

THE UNIVERSITY OF MANITOBA

OVERALL AND LOCAL RATE EFFECTS IN MULTIPLE SCHEDULES
WITH DIFFERENT RESPONSES IN EACH COMPONENT

by

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**A dissertation submitted to the Faculty of Graduate Studies of
the University of Manitoba in partial fulfillment of the requirements
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ABSTRACT

Four male albino rats were trained to bite a response lever in the presence of one stimulus (Component CB) and to press the same lever in the presence of a different stimulus (Component CP) in a successive discrimination task. The stimuli alternated every three minutes and each was presented 20 times in a session. Food reinforcement was presented according to two independent but equal variable interval tapes only one of which ran during each of the stimuli. After extended training on this multiple variable-interval variable-interval schedule, extinction was scheduled for either biting (two subjects) in CB or pressing in CP. Following a return to the variable-interval schedule in both CB and CP, extinction was scheduled for either bites or presses with subject assignment to schedule conditions being reversed.

Overall positive contrast (an increased rate of responding over baseline during one component of a multiple schedule, with extinction scheduled for responding in the other component), when measured on biting or pressing, was observed with only two subjects and with the same two subjects in both cases. These same two subjects and one other (that is, three of four subjects) showed local positive contrast (marked increases over baseline in rate of biting during early portions of CB and in rate of pressing during early portions of CP with extinction in CP and CB, respectively). The fourth subject showed none of these effects. For all four subjects, rates tended to progressively decrease across the components, but were generally higher than baseline when overall contrast was observed.

The results with regards to overall rates are inconsistent and not always clear. The consistent increases in rate of responding early in the component (found in six of eight cases and with three of four subjects) both in the presence and absence of overall contrast and the fact that rates during later portions of the component increased when, and only when, overall contrast was observed, indicate that local and overall contrast effects may be (at least in part) independent from one another.

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- Ug - my dear friend, who's absence from my current community is all too noticeable.

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REVIEW OF THE LITERATURE AND
STATEMENT OF THE PROBLEM

In a multiple schedule two (or more) stimuli are alternated with each other and each has a particular schedule of reinforcement associated with it. Qualitative aspects of behavior appropriate to the schedules of reinforcement in each component are typically observed in multiple schedules (Ferster and Skinner, 1957), but quantitative aspects of behavior, such as mean rates of responding during each component, have been shown to depend in part on the schedule in the other components (Reynolds, 1961). Of the possible behavioral interactions which may occur in a two-component multiple schedule, positive contrast is the most studied. Positive contrast was (initially) defined to occur when the absolute rate of responding during one component (S_1) increases as a result of a decrease in the rate of responding during the other component (Reynolds, 1961). However, since a reduction in the rate of reinforcement while the rate of responding is held constant has not yet been accomplished, it is not known whether a reduction in responding or in reinforcement is directly responsible for the increased rate of responding during S_1 . Bloomfield (1969) concluded in his review of the contrast literature, that anything which lowers the relative value of S_2 (that is, anything which would result in S_2 being chosen over S_1 , by the subject) such as punishment (see Brethower and Reynolds, 1962) will lead to an increased value for S_1 and thus to an increased rate of responding during S_1 (regardless of whether or not responding occurs

during S_2). Premack (1969) comes to essentially the same conclusion in his review. This hypothesis does seem able to account for contrast (or the absence of contrast) under a variety of conditions under which a preference (or no preference) for S_1 , has been shown to exist. That is, when S_1 is shown to be (or not to be) chosen by the subject over S_2 .

For example, regarding the absence of contrast, Wilkie (1972) found no contrast using a mult VI VT schedule (multiple variable-interval variable-time schedule, where a variable-interval schedule is one in which responses are reinforced after varying intervals of time and a variable-time schedule is one in which reinforcement occurs independently of responding after varying intervals of time), although there was a reduced rate of responding under the variable-time schedule. Wilkie showed that the subjects did not prefer VI over VT schedules. Regarding the occurrence of contrast, Brethower and Reynolds (1962) found contrast in S_1 when responding in S_2 was reduced by punishment, even though there was little or no reduction of reinforcement in S_2 . Since animals show a preference for non-punishment over punishment, this supports Bloomfield's (1969) hypothesis.

Another possible explanation of interactions in multiple schedules comes from Pear and Wilkie (1971). They suggest that contrast is more likely when a strong degree of stimulus control is established under a mult VI VI schedule of food reinforcement than when it is not.

Another hypothesis which seems to handle much of the data on contrast is one proposed by Halliday and Boakes (1972). They suggest a "response inhibition rebound" hypothesis, stating that "...in any situation where at least one stimulus is associated with the inhibition of a

particular response....a 'rebound' effect occurs when another stimulus, in whose presence that response is an appropriate one, is presented, so that the response is made with extra vigor (p. 94)." This seemed to cover all cases of contrast where S_2 response rate was reduced (e.g., through aversive stimulation, differential-reinforcement-of-low-rate schedules, and decreased rate of reinforcement) and to cover conditions which did not produce contrast but did involve a reduced rate during S_2 (e.g., "errorless" - discrimination (Terrace, 1966; 1972); and free-reinforcement (Boakes, 1973; Halliday and Boakes, 1972; Wilkie, 1972). However, much of Halliday and Boakes' account is based on the pigeon's key-pecking response and does not extend to cases where contrast would be predicted but did not always occur [(e.g., with the rat's lever pressing (Pear and Wilkie, 1971) and with pigeon's lever pressing (Westbrook, 1973)] To account for such instances, Halliday and Boakes suggest (1) the involvement of responses other than those directly maintained by the reinforcement contingencies [e.g., "autoshaped" responses, defined as those responses which emerge as a result of unconditional forward pairings of a key-light stimulus and food, in the case of the pigeon's key peck (see Brown and Jenkins, 1968)] and (2) that the kind of interaction between behaviors in the components of a multiple schedule may be determined by the form of the response which is inhibited. Thus, if the inhibited response or these "other" responses not directly involved in the prevailing contingencies (e.g., auto-shaped responses) are incompatible with the S_1 response, then contrast would not be expected.

Gamzu and Swartz (1973) also emphasized the importance of auto-shaped responses in positive contrast. They stated that "...any new

source of control over responding may well be responsible for the positive contrast elevation effect (p. 17).", if that new source of control affects the occurrence of auto-shaped (or others) key pecks which are added to the operantly maintained key pecking.

Rachlin (1973) proposed an hypothesis in which the suggestions of Halliday and Boakes (1972) and Gamzu and Swartz (1973), with regards to contrast and responses other than the operantly maintained responses, are made more explicit. His hypothesis states that "...a transition from a stimulus signalling a period of low reinforcement value to a stimulus signalling a period of high reinforcement excites certain responses irrespective of other contingencies. The excited responses are most frequent immediately after the point of transition and subsequently decrease in frequency (p. 232)." Accordingly, contrast is a coincidence of the reinforced responding with responses produced by a stimulus change. Positive contrast, then, is the summation of the responses excited by a change to a period of higher reinforcement value and the operant responses generated by the reinforcement schedule in effect during that period.

In conclusion, Rachlin (1973), Gamzu and Swartz (1973), and Halliday and Boakes (1972) all regard the topography of the reinforced response as important in determining the type of interaction obtained in multiple schedules. Unfortunately, not much information is available with regards to this aspect. Premack (1969) trained rats to press a lever in the presence of one stimulus and to run in a wheel in the presence of another. Stimulus presentations were separated by 16 hours. Positive contrast was observed with only one rat and that when reinforce-

ment rate was decreased for running. Further information was obtained by Scull and Westbrook (1973) in a study using pigeons to peck a key in one component and to press a bar in the other component of a mult VI VI schedule of food reinforcement. After stabilization on mult VI VI, the schedule was changed to extinction for the key pecks or bar presses. When the key-peck component was the constant component, one subject showed contrast, one showed induction--i.e., a decreased rate of responding in the constant component with a decreased rate of responding in the component that was changed--and another subject showed no change. When the bar-press component was the constant component for three other subjects, all showed induction. Four other subjects were run under slightly different, but essentially identical, conditions. Two subjects, one each under extinction for bar pressing and for key pecking, showed induction and two subjects showed no change. In summary, then, only one subject out of seven showed contrast under the multiple key-peck bar-press schedule. These results, except for the one incidence of contrast, are consistent with Halliday and Boakes' (1969) notion of contrast, which predicts that with different responses in each component an increased tendency to perform an inhibited response would interfere with other operant responses.

The above findings indicate the importance of the response variable no matter which hypothesis one favors. Indeed, the failure to consistently produce contrast in rats may be directly related to the fact that most published (and, probably unpublished) studies on contrast in rats used lever-pressing responses. This would be the case if the

responses which result due to the effects of going from a signal for low frequency reinforcement to one for high frequency of reinforcement were incompatible with the lever-press response.

The present experiment was conducted to further investigate this variable, using rat's lever pressing and lever-biting responses maintained on a mult VI VI schedule of reinforcement. Lever biting was chosen as it more closely parallels the pigeon's key-peck response than does lever-pressing, as both biting and pecking are principal components of the consummatory and aggressive behavior patterns for the respective species. Contrast might, therefore, be more likely to occur when measured on biting as contrast with pigeon's key-pecking has been reliably produced. If Rachlin (1973) or Gamzu and Swartz (1973) are correct in their hypotheses, then one could expect contrast with both the biting response and the pressing response. On the other hand, if Halliday and Boakes (1969) are correct, then contrast should not occur with either response, due to the incompatibility of lever pressing and biting under the present procedure.

