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BEHAVIORAL CONTRAST AS DIFFERENTIAL TIME ALLOCATION

K. GEOFFREY WHITE[1]

VICTORIA UNIVERSITY OF WELLINGTON, NEW ZEALAND

In Experiment I, hooded rats were exposed to multiple variable-interval schedules of reinforcement in which manipulanda and reinforcement magazines at opposite ends of the experimental chamber were associated with the different components. Time allocated to each component was measured by recording the time spent by the subject in the appropriate half of the chamber. Positive behavioral contrast was observed for the comparison between multiple variable-interval 30-second variable-interval 30-second and multiple variable-interval 30-second variable-interval 90-second conditions for both response frequency and time allocation measures, but not for mean local response rate (response frequency per time allocated to a component). In Experiment II, rats were exposed to multiple variable-time schedules in which reinforcement was response independent. Time allocated to each component was measured for two conditions, multiple variable-time 30-second variable-time 30-second and multiple variable-time 30-second variable-time 90-second. Positive behavioral contrast of time allocation was exhibited. The results indicated that time allocation was differentially sensitive to changes in reinforcement probability, and that behavioral contrast may result from the differential allocation of time to the different components of the multiple schedule.

Key words: time allocation, behavioral contrast, multiple schedules, variable-interval schedules, variable-time schedules, response-independent reinforcement, lever pressing, rats

In a typical multiple schedule, two components alternate in succession, each lasting for a fixed period of time. Independent variable-interval (VI) schedules associated with different stimulus conditions are in effect in the different components. When the reinforcement density in one component is decreased while the other remains unaltered, there is an increase in the response rate in the unaltered component concurrent with a response-rate decrease in the changed component. This phenomenon, known as positive behavioral contrast, has been extensively investigated over the last decade (Freeman, 1971; Mackintosh, 1974).

Behavioral contrast is usually measured as an increase in total frequency of responses recorded in the unaltered component (Reynolds, 1961). In addition, transient changes in the local rate of response are observed when response frequency is recorded during successive segments of each component (Buck, Rothstein, and Williams, 1975; Menlove, 1975; Nevin and Shettleworth, 1966). In multiple schedules, component duration is normally determined by the experimenter, and serves as a convenient time base for measuring response rate. An increase in response frequency in the unaltered component (*i.e.*, positive contrast) is therefore also manifested as an increase in response rate. Increases in both frequency and rate of response are thereby seen as equivalent indices of contrast.

Within a component of a multiple schedule, the subject may engage in activities other than responding (Herrnstein, 1970). Therefore, if the time allocated by the subject to responding is measured, response-rate changes may reflect differences in time allocation in the different components. That is, an observed increase in response frequency or rate may result from the fact that more time is allocated to responding in the unaltered component. The present experiments were de-

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signed to explore the role of differential time allocation in behavioral contrast for hooded rats.

EXPERIMENT I

Experiment I was designed to overcome a problem with previous contrast experiments (such as Terrace, 1968) where the differential condition follows nondifferential (baseline) training, namely that an overall increase in responding in the unaltered component may occur over time, regardless of changes in reinforcement density in the other component. The present design controlled for the order effect by preceding and following differential training by nondifferential training. The order effect was further controlled by continuing the nondifferential training of a second group of subjects while the first group was in the differential condition. The second group of subjects was then given differential training (*cf.* Gutman, Sutterer, and Brush, 1975).

In order to measure time allocation in Experiments I and II, the reinforcement sources (and manipulanda) associated with each component were physically separated by placing them at opposite ends of the experimental chamber. By recording the time the animal spent in each half of the chamber, a measure of the time allocated to each component was possible.

METHOD

Subjects

Eight experimentally naive female hooded rats, approximately six months old at the beginning of the experiment, were maintained at 80 to 85% of their free-feeding body weights. Water was continuously available in the living cages. Supplementary feeding after each session ensured maintenance of their prescribed body weights.

