals changes in the reinforcement contingencies. According to Rachlin, therefore, local rate changes, not overall changes, are most central to multiple schedule interactions. Further, overall contrast should not occur without the appropriate accompanying local changes in response rate at the beginning of the component.

The present paper reports an experiment, done for a completely different purpose, showing that the local rate changes proposed by Rachlin are, in fact, not necessary for behavioral contrast to occur. Extensive training was given to pigeons on a multiple variableinterval extinction schedule of reinforcement, where the two components alternated semirandomly instead of regularly. Responding during the VI components were recorded separately as a function of whether the preceding component was another VI component or extinction. An examination of these data reveals marked deviations from the sequential effects previously obtained, in spite of the occurrence of sustained behavioral contrast.

METHOD

Subjects
Six experimentally naive mixed-breed pigeons were maintained at 80% of their free-feeding body weights.

Apparatus
A standard Grason-Stadler three-key pigeon chamber was used. Only the center key was used. The key was illuminated by a 6-V IEE in-line projector located behind the key. A houselight

was located behind a translucent window in the upper right-hand corner of the front panel.

Procedure
Table 1 provides the sequence of training after the first session in which the pigeons were trained to keypeck. The stimulus correlated with the VI schedule was a pattern of three vertically aligned white dots. The negative stimulus was a pattern of three horizontally aligned white dots for Subjects 1, 10, and 52, and a diffuse blue light for Subjects 42, 49, and 51. The TO condition presented at the end of training involved turning off the keylight with the houselight remaining on, while the BO condition involved completely darkening the chamber. The VI 120-sec schedule included 18 different intervals constructed from the distribution of Fleshler and Hoffman (1962).

Each stimulus component continued for 90 sec. During the multiple schedule the VI and Ext components alternated quasirandomly according to a 10-position stepper. The sequence of components, which remained unchanged throughout training was EXT, VI, VI, EXT, EXT, VI, EXT, VI, VI, EXT. Each component followed its predecessor immediately, except for a brief flicker of the keylights resulting from the operation of the stepper switch. All sessions terminated after 50 stimulus periods had occurred.

RESULTS

Figure 1 shows those subjects trained with the blue light as S−. Figure 2 shows those subjects trained with the horizontal dots as S−. For each figure, the data are divided into those S+ periods which were immediately preceded by an S− period and those S+ periods preceded by another S+ period. This distinction was maintained during VI baseline conditions in order to provide a
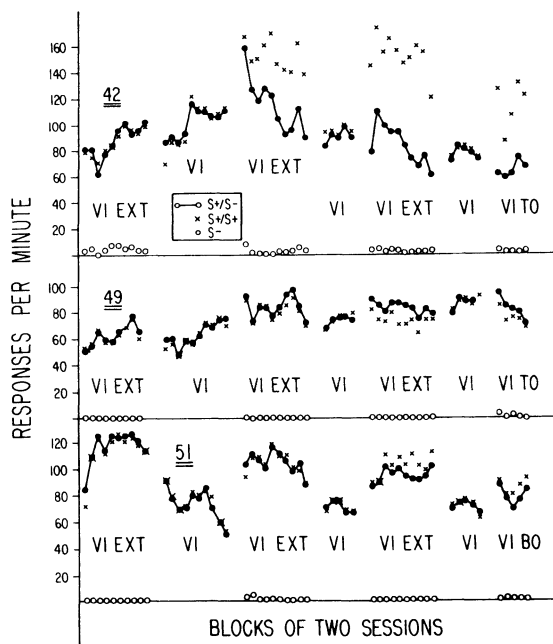