Furthermore, Nevin and Shettleworth (1966) and Arnett (1974) present data which suggest that overall contrast might reflect two, at least partially, independent processes. Their respective findings showed increases above baseline in response rates early in the constant component (local contrast) of a multiple schedule when extinction was scheduled in one component both in the absence and presence of increases in overall rates during the constant component. Rates within components (local rates) as well as total (overall) rates were recorded to explore this possibility.

METHOD

Subjects

Four male Wistar albino rats, obtained from the Canadian Breeding Farms, and approximately 90 days old at the start of the experiment served as subjects and are hereafter referred to as 20A, 31A, 26A, and 32A. The subjects were first maintained on free food (Purina Rat Chow) until a stable weight (less 3% deviation from the mean weight for the last four days, of any one weight over these four days) was obtained. They were then put on a food-deprivation schedule and their weights lowered to and maintained at 80% of their respective mean free-feeding stable weights. Subjects were housed in individual cages, where water was always available, in a temperature controlled room with a 12-hour light/dark cycle.

Apparatus

The experimental space was a dual-lever, Leigh Valley Electronics operant conditioning chamber, Model 1316, mounted in a LVE, Model 1316C, cubicle. The inside dimensions of the chamber were 7.5-in high and 12-in long by 8-in wide (19 cm x 30.6 cm x 20.3 cm). Only one lever was used. The opening for the other lever was covered by a piece of aluminium screwed to the wall. The lever was mounted 1 1/3-in (2.8 cm) above the grid floor on one of the 8-in wide walls, 7/8-in (2.2 cm) from the adjoining 12-in wall, to the right of the feeder (a dipper) which was centered on the same 8-in wide wall. The lever was specially designed with two microswitches, one for recording downward pressure (lever presses) of more than 30 grams (.0294 N), and the other for recording

pressure of more than 200 grams (.1960 N) exerted simultaneously to the top and bottom of the lever (lever bites).

Food reinforcement, consisting of .01 ml of a 1:1 mixture of Bordens sweetened condensed milk and tap water, was delivered by the feeder from the normally-up position. The feeder made an audible click when operated.

A 7-watt House light was used as a stimulus. An exhaust fan mounted on the cubicle provided ventilation. Masking noise, produced by a Grason-Stadler noise generator (Model 901B), was played through a speaker mounted on the inside of the cubicle.

A digital logic system, standard electromechanical equipment, and a Gerbrands cumulative recorder were used for all programming and recording and were located in a room adjacent to the one housing the chamber. Two identical variable-interval tapes with a mean inter-reinforcement interval (IRI) of 27.5 seconds were used to arrange reinforcements. To generate the IRIs, two parameters were used: T, a fixed time period; and P, the probability that the first response within any one T would be reinforced. Mean IRI is defined as T/p , thus, to generate a tape with a mean IRI of approximately 30 seconds, T was set at 3 sec and P at 0.10. An additional restriction was that the tape sequence should not be repeated within any one session. Therefore, as each session was to be 120 minutes, the tapes had to be 1200 T intervals long (i.e., tape at 3600 sec for one complete revolution). With P at 0.10, 120 intervals would be selected for reinforcement.

The first two digits of numbers contained in four-digit random-

numbers tables were used to determine the assignment of reinforcement to each T interval. Since $P = 0.1$, reinforcement was assigned to each T interval associated with the digits 00 to 09 and no reinforcement was assigned to T intervals associated with the digits 10 to 99 (thus, on the average, in 10 out of every 100 numbers, or T intervals, reinforcement would be assigned).

Starting with one number (the first T interval) in the random-numbers table, each successive number was inspected until a P value was encountered. This procedure was followed until reinforcement had been assigned to 120 of the 1200 available T intervals. Finally, these intervals were adjusted such that 12 intervals ended with each of the digits 0 to 9. The resulting sequence and values of the IRIs are shown in Table 1.

Procedure

The subjects were randomly assigned to the four cells of a two by two matrix, one side of which designated the response (either lever presses or bites) to be reinforced in the presence of light-on and the other side of which designated the first response to be shaped and extinguished on a mult variable-interval extinction (mult VI EXT) schedule. The matrix is shown in Table 2. This facilitated counterbalancing of subjects according to the sequence of shaping and schedule changes and according to the stimulus condition in the presence of which each of the two responses were reinforced and extinguished.

Initial training. According to assignment, each of the subjects was shaped to bite or press the lever in the presence of the appropriate

TABLE 2

Two by two matrix used for counterbalancing random assignment of subjects to stimulus condition in which bites and presses were reinforced and to order of shaping and extinction of bites and presses. Subject assignments are shown in the four cells of the matrix.

Response Reinforced
in the
Presence of Light-on

		PRESSES	BITES
First Response Shaped and Extinguished	PRESSES	Subject 20A	Subject 31A
	BITES	Subject 26A	Subject 32A

stimulus condition (housetlight-on or -off) during the first session. During the second session, this response was reinforced according to a fixed-ratio one (FR1) schedule (i.e., each occurrence of the response was reinforced). The third and fourth sessions followed the same procedure for the other response. The schedule was then changed to mult FR1 FR1 for one session. The two stimuli alternated regularly every three minutes.

Table 3 summarizes the procedure (after training) for each subject and gives the number of sessions received under each condition. During mult FR1 FR1 and all subsequent schedules, a two-second "protection" contingency was in effect such that the response (either a bite or a press) upon which reinforcement was contingent at any given time could not be reinforced for two seconds following an occurrence of the response (press or a bite) upon which reinforcement was not contingent. A pilot study conducted in this lab indicated that without such a contingency the two responses would be likely to occur frequently at the same time. For convenience, the component during which reinforcement was contingent upon biting is hereafter termed Component B (CB) (and biting and pressing during that component are called CB-biting and CB-pressing) and the component during which reinforcement was contingent upon pressing is termed Component P (CP) (and pressing and biting during that component are called CP-pressing and CP-biting). Also, the response for which a particular schedule was in effect is given after each schedule notation as either "B" for biting or "P" for pressing.

TABLE 3

Summary of procedure and number of sessions under each condition for each subject. The schedule on the right was in effect during the press component (CP) and the schedule on the left was in effect during the bite component (CB). (Does not include initial training).

Subject	Phase									
	Mult		Mult		Mult		Mult		Mult	
	VI	VI	VI	EXT	VI	VI	EXT	VI	VI	VI
20A	92		10		30		10		10	
31A	111		10		32		10		17	
	Mult		Mult		Mult		Mult		Mult	
	VI	VI	EXT	VI	VI	VI	VI	EXT	VI	VI
26A	111		10		33		10		12	
32A	90		10		45		11		4	

Mult VI (B) VI (P). On the sixth session the schedule was changed to multiple variable-interval 27.5 sec (biting) variable-interval 27.5 sec (pressing) [mult VI (B) VI (P)]. Component duration remained at three minutes with regular alternation. Each component was always associated with its own tape which ran only when that component was in effect. Reinforcements set up and not delivered were cancelled at the end of that presentation of the component.

Shift from mult VI (B) VI (P) to mult VI (B) EXT (P) or mult EXT (B) VI (P). Schedule changes were initially to be contingent upon a strict stability criterion based on rates of biting and pressing. However, since this criterion (or even a less strict one) was not met after extensive exposure to mult VI(B) VI(P) the criterion for a change from mult VI(B) VI(P) to either mult VI(B) EXT(P) or mult EXT(B) VI(P) was changed to a requirement of not less than 10 consecutive sessions without an apparatus failure or other deviation from the daily procedure (this decision was made after subjects 20A and 32A had received 80 sessions on mult VI(B) VI(P) and subjects 31A and 26A had received 83 sessions).

Once this requirement had been satisfied, the schedule in effect during CP, for 20A and 31A, and during CB for 26A and 32A, was changed to extinction (EXT), i.e., reinforcement was no longer delivered for the previously reinforced response. This made the schedules now in effect mult VI(B) EXT(P), for 20A and 31A, and mult EXT(B) VI(P), for 26A and 32A. These schedules were in effect for 10 sessions for all subjects.

Shift from mult VI(B) EXT(P) or mult EXT(B) VI(P) to mult VI (B) VI(P). The subjects were next returned to mult VI(B) VI(P) which remained in effect for a minimum of 20 sessions. Thus there were 10 sessions following extinction and an additional 10 sessions preceding the next schedule change. This number, as a minimum, was necessary primarily for recording purposes (see below).

Shift from mult VI(B) VI(P) to mult EXT(B) VI(P) or mult VI(B) EXT(P). Next the subjects that had previously received extinction during CP received extinction during CB, and, conversely, subjects that previously received extinction during CB received extinction during CP. Thus, the schedule was mult EXT(B) VI(P), for 20A and 21A, and mult VI (B) EXT(P), for 26A and 32A. Ten sessions were conducted under these conditions.