Apparatus

The experimental space was a modified Lehigh Valley chamber (Model 143-21) with floor dimensions of 30 cm by 24 cm wide. The modification involved the addition of a second identical liquid dipper, stimulus light, and retractable lever to the opposite end of the chamber from the existing dipper, light, and lever. Each retractable lever was mounted 2 cm above the floor, 8.5 cm to the right of the central dipper, and 5 cm below the stimulus light. A minimum force of 0.12 N was sufficient to operate either lever. Effective responses produced a feedback relay click. The reinforcer was a sweetened condensed milk solution mixed one part milk to one part water. Each dipper when filled held 0.01 cc of condensed milk.

The aluminum floor was pivoted at the centre. Switches at each end of the floor were closed when the floor was tilted. When the subject was at the left end of the chamber, the switch at the left end of the floor was closed, thus allowing the direct recording of time spent by the animal at the left end. Time allocated to the right end of the chamber was recorded when the switch at the right end of the floor was closed. Masking noise was provided and general illumination was produced by a centrally located standard houselight. Electromechanical relay apparatus, which controlled and recorded experimental events, was located in an adjacent room. A small one-way mirror allowed observation of the experimental chamber from the room containing the porgramming apparatus.

Procedure

Sessions were conducted daily. Adaptation to the chamber and magazine training in Session 1 were followed by reinforcing successive approximations to lever pressing. For four subjects, shaping to press the left lever and 50 continuously reinforced left-lever responses were followed by shaping to press the right lever and 50 continuously reinforced right-lever responses. For the other four subjects, shaping and continuous reinforcement at the right end of the chamber preceded shaping and continuous reinforcement at the left end. In Session 2, a further 50 continuously reinforced lever presses on one side were followed by 50 continuously reinforced responses on the other side, in the order left before right for four subjects and right before left for the other four. In Sessions 3 and 4, responding in both components was reinforced according to VI 10-sec schedules, 3 min of each component alternating through 18-min sessions.

For 20 sessions from Session 5, nondifferential (baseline) training conditions were in effect for each of the four rats in the first group. Three-minute periods, during which left-lever responses were reinforced by left-dipper presentations according to a VI 30-sec schedule, alternated directly with 3-min periods during which right-lever responses were reinforced by right-dipper presentations also according to a VI 30-sec schedule (*mult* VI 30-sec VI 30-sec). Whenever one component was in effect, the lever associated with the other was retracted, its stimulus light was off, and the associated dipper was never presented. Session duration was always 30 min. The four rats in the second group were exposed to precisely the same nondifferential condition for 35 sessions from Session 5.

For the first group of subjects, differential training was conducted for 15 sessions from Session 25. The general conditions of differential training were the same as for the previous nondifferential training, except that reinforcement rate in the right component was decreased. Right-lever responses were now reinforced by right-dipper presentations according to a VI 90-sec schedule (*mult* VI 30-sec VI 90-sec). Following differential training for the first group, 15 sessions of nondifferential training from Session 40 were conducted. For the second group of subjects, the condition for 15 sessions from Session 40 was *mult* VI 30-sec VI 90-sec.

RESULTS

Three measures were recorded, response frequency in each component per session, total time allocated to each component per session (*i.e.*, time spent on the side of the chamber corresponding to the component in effect, during that component), and changeovers from one side to the other during each component. The time-allocation measures for each component were independent of one another and had a maximum possible of 900 sec (equal to the total duration per session of each component). A fourth measure, mean local response rate, was derived from the first two and provided an index of the average momentary rate of responding in a component over the session. Mean local rate was calculated by dividing response frequency in a component by the time allocated to that component for each session. Note that the mean local rate measure differs from local response rate (per component segment) and overall response rate (per session) used in previous studies of behavioral contrast.

Response frequency in each component, time allocated to each component, and mean local response rate in each component were averaged over the four subjects in each of the two groups and are plotted over sessions in Figures 1, 2, and 3. Data for individual subjects were treated by averaging the measures for Sessions 10 to 24, Sessions 25 to 34, and Sessions 40 to 54. Table 1 presents these averages for the two conditions, *mult* VI 30-sec VI 30-sec (A), and *mult* VI 30-sec VI 90-sec (B). Table 2 presents the mean changeover responses per session from left to right during the left component and from right to left during the right component for the nondifferential and differential conditions.