Figure 1. Rate of responding for subjects trained with blue as S−. Rate in a VI component following a VI component (S+/S+) and in a VI component following an EXT component are presented separately (S+/S−).
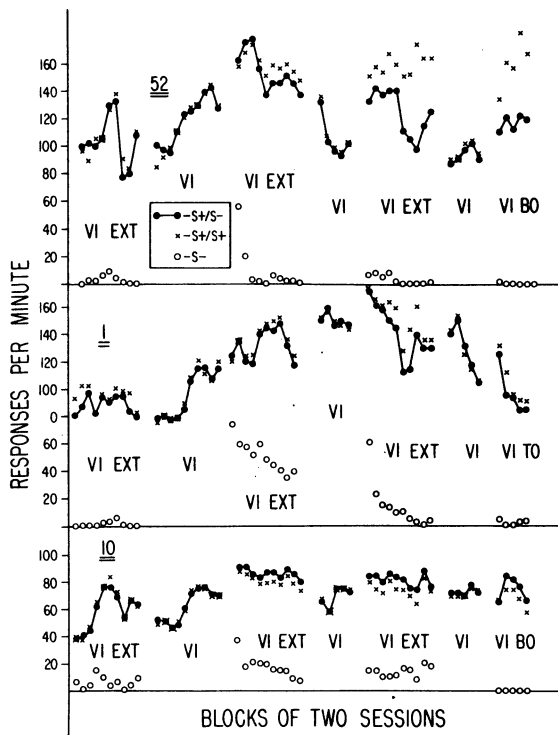
Figure 2. Rate of responding for subjects trained with horizontal dots as S−. Rate in a VI component following a VI component (S+/S+) and in a VI component following an EXT component are presented separately (S+/S−).

measure of the normal variability in response rate when the S− components were removed. Also shown is the rate of responding during S− components. It is evident that neither the degree of contrast nor the type of sequential effect obtained was systematically affected by the type of stimulus associated with extinction.

The degree of contrast varied greatly as a function of the particular subject. Pronounced differences between the baseline VI and the mult VI Ext were obtained for three subjects (42, 51, and 52), a smaller difference was obtained for two others (49 and 10), while one subject (1) responded at extremely high rates during all conditions, making its data impossible to interpret.

The major data of interest are the large differences in responding as a function of the two types of S+ stimulus periods. Two subjects (10 and 49) showed the usual effect of slightly greater responding in the first S+ period, but the remaining two subjects showed the opposite effect. For the latter, the greater responding developed gradually with training, sometimes in the second exposure to the multiple schedule, and sometimes in the third exposure, suggesting that the birds were only gradually discriminating the temporal features of the alternation pattern of the schedule's components.

DISCUSSION

The present study demonstrates that sustained behavioral contrast can be accompanined by rate increases at the *end* of a VI component rather than at the *beginning*. This finding is contrary to the theoretical position of Rachlin (1973) who stated that local changes at the beginning of the component were the essential ingredient to multiple schedule interactions. At least one other study (Nevin & Shettleworth, 1966) has shown sustained overall contrast without the intial local rate increase, but the present data are unique in demonstrating a local rate change just the opposite to that suggested by Rachlin.

Since the most likely candidate for explaining the rate increase at the end of the component is the discrimination of the temporal pattern of component alternation, it is of interest to examine the possible signal value of those temporal cues. According to the contrast interpretation of Gamzu and Schwartz (1973) the temporal cues should elicit higher response rates only if they signal increases in reinforcement probability. The latter portion of the VI component preceded extinction, however, so presumably its cue value was to signal a decrease in reinforcement. Increases in response rate during a signal prior to extinction have been demonstrated before (Pliskoff, 1961; 1963; Wilton & Gay, 1969). Apparently, therefore, transitions from VI to extinction, and from extinction to VI, *both* can produce rate increases during the VI component.

A major question raised by the present data are the determinants of the type of sequential effect actually obtained. Most previous studies (Boneau & Axelrod, 1962; Catania & Gill, 1964; Terrace, 1966) have found only the initial local rate increase, although the effects were often transitory. In addition, two of the six subjects in the present study showed consistently higher rates in the initial component. At least one study (Arnett, 1973) has shown an elevated rate increase in the beginning of the VI component which was sustained over many sessions. When compared with the present study, the only noteworthy procedural differences were the duration of the components (90 sec vs. 180 sec), regular vs. irregular conponent alternation, and the amount of responding maintained during the S−. Whether any of these variables is critical to the type of sequential effect obtained is yet to be determined.

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