Shift from mult EXT(B) VI(P) or mult VI(B) EXT(P) to mult VI(B) VI(P). The final phase involved a return to mult VI(B) VI(P). A minimum of 10 sessions were conducted for each subject.

Total numbers of bites and presses (overall rates) were recorded for each component. In addition response rates within the three minute components (local rates) were determined during each component for the response appropriate to the constant component and during the constant component only for the other response. For this purpose each component was divided into five 36-second segments and responding recorded as indicated. A stepping switch was used to separate and channel responding. CP-bites and CB-pressing which occurred within the first 10 seconds following a stimulus change were also recorded separately.

Sessions were conducted seven days per week, except for occasional weekends, for two hours each day for each subject.

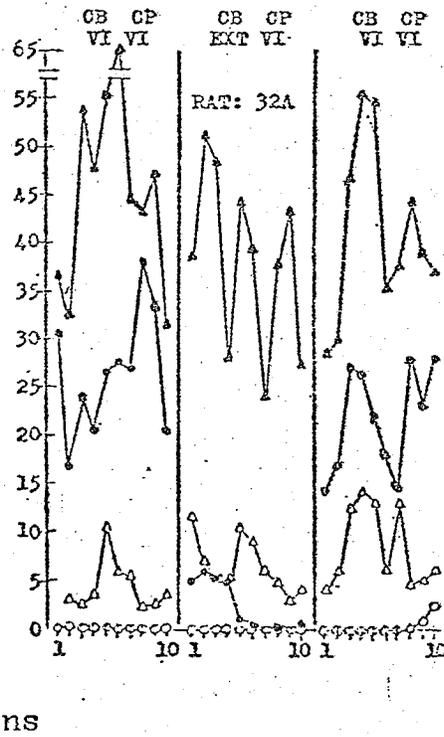
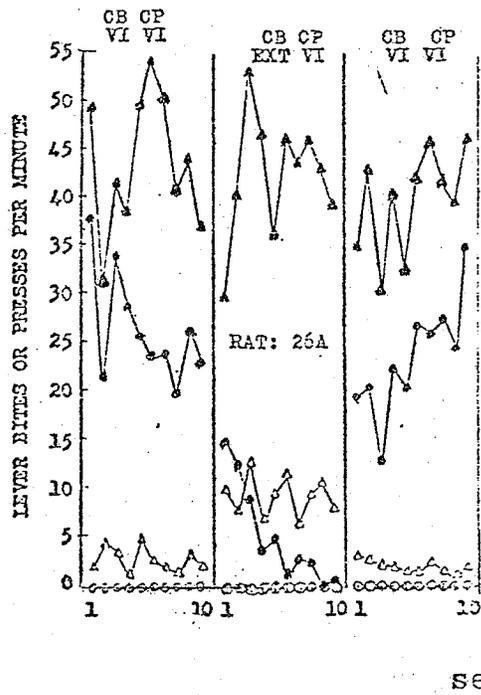
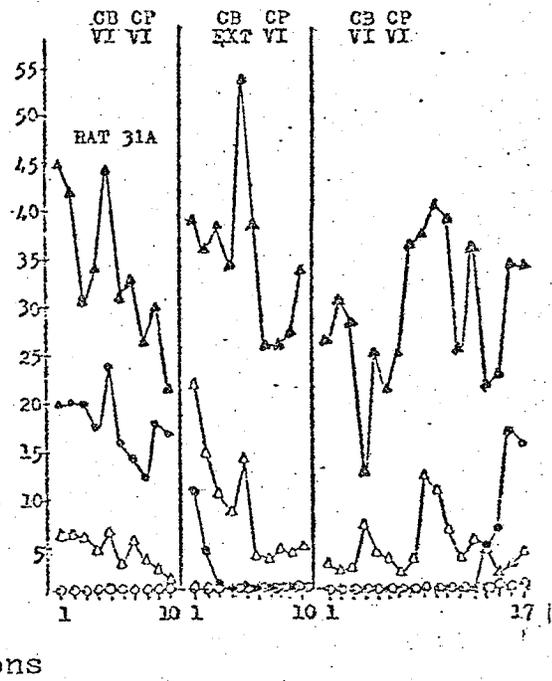
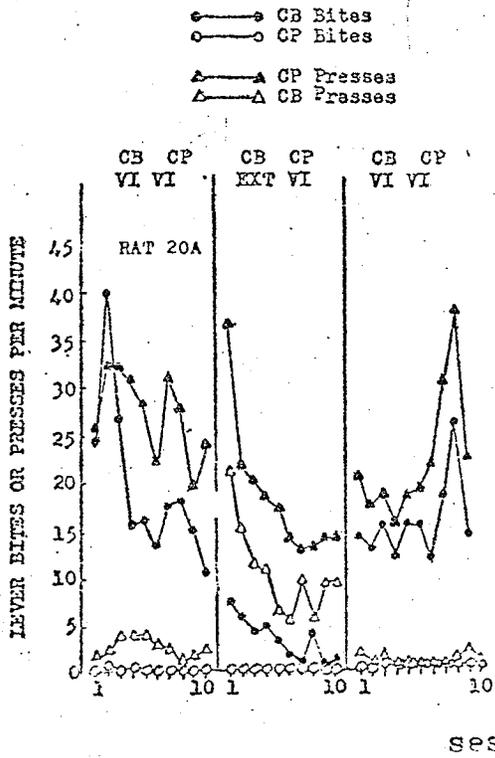
RESULTS

For convenience of presentation, data from all four subjects involving the shifts between mult VI(B) VI(P) and mult EXT(B) VI(P) are discussed together, as are data involving the shifts between mult VI(B) VI(P) and mult VI(B) EXT(P)--even though subjects differed with regard to the order in which they were exposed to these shifts. In addition, only the last ten sessions of mult VI(B) VI(P) prior to a shift and the first 10 sessions of mult VI(B) VI(P) following a shift are presented. All sessions under mult EXT(B) VI(P) and mult VI(B) EXT(P) are included. The data are subdivided into overall rate effects and local rate effects.

Overall Rate Effects

Mult VI(B) VI(P) preceding shift to mult EXT(B) VI(P). Sessional mean rates of biting and pressing in each component during the last 10 sessions of mult VI(B) VI(P) preceding the shift to mult EXT(B) VI(P) are shown in Figure 1 for all four subjects. The schedules in effect during CB and CP are shown above each panel.

Both rate of CP-pressing and CB-biting were quite variable for subjects 26A and 32A and slightly more stable for subjects 20A and 31A. These patterns obtained despite extensive exposure to the mult VI(B) VI(P) schedule. Rate of CB-biting was typically lower than the rate of CP-pressing for all subjects.



sessions

FIGURE 1

CP bites were also much lower than CB presses, averaging less than one response per minute for all subjects. Both were quite stable.

Shift from mult VI(B) VI(P) to mult EXT(B) VI(P). Mean rates of biting and pressing in both components, by each subject, under mult EXT(B) VI(P) are shown in the center panels of Figure 1. CB biting showed a steady, negatively accelerated decrease to zero in all cases. CP biting remained low, usually at zero.

CP pressing showed a marked change for 20A (Fig. 1) increasing well above baseline (mult VI(B) VI(P)) during the first session and then gradually decreasing to and levelling off, at session seven, well below baseline levels. Subject 31A (Fig. 2) pressed at a higher rate during CP during the first five sessions of mult EXT(B) VI(P) than it had during the last five baseline sessions, but not higher than rates recorded over the first five sessions. CP pressing for rats 26A and 32A showed no apparent change. That is, no contrast. Thus, contrast was observed in two of the four subjects; the effect was, however, weak and quite transitory. CB pressing increased above baseline in all cases, remaining higher over all 10 sessions for 20A and 26A and eventually returning to baseline levels for 31A and 32A.

Shift from mult EXT(B) VI(P) to mult VI(B) VI(P). The first 10 sessions of mult VI(B) VI(P), after mult EXT(B) VI(P), are presented in the right hand panels of Figure 1 for each subject. Rate of CB biting quickly returned to near baseline levels for all subjects except for 31A, which did not start biting again until session 14. CP biting again occurred at rates slightly above zero for all subjects, once CB biting resumed.

Rates of CP pressing showed increases over those recorded during mult EXT(B) VI(P), but not above previous baseline levels, for subjects 20A and 32A, and remained about the same for subjects 26A and 31A. CB pressing returned to baseline for 26A, went below baseline for 20A, remained at about the same levels [as under mult EXT(B) VI(P)] for 31A, and eventually returned to baseline for 32A.

Summary of Overall Rate Effects Produced by Shifting

from Mult VI(B) VI(P) to mult EXT(B) VI(P)

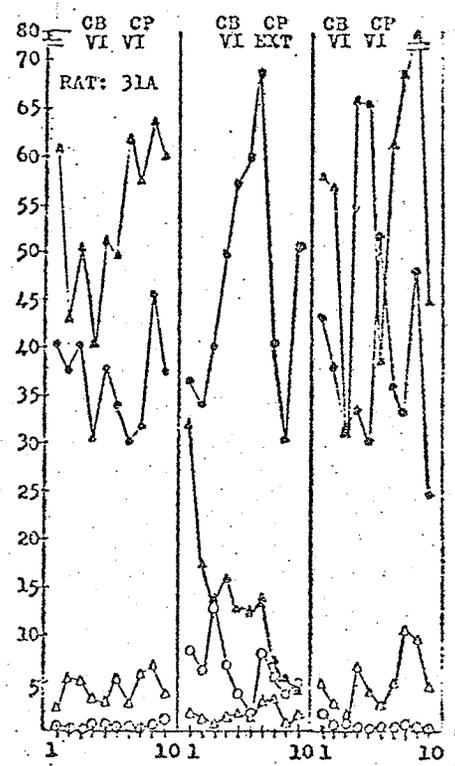
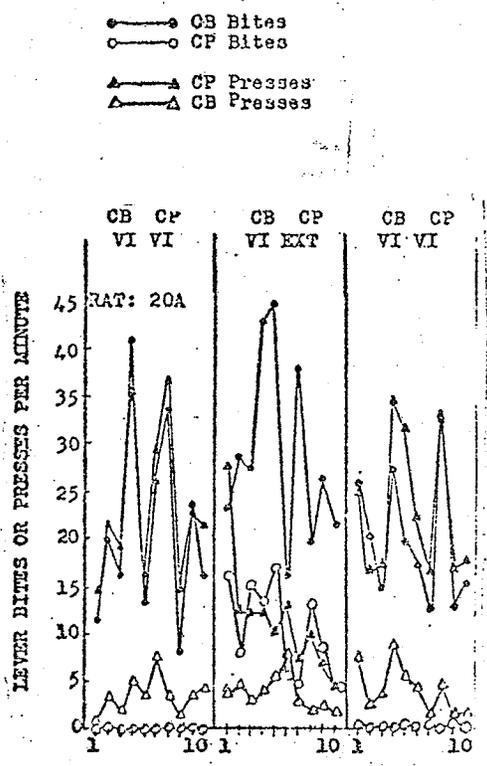
The principal effects of introducing mult EXT(B) VI(P) were:

1. CP pressing - showed contrast over the first five sessions for subject 31A and over the first session for subject 20A. No contrast was observed for subjects 26A and 32A.
2. CB pressing - increased in all cases then tended to decrease.
3. CB biting - decreased to or near zero for all subjects.
4. CP biting - remained low, usually at zero for all subjects.

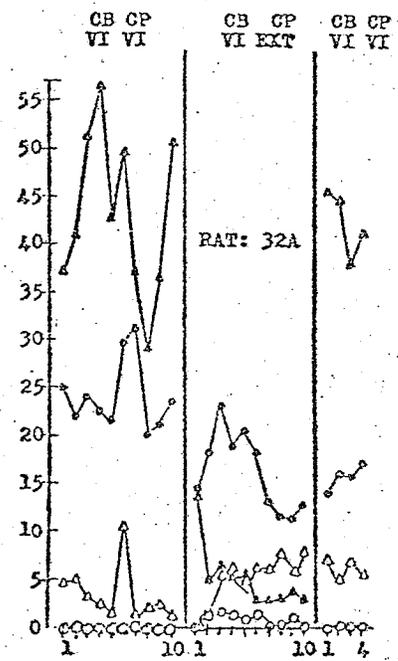
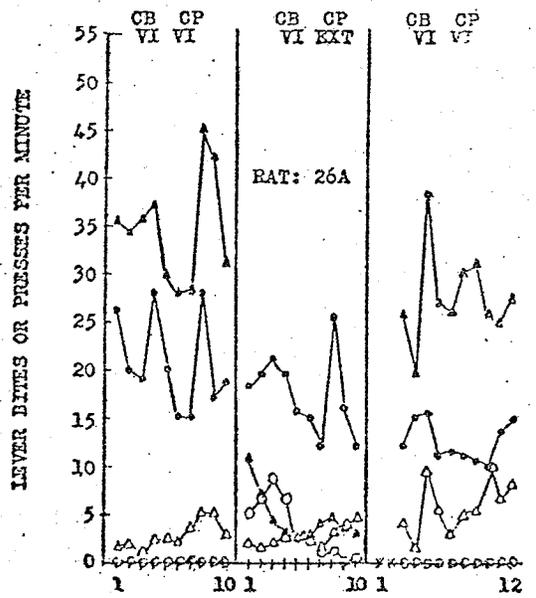
Mult VI(B) VI(P) preceding shift to mult VI(B) EXT(P). Sessional mean rates of biting and pressing in each component during mult VI(B) VI(P) (left hand panels) preceding the shift to mult VI(B) EXT(P) are shown in Figure 2. CB biting and CP pressing are again shown to be quite variable for all subjects, with both measures being slightly more stable for subjects 26A and 32A than for subject 20A. Again, rate of biting was typically lower than rate of pressing.

CP biting was again at or near zero. Both CP biting and CB pressing were quite stable.

Shift from mult VI(B) VI(P) to mult VI(B) EXT(P). Rates of



sessions



sessions

FIGURE 2

biting or pressing, by each subject, under mult VI(B) EXT(P) are plotted in the center panels of Figure 2. Rate of CP pressing decreased below baseline, but remained above 2.5 response per minute for all subjects. CB pressing decreased to and remained below baseline for 31A, showed little or no change for 20A and 26A, and first decreased below baseline for one session and then increased to and remained above baseline for 32A.

Rate of CB biting increased at a negatively accelerated rate, above baseline, until sessions 5 and 7, for subjects 20A and 31A, respectively. After these sessions CB biting decreased to and remained near baseline for both subjects. Rate of CB biting for 26A showed no apparent change and for 32A decreased and remained below baseline. Thus, contrast was observed with two subjects only. The effect was much more apparent here than under mult EXT(B) VI(P). CP biting showed initial increases over baseline for all subjects with the largest increases occurring for subjects 20A and 31A, which also showed increases in CB biting. For subjects 26A and 32A, CP biting returned to baseline levels by sessions 9 and 7, respectively. For subjects 20A and 32A, CP biting did not return to baseline.

Shift from mult VI(B) EXT(P) to mult VI(B) VI(P). Mean rates of biting and pressing in each component, by each subject, during the first sessions of mult VI(B) VI(P) following mult VI(B) EXT(P) are presented in the right-hand panels of Figure 2. Twelve sessions are shown for subject 26A and four sessions, only, for subject 32A, due to apparatus failures for 26A and disease for 32A. Ten sessions are shown for subjects 20A and 31A. CP pressing is shown to have returned to

near baseline levels for all subjects. CB pressing showed no change for subjects 20A and 32A, slightly increased above baseline for 26A, and returned to baseline levels for 31A.

Rate of CB biting remained near baseline for subjects 20A and 31A and slightly below baseline for subjects 26A and 32A (note: subject 26A experienced incomplete sessions - denoted with "X's" in Figure 3 - during this phase and both 26A and 32A had shown symptoms of illness following the initiation of the phase).

Summary of Overall Rate Effects Produced by Shifting from Mult VI(B) VI(P) to Mult VI(B) EXT(P)

The principal effects of introducing mult VI(B) EXT(P) were:

1. CB biting - showed positive contrast for two subjects, 20A and 31A, subject 26A showed little change and subject 32A showed a decrease.
2. CP biting - increased and then decreased for all subjects.
3. CP pressing - decreased to near 2.5 responses per minute for all subjects.
4. CB pressing - effects not consistent across subjects, but rate tended to stay low.

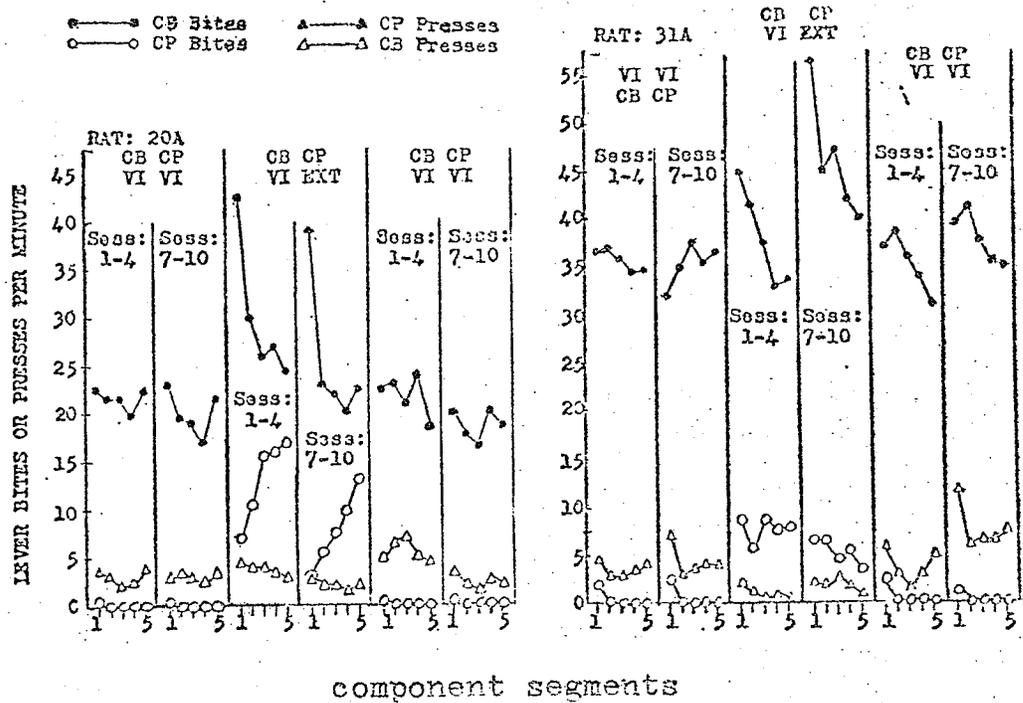
Local Rate Effects

Local rate effects (that is, rates within the 3-min components) of biting and pressing in each component, by each subject, are presented in Figures 3 and 4. Note that when CP pressing (Figure 3), is plotted, CB biting is not and vice versa. With few exceptions (noted below), local rates are presented for the first and last four sessions of the

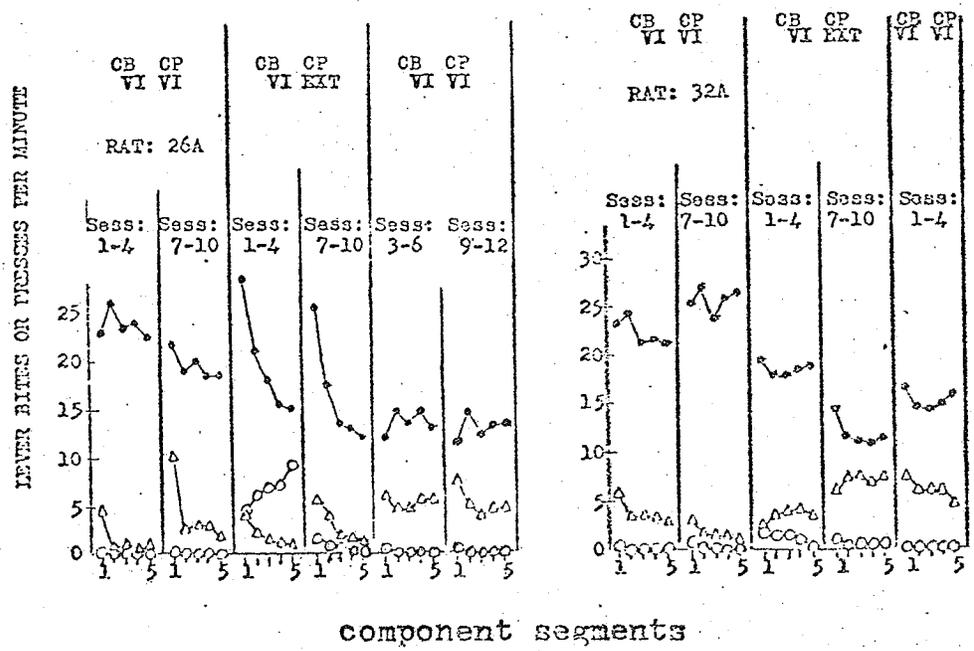
10 sessions for each of the schedule conditions shown in Figures 1 and 2. Under mult VI(B) VI(P) following mult EXT(B) VI(P) (Figure 3), rates for subject 31A were calculated over sessions 10 through 13 and 14 through 17, and under mult VI(B) VI(P) following mult VI(B) EXT(P) (Figure 4), rates for subject 26A were calculated over sessions 3 through 6 and 9 through 12, and for subject 32A, over the first four sessions only. These exceptions were due to subject 31A not biting in CB until session 14 following the change, and apparatus failures and illness for subjects 26A and 32A, respectively.

Mult VI(B) VI(P) preceding mult EXT(B) VI(P). Local rates of pressing during CP and CB, and of biting during CP, for the first four and last four sessions of the last 10 sessions under mult VI(B) VI(P) preceding mult EXT(B) VI(P) are presented in the first pair of panels of Figure 3, for each subject.

Distinctive individual subject patterns of CP pressing are evident. Subject 26A showed a markedly lower rate of CP pressing during the first segment than during later segments of the component. Responding was very stable over later segments. Over the first block of sessions shown, CP pressing for both subjects 20A and 32A was fairly stable across the first four segments (with rates during the first two segments being the lowest), and then showed a sharp drop in the final segment. Over the second block of sessions CP pressing was highest during the first two segments and fairly stable over the remaining three segments. For subject 31A, CP pressing was quite stable across the component and showed no significant change across the two blocks of sessions.



component segments



component segments

FIGURE 3

For all subjects, both CB pressing and CP biting were highest during the first segment of their respective components and were quite stable across the remaining segments. Rate of CB pressing was always higher than CP biting which was typically at zero over the last four segments.

Shift from mult VI(B) VI(P) to mult EXT(B) VI(P). Local rates of pressing during CP and CB, and of CP biting, for the first and last four sessions of the 10 sessions of mult EXT(B) VI(P), are presented in the second pair of panels of Figure 3, for each subject. Major changes in the across-component patterns of CP pressing are apparent for subjects 20A, 26A, and 31A. Rat 26A now pressed at a higher rate during the first two segments than it did during the remaining segments, with rates during the first segment being slightly lower than rates during the second segment. These differences were such that rate of responding was greater than baseline during the first segment, and less than baseline during the last three segments. Rat 20A showed higher rates of CP pressing during the first segment than during all later segments, but not higher than all baseline rates. Although rate of CP pressing was highest, over the last block of baseline sessions, during the first segment of CP, the differences between rate of first segment responding and rate of responding during later segments was dramatically increased under mult EXT(B) VI(P). For subject 31A, rate of pressing during the first component-segment was also much higher than it was during subsequent segments and higher than it was during all segments during baseline. In general, CP pressing by 31A was quite

stable and close to baseline levels across the later segments. Thus, the higher rates in the first segment reflected increased rates of pressing during that segment and not decreased rates in later segments. Rat 32A over the last block of sessions under mult VI(B) VI(P) pressed at a higher rate during the first segment of CP than during all later segments. With the shift to mult EXT(B) VI(P), rate of CP pressing early in the component went below rates in some of the later segments. That is, the effect was reversed from that for subjects 20A, 31A, and 26A. Note that the changes which were observed occurred during the first block of sessions and persisted over the second block of sessions under mult EXT(B) VI(P), for all subjects.

The marked increases in CP pressing and the decrease to zero of CP biting shown in Figures 1 to 4 are seen again in Figures 3 through 4. The pattern across components of CB pressing were quite similar to those displayed during baseline for subjects 31A, 26A, and 32A. The pattern for subject 20A, however, changed from a decreasing one to an increasing one. As with CP pressing these patterns were evident during both of the blocks of sessions shown for mult EXT(B) VI(P).

Shift from mult EXT(B) VI(P) to mult VI(B) VI(P). Local rates of pressing during CP and CB, and of CP biting, for the first and last four sessions of the first 10 sessions under mult VI(B) VI(P) following mult EXT(B) VI(P) (note the exception in sessions for which rates were calculated for 31A), are presented in the final pair of panels of Figure 3 for each subject. With the return to mult VI(B) VI(P), CP pressing returned to baseline levels and patterns for subjects 20A, 26A, and 32A. For rat 32A this meant that rate of CP pressing was

highest during the first segment of CP. Once subject 31A had started to bite in CB (at session 14), CP pressing returned to the typical baseline pattern. Rate of CB pressing also quickly returned to baseline levels and patterns for subjects 20A and 26A, and for subject 31A by sessions 14 through 17. The pattern of CP pressing displayed by 32A remained as it was under mult EXT(B) VI(P) and baseline.

CP biting for all subjects also returned to the typical baseline pattern (i.e., highest rates during the first segment and near zero rates thereafter), once CB biting had started.

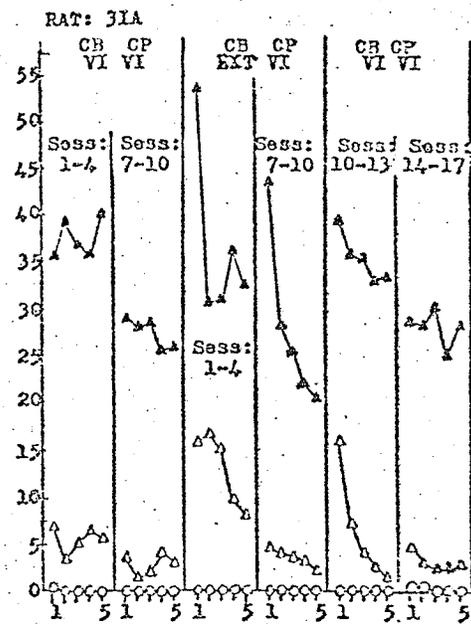
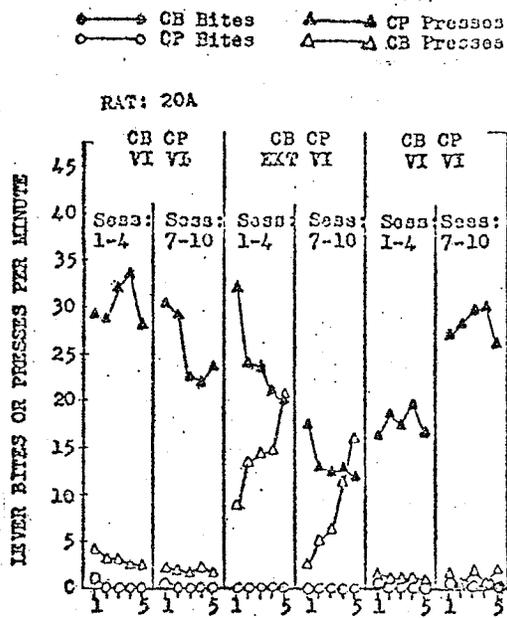
Summary of Local Rate Effects Produced by Shifting

From Mult VI(B) VI(P) to Mult EXT(B) VI(P).

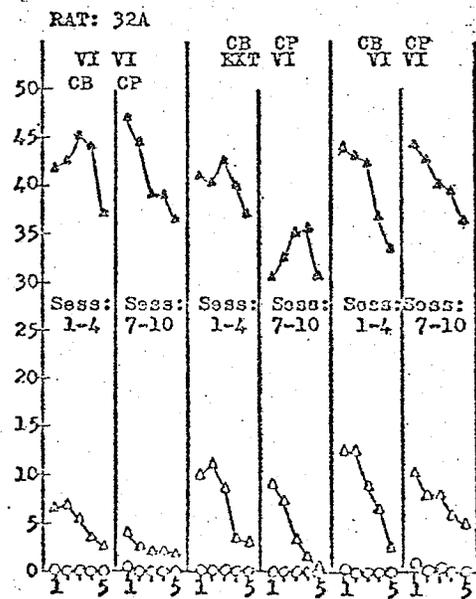
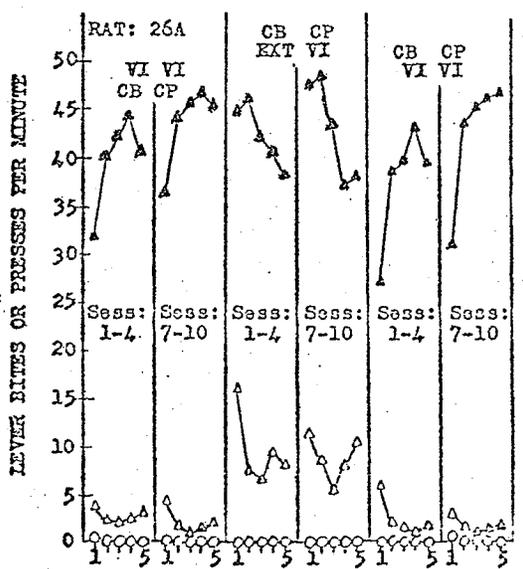
The principal effects of introducing mult EXT(B) VI(P) were:

1. CP pressing - (a) increased during early segments for subjects 31A, 26A, and 20A, and decreased for subject 32A. (b) tended to decrease across later segments for these subjects. (c) increased above baseline during later segments for 31A, when overall rate increases were observed.
2. CB pressing - local effects not consistent across subjects.
3. CP biting - went to zero in early segment and stayed at zero in later segments.

Mult VI(B) VI(P) preceding shift to mult VI(B) EXT(P). Local rates of biting in each component, and of CP pressing, for the first and last four sessions of the last 10 sessions of mult VI(B) VI(P) preceding the shift to mult VI(B) EXT(P), are presented in the first pair of panels of Figure 4, for each subject. Mean rate of CB biting was



component segments



component segments

FIGURE 4

fairly stable across the five component segments, for all subjects. Rates of CP biting and CB pressing (except for subject 20A) were both higher during the first segment of the component than they were during later segments. CB pressing by subject 20A was fairly stable across the component. During later segments, rate of CP biting was typically at zero and CB pressing was typically above zero.

Shift from mult VI(B) VI(P) to mult VI(B) EXT(P). Local rates of biting in each component, and of CB pressing, for the first and last four sessions of the 10 sessions under mult VI(B) EXT(P), are presented in the second pair of panels of Figure 4, for each subject. With the shift to mult VI(B) EXT(P) came major quantitative and qualitative changes in CB biting for all four subjects. The resultant pattern of responding displayed, for the most part, by each subject was similar to that displayed by subjects 20A and 31A for CP pressing under mult EXT (B) VI(P) (see Figure 3, center pair of panels). Rate of biting during the first segment of the components over the first four sessions under mult VI(B) EXT(P) for 26A and over both blocks of sessions for subjects 20A and 31A, was higher than it was during all segments under baseline conditions. It was also higher than it was during all later segments, for each of the four subjects, over both blocks of sessions under mult VI(B) EXT(P). This latter effect was less pronounced, but present, with subject 32A. During the last four component segments, rate of CB biting was (1) higher than baseline rates for these same segments for subject 20A over the first four sessions and for subject 31A over the second four sessions of mult VI(B) EXT(P), (2) equal to

Leaf blank to correct numbering.

baseline rates for 20A over the last four sessions and for subject 31A over the first four sessions of mult VI(B) EXT(P) and (3) generally lower than baseline rates for subjects 26A and 32A over both the first and last four sessions of mult VI(B) EXT(P).

CP biting increased over and remained above baseline during all segments for all four subjects. As with CB pressing under mult EXT(B) VI(P), CP biting here did not show any pattern common to all subjects. For subject 20A, over both the first and last four sessions, and 26A, over the first four sessions only, rates increased across segments. Subjects 31A and 32A, and subject 26A over the last four sessions, displayed a decreasing pattern of CP biting across the component.

CB pressing showed no change in pattern for subject 20A. The peak during the first segment of the component under mult VI(B) VI(P) was absent under mult VI(B) EXT(P) for subject 31A, and lower, relative to later segments, for 26A. Rates during later segments were generally lower than baseline for both 26A and 31A. CB pressing by subject 32A increased over baseline, making the rate during the first segment lower now than rates during later segments.

Shift from mult VI(B) EXT(P) to mult VI(B) VI(P). Local rates of biting in each component, and CB pressing, for the first and last four sessions of the first 10 sessions of mult VI(B) VI(P) following mult VI(B) EXT(P) (note exceptions in sessions for which rates were calculated for subjects 26A and 32A), are presented in the third pair of panels of Figure 4, for each subject. Rates of CB biting and CP biting for subjects 20A and 31A both returned to baseline levels and patterns.

For subject 26A, CB biting during the first segment of the component fell below levels for later segments which in turn were below baseline and at about the same level as under mult VI(B) EXT(P). There was little change in rates of CB biting from those under mult VI(B) EXT(P) by subject 32A; the pattern remained the same, as well. CP biting for subjects 26A and 32A returned to baseline levels and patterns.

CB pressing was higher than baseline during all component segments for subjects 31A (except for the third segment during the first block of sessions) 26A, and 32A, with rates again being highest during the first segment. For subject 20A, CB pressing went slightly above baseline for the first four sessions of mult VI(B) VI(P), showing an "inverted-U" pattern across the component; by the last four sessions, CB pressing returned to baseline levels.

Summary of Local Rate Effects Produced by Shifting from Mult VI(B) VI(P) to Mult VI(B) EXT(P).

The principal effects of introducing mult VI(B)EXT(P) were :

1. CB biting - (a) increased during early segments for subjects 20A, 31A, and 26A. (b) tended to decrease across segments for all subjects. (c) increased, in later segments, above baseline levels for subjects 20A, and 31A [during the last block of sessions under mult VI(B) EXT(P)] and decreased below baseline for subjects 26A and 32A.
2. CP biting - increased above baseline in all segments for all subjects, no consistent pattern across subjects.
3. CB pressing - local effects not consistent across subjects.

Table 4 presents the mean rates (in responses per second times

TABLE 4

Mean rate of CP biting which occurred during the first 10 seconds (R_A) and the last 26 seconds (R_B) of the first segment of the component, for each subject, under each schedule condition and block of sessions shown in Figures 3 and 4. Rates are in responses per second and have been multiplied by 100.

Schedule			Rat							
			20A		31A		26A		32A	
CB	CP	Sessions	R_A	R_B	R_A	R_B	R_A	R_B	R_A	R_B
VI	VI	1-4	5.1	0.2	1.4	0.5	3.0	0.3	0.9	0.2
		7-10	2.0	0.4	2.1	0.0	1.8	0.0	2.4	0.2
EXT	VI	1-4	0.3	0.0	0.0	0.0	0.1	0.0	0.1	0.0
		7-10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
VI	VI	1-4	1.6	0.6	0.0	0.0	0.0	0.0	1.5	0.2
		7-10	1.9	0.2	1.9	0.3	1.4	0.5	2.4	1.3
VI	VI	1-4	2.6	0.3	7.4	1.5	1.3	0.2	2.5	0.2
		7-10	2.6	0.0	11.0	1.5	1.0	0.3	3.4	0.5
VI	EXT	1-4	9.3	12.3	6.6	17.5	4.1	8.2	2.9	3.2
		7-10	4.0	5.4	13.9	9.7	2.8	2.3	2.0	11.5
VI	VI	1-4	1.4	1.2	3.5	1.6	1.5	0.0	1.1	0.1
		7-10	1.1	0.9	6.1	0.4	0.6	0.7	xxx	xxx

100 of CP biting, and Table 5 of CB pressing, by each subject for the first 10 seconds and the remaining 26 seconds of the first segment of the component, taken over the sessions shown in Figures 3 and 4.

In general, under mult VI(B) VI(P) rates of CP biting and of CB pressing during the first 10 seconds of the component were higher than or equal to rates of the same during the next 26 seconds of the component. These data indicate that the subjects might not have stopped biting or pressing immediately upon a change from CB to CP or CP to CB, respectively.

SUMMARY OF THE MAIN FINDINGS

The main findings with regards to shifting from mult VI(B) VI(P) to either mult VI(B) EXT(P) or mult EXT(B) VI(P) were as follows:

1. Overall rate changes - (a) Rate increases of CB biting or CP pressing during the constant component were observed in the total of eight opportunities for the four subjects (two with biting and all four involving only two subjects). (b) Both CB pressing and CP biting tended to increase and then decrease when extinction was in effect during CB or CP, respectively. (c) Little or no change was observed in rate of CB pressing or CP biting when extinction was in effect during CP or CB, respectively. (d) Both CB biting and CP pressing decreased when extinction was in effect during CB or CP, respectively.

2. Local rate change - (a) Rate increases of either CB biting or CP pressing during early portions of the constant component were observed with all but one subject and in six of eight cases. (b) Rate increases of either CB biting or CP pressing during later segments of the constant component were observed when, and only when, overall rate increases in the

TABLE 5

Mean rate of CB pressing which occurred during the first 10 seconds (R_A) and the last 26 seconds (R_B) of the first segment of the component, for each subject, under each schedule condition and blocks of sessions shown in Figures 3 and 4. Rates are in responses per second and have been multiplied by 100.

Schedule			RAT							
			20A		31A		26A		32A	
			CB	CP	Sessions	R_A	R_B	R_A	R_B	R_A
VI	VI	1-4	6.2	6.6	19.9	8.1	16.0	2.9	12.5	9.2
		7-10	5.4	2.4	8.5	5.0	18.1	2.8	10.2	5.1
EXT	VI	1-4	6.9	16.9	17.6	28.7	26.2	27.2	17.4	16.8
		7-10	2.6	5.1	5.3	8.1	18.8	19.0	13.0	16.1
VI	VI	1-4	2.1	2.4	25.0	25.9	20.2	5.8	17.1	26.5
		7-10	4.4	1.4	11.3	5.8	13.5	1.4	20.2	16.1
VI	VI	1-4	7.1	5.7	15.3	4.5	16.8	4.3	13.4	8.2
		7-10	6.3	4.7	17.5	9.5	35.8	9.6	10.9	2.7
VI	EXT	1-4	10.4	6.6	4.1	3.1	6.4	6.4	2.6	5.4
		7-10	5.9	4.3	4.0	3.5	4.4	8.0	3.5	12.0
VI	VI	1-4	7.9	8.2	14.3	8.1	15.8	7.4	15.8	11.0
		7-10	7.5	4.7	22.5	18.5	16.2	11.2	xxxx	xxxx

same response were observed. (c) Rates of CB biting and CP pressing tended to decrease across the component. (d) No consistent results were obtained across subjects with CB pressing or CP biting. (e) No data was collected for CB biting or CP pressing when extinction was scheduled for that response.

DISCUSSION

Overall Rate Effects

The present results with respect to overall rate effects are inconclusive. Positive contrast (an increased rate of responding over baseline during one component of a multiple schedule, with extinction scheduled for responding in the other component), when measured on biting, was observed with only two subjects; whereas, the other two rats showed either no change or negative induction (a decrease in rate of biting with extinction for pressing). One of the subjects (Rat 31A) showed contrast for biting and also for pressing, although the effect was less pronounced for pressing. Rat 20A also showed an increased rate of CP pressing, but only during the first session of mult EXT(B) VI(P), and rate of CP pressing subsequently decreased below baseline (negative induction). Again the other two rats showed little or no change in rate of CP pressing under mult EXT(B) VI(P). This difference might be related to procedural differences between the two sets of rats. The two rats which did show contrast experienced mult VI(B) EXT(P) prior to mult EXT(B) VI(P) and vice versa for the other two (see Table 2). That this difference was indeed somehow responsible does seem unlikely as contrast has not previously been reliably produced with rats. For

example, Pear and Wilkie (1971) found both contrast and induction and Zimmerman and Schuster (1962) found induction with rats pressing a lever. Furthermore, Scull and Westbrook (1973) using two different responses (key pecking and bar pressing by pigeons) in a multiple schedule, observed contrast in only one of ten cases. Nevertheless, the possibility does exist that the order of presenting the conditions was important in the present study, and further consideration of this may be warranted if similar studies are to be conducted.

The absence of contrast in the present experiment in five of eight cases does not lend support to Pear and Wilkie's (1971) notion that the degree of stimulus control over responding is an important determinant of the type of interaction to occur in multiple schedules. Positive contrast is, according to them, most likely under conditions of strong stimulus control. Since, in the present study, different responses were reinforced in each component, one would expect a strong degree of stimulus control, and thus, positive contrast when extinction occurred in one of the components. The high rates of biting during CB and pressing during CP; the low rates of biting during CP and of pressing during CB do suggest that strong stimulus control was obtained.

On the other hand, if Halliday and Boakes' (1969) "rebound" hypothesis is accurate, then contrast would not be expected regardless of the degree of stimulus control obtained from the present procedure. According to their hypothesis, in a multiple schedule involving different responses in each component, extinction of one response should increase the subject's tendency to perform that response in the constant component and thereby lead to decreased rate of the other responses in

the constant component. Although this notion does hold for Scull and Westbrook's (1973) findings [except for one pigeon which did show contrast under mult VI (key peck) EXT (bar press)] and those of much earlier work, it fails to account for the occurrence of contrast in three of eight cases in the present study. Further doubt is cast on the validity of this hypothesis by the fact that CP biting and CB pressing did not show significant increases (and in fact showed little change or a decrease) with extinction of CB biting or CP pressing, respectively. Of course, the delay contingency used to decrease the likelihood that the "wrong" response would be reinforced, could have worked against the increased occurrence in the constant component of the response undergoing extinction in the other component. The observance of a decrease in CB pressing under mult VI(B) EXT(P) does, however, help support the position that no "rebound" effect occurred.

In conclusion, with regard to overall rate effects, no obvious differences were observed between types of interactions (i.e., contrast or induction) which occurred between components with biting or pressing as the response reinforced during the constant component. This indicates that, at least when these two responses are both involved, the response variable is not functional in determining the type of interaction that will occur in a multiple schedule. Since the results were inconsistent and possibly peculiar to the schedules and procedure used here, however, no definite clarification of the importance of the response variable is possible. The results do not support either the stimulus control hypothesis of Pear and Wilkie (1971) or the response-inhibition "rebound" hypothesis of Halliday and Boakes (1969).

The occurrence of CP bites and CB presses is interesting and commands some comments not directly pertinent to contrast. Direct observations of the subjects in the experimental chamber indicated that the two-second delay contingency (used to minimize the adventitious reinforcement of CP biting and CB pressing) was effective. The responses were found to be executed by a complete shift from the topographies typical to pressing to the stereotypical stance assumed for biting, and vice versa. Given these observations, the fairly high rates of CB pressing and lower, but consistent, rates of CP biting under mult VI(B) VI(P) cannot be explained in terms of actual bites which occurred with a press from the press-stance or vice versa. The fact that most of the CP bites under mult VI(B) VI(P) occurred within the first 10 seconds of the component indicates that most (or all) CP biting was due to a continuation of biting appropriate to CB, i.e., "run-throughs". Run-throughs may account for some of the CB pressing but not all as rates were quite high in later component segments. No direct information is available (such as rates at various times since reinforcement) that would assist in accounting for the occurrence of CB pressing late in the component. It is however, possible that as time since reinforcement increased in CB, the prevailing conditions would more closely approximate those under which pressing was reinforced; namely, those under which biting was extinguished. Under such conditions pressing might have occurred. Why this would not be the case with biting is not clear.

Also difficult to account for are the increased rates of CB pressing and CP biting which occurred under mult EXT(B) VI(P) and mult VI(B)

EXP(P), respectively. This suggests that strong stimulus control by the houselight may not have been obtained and that more important than this was the response-reinforcer relationship. It is also possible that, under extinction for pressing or biting, as the rate of the extinguished response decreased, the likelihood of the subject engaging in the alternative response (biting or pressing) increased since, as noted above, conditions more closely approximated those under which that response was reinforced (i.e., extinction for the other response). As the alternative response occurred and was not reinforced during the extinction component its rate would also decrease--as was indeed the case for each subject under each condition. Since increases in CB pressing and CP biting occurred when (1) increases, (2) no changes, and (3) decreases in CP pressing and CB biting, respectively occurred, no apparent relation exists between the direction of change of the reinforced response in the constant component and direction of change in the rate of that response in the changing component. In summary, we find that the occurrence of what could be called "errors" presents some interesting interactions in multiple schedules and possibilities for further research.

Local Rate Effects

With the shift to extinction (for bites or presses) the rate of the response reinforced during the constant component increased during the early part of the component over rates during the same component under mult VI(B) VI(P) and then decreased with the passage of time in that component. Although in two cases during baseline responding early in the component was slightly higher than later in the component, the shift at extinction greatly enhanced this difference. This effect was

observed with all but one subject and in six out of eight cases, and is similar to that observed by Arnett (1973), Boneau and Axelrod (1962), Gamzu and Swartz (1973), Nevin and Shettleworth (1966), and Rachlin (1973).

Rachlin (1973), it will be recalled, proposed that the occurrence of increased rates of responding early in the constant component (and overall positive contrast) is the result of the transition from a signal for low reinforcement to one of high reinforcement. This change excites certain responses that add to those maintained by the operant contingencies in operation. Nevin and Shettleworth (1966) account for local rate effects which occur early in the component (or what they term "transient" contrasts) in terms of Pavlovian theory. Positive transient contrast is, according to this interpretation, the short-term after-effects of excitation produced by the presentation of the stimulus associated with the higher rate of reinforcement. This aspect of their interpretation is similar to Rachlin's (1973) and Gamzu and Schwartz's (1973) but a principle difference does exist with regard to their accounts of overall contrast (or "sustained contrasts", Nevin and Shettleworth, 1966). Rachlin (1973) and Gamzu and Schwartz (1973) used the same principle to account for both local and overall contrast, whereas Nevin and Shettleworth state that something, in addition to the transient contrast, must be responsible for the sustained contrast which they observed. They present two reasons for this (at least partial) independence of transient and sustained contrast. First, they found that an overall rate of responding in the constant component could be shifted without changing the pattern of responding within the constant component. Second, the

sustained contrast effects outlasted the transient effects over extended training. Nevin and Shettleworth do not discount the possibility of overall rate measures indicating contrast when only transient increases early in the component occur and add to other responding (Rachlin's hypothesis), but they also make it clear that this is not the only possibility when overall contrast is observed. Arnett (1973) also suggests, on the basis of one of her subjects (Pigeon 3209), the independence of local rate effects and overall rate effects. This subject showed increased rates of key pecking early in the constant component followed by decreases (local effects), but not overall contrast; whereas two other subjects showed both local and overall contrast. Arnett (1973) points out that the baseline (mult VI VI) performance of Pigeon 3209 was quite variable and that the ten sessions used to represent baseline performance might have been inadequate to assess any contrast effects. However, if the absence of contrast was not due to a variable baseline, the independence of local and overall contrast is clearly possible. The present results lend support to this possibility.

Either Rachlin's (1973) or Nevin and Shettleworth's (1966) formulation could account for the local rate effects observed in the present experiment. However, two points indicate that the overall contrast observed here was, at least in part, independent from the factors leading to the local contrast. First, in three of the six cases where local rate contrast effects were observed, overall contrast was absent, which is what Arnett (1973) found in one of three cases. As in Arnett's study, baselines were quite variable in the present experiment. However, this was the case both when contrast occurred and when it was absent,

indicating that a variable baseline may not have been responsible for Arnett's Pigeon 3209 not showing both overall and local contrast or for both overall and local contrast not always occurring in the present study. The second point is that in those cases where overall contrast was observed [with Rat 20A, under mult VI(B) EXT(P); and Rat 31A under mult VI(B) EXT(P) and mult EXT(B) VI(P)], local rates increased in all component segments over what they were during baseline. This was never the case when overall contrast did not occur. Although this second point does not contradict Rachlin, it does, in conjunction with the first point, support Nevin and Shettleworth (1966) and Arnett (1973).

As Arnett (1973) points out "...present descriptions of behavioral contrast in terms of an increase in overall response rate may be preventing a better understanding of the conditions producing behavioral interaction in multiple schedules" (p. 498). The present results certainly support this notion and clearly point out the importance of investigating local effects in their own right, especially since the local effects observed here were consistent across three of four subjects and across both responses.

SUMMARY AND CONCLUSIONS

The present study sought to clarify some of the effects of shifting from mult VI(R1) VI(R2) to mult VI(R1) EXT(R2), where R1 and R2 are two different responses (i.e., lever biting and lever pressing) reinforced as indicated during the two components of a multiple schedule of food reinforcement. With regard to overall rate changes, it was found that for:

- (1) R1 during the VI component: contrast may occur but not consistently across subjects.
- (2) R1 during the EXT component: first increases occur followed by decreases.
- (3) R2 during the VI component: little or no change was observed.
- (4) R2 during the EXT component: decreases were observed.

With regard to local rate effects, it was found that for:

- (1) R1 during the VI component: (a) rates during early component segments tended to increase above baseline (local contrast), both in the presence and absence of overall rate increases. (b) Rates tended to progressively decrease across segments. (c) Rates during later segments tended to increase above baseline when overall contrast occurs.
- (2) R1 during the EXT component: the local rate effects were not consistent across subjects.
- (3) R2 during the VI component: the local rate effects were not consistent across subjects.
- (4) R2 during the EXT component: no data was collected on local effects.

These findings were consistent across the two responses used and are consistent with the findings of Arnett (1973), with regard to local effects, and with Scull and Westbrook (1973) with regard to overall rate effects.

On the basis of these general findings the following conclusions were made:

- (1) The absence of positive contrast in five of eight cases does not

support the stimulus control hypothesis of Pear and Wilkie (1971), since a strong degree of control was obtained with different responses required in each component.

- (2) The occurrence of contrast in three of eight cases and the absence of increases in CP biting or CB pressing during extinction for biting or pressing, do not support Halliday and Boakes '(1969) response-inhibition "rebound" hypothesis.
- (3) The occurrence of local contrast in both the absence and presence of overall contrast and the occurrence of increased rates in all component segments only when overall contrast was observed, suggest the, at least partial, independence of local and overall contrast effects.
- (4) On the basis of this possible independence, or at least of the reliable findings with the local rate measures, it is suggested that local rates as well as overall rates, be looked at when investigations of contrast are made, if a clear description of interactions in multiple schedules is to be obtained.

REFERENCES

- Arnett, F.B. A local rate of response and interresponse time analysis of behavioral contrast. Journal of the Experimental Analysis of Behavior, 1973, 20, 489-498.
- Bloomfield, T.M. Behavioral contrast and the peak shift. In R.M. Gilbert and N.S. Sutherland (Eds.), Animal discrimination learning. New York: Academic Press, 1969.
- Boakes, R.A. Response decrements produced by extinction and by response independent reinforcement. Journal of the Experimental Analysis of Behavior, 1973, 19, 293-302.
- Boneau, A., & Axelrod, S. Work decrement and reminiscence in pigeon operant responding. Journal of Experimental Psychology, 1962, 64 352-354.
- Brethower, D.M., & Reynolds, D.S. A facilitative effect of punishment on unpunished behavior. Journal of the Experimental Analysis of Behavior, 1962, 5, 191-199.
- Brown, P., & Jenkins, H.M. Auto-shaping of the pigeon's key peck. Journal of the Experimental Analysis of Behavior, 1968, 11, 1-8.
- Ferster, C.B., & Skinner, B.F. Schedules of reinforcement. New York: Appleton-Century-Crofts, 1957.
- Freeman, B.J. Behavioral contrast: Reinforcement frequency or response reduction? Psychological Bulletin, 1971, 75, 347-356.
- Gamzu, E., & Schwartz, B. The maintenance of key-pecking by stimulus contingent and response independent food presentation. Journal of the Experimental Analysis of Behavior, 1973, 19, 65-72.

- Halliday, M.S., & Boakes, R.A. Discrimination involving response independent reinforcement: Implications for behavioral contrast. In R.A. Boakes and M.S. Halliday (Eds.), Inhibition and learning. London: Academic Press, 1972.
- Nevin, J.A., & Shettleworth, S.J. An analysis of contrast effects in multiple schedules. Journal of the Experimental Analysis of Behavior, 1966, 9, 305-315.
- Pear, J.J., & Wilkie, D.M. Contrast and induction in rats on multiple schedules. Journal of the Experimental Analysis of Behavior, 1971, 15, 289-296.
- Premack, D. On some boundary conditions of contrast. In F.T. Tapp (Ed.), Reinforcement and behavior. New York: Academic Press, 1969.
- Rachlin, H. Contrast and matching. Psychological Review, 1973, 80, 217-234.
- Reynolds, T.S. Behavioral contrast. Journal of the Experimental Analysis of Behavior, 1961, 4, 57-71.
- Scull, J., & Westbrook, R.F. Interactions in multiple schedules with different responses in each of the components. Journal of the Experimental Analysis of Behavior, 1973, 20, 511-519.
- Terrace, H.S. Stimulus control. In W.K. Honig (Ed.), Operant behavior: Areas of research and application. New York: Appleton-Century-Crofts, 1966.
- Terrace, H.S. Conditioned inhibition in successive discrimination learning. In R.A. Boakes and M.S. Halliday (Eds.), Inhibition and

learning. London: Academic Press, 1972.

Westbrook, R.F. Failure to obtain positive contrast when pigeons press a bar. Journal of the Experimental Analysis of Behavior, 1973, 20, 499-510.

Wilkie, D.M. Variable-time reinforcement in multiple and concurrent schedules. Journal of the Experimental Analysis of Behavior, 1972, 17, 59-66.

Zimmerman, J., & Schuster, C.R. Spaced responding in multiple DRL schedules. Journal of the Experimental Analysis of Behavior, 1962, 5, 497-504.