Response frequency. Positive contrast was exhibited in the averaged data for subjects in the first group (Figure 1), in that mean response frequency in the unaltered (left) component (unfilled symbols) during *mult* VI 30-sec VI 90-sec was higher than in the preceding and subsequent *mult* VI 30-sec VI 30-sec conditions. In addition, contrast occurred in the first group, in that the mean left-component response frequency was higher than that for the second group of subjects in the nondifferential condition over the same sessions (Sessions 25 to 34). Positive contrast was exhibited

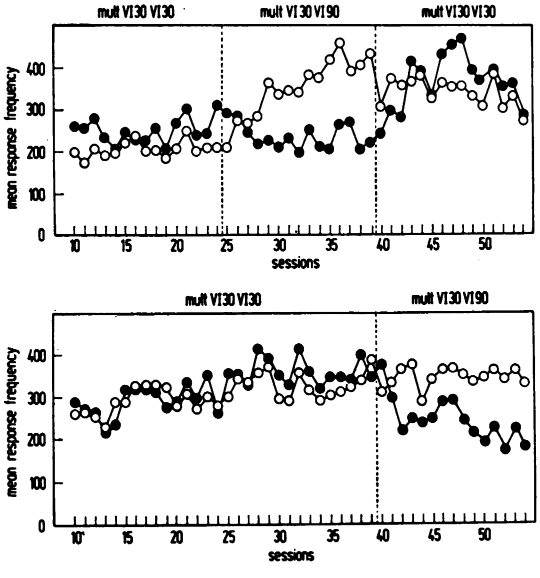

Fig. 1. Mean response frequency in left (unfilled circles) and right (filled circles) components per session in Experiment I. Data for subjects in the first group are shown in the top panel; data for subjects in the second group are shown in the bottom panel.

Table 1

Mean response frequency, time allocated, and mean local response rate (responses per second) for left (L) and right (R) components. Each measure is the average of 15 sessions for each subject. Condition A was *mult* VI 30-sec VI 30-sec and Condition B was *mult* VI 30-sec VI 90-sec. Standard deviations for frequency and time measures are shown in parentheses.

Subject	*Component*	*Response Frequency*			*Mean Time (seconds)*			*Mean Local Response Rate*		
		A	*B*	*A*	*A*	*B*	*A*	*A*	*B*	*A*
S19	L	244 (59)	608 (191)	559 (125)	734 (31)	793 (55)	722 (79)	0.33	0.76	0.77
	R	263 (58)	260 (34)	413 (102)	698 (84)	616 (50)	717 (63)	0.37	0.42	0.57
S20	L	222 (28)	351 (72)	346 (37)	737 (37)	804 (60)	773 (48)	0.30	0.44	0.45
	R	253 (58)	252 (58)	455 (108)	638 (107)	565 (45)	768 (59)	0.38	0.44	0.59
S21	L	224 (52)	282 (23)	277 (40)	737 (36)	868 (12)	844 (34)	0.30	0.33	0.33
	R	277 (51)	238 (61)	345 (94)	788 (51)	580 (103)	727 (99)	0.35	0.41	0.47
S22	L	139 (24)	179 (20)	186 (20)	708 (43)	815 (43)	766 (57)	0.20	0.22	0.24
	R	214 (27)	194 (28)	250 (26)	741 (65)	555 (81)	740 (75)	0.29	0.35	0.34
Group	L	207	355	342	729	820	776	0.28	0.44	0.45
Mean	R	252	236	366	716	579	738	0.35	0.40	0.49
		A	*A*	*B*	*A*	*A*	*B*	*A*	*A*	*B*
S23	L	380 (56)	430 (71)	361 (50)	794 (40)	804 (50)	865 (20)	0.48	0.53	0.42
	R	264 (83)	445 (92)	290 (81)	632 (59)	789 (60)	624 (82)	0.42	0.56	0.47
S24	L	178 (25)	172 (27)	197 (17)	727 (44)	732 (38)	792 (40)	0.24	0.24	0.25
	R	214 (26)	231 (26)	152 (38)	687 (45)	714 (72)	554 (46)	0.31	0.33	0.27
S25	L	252 (31)	314 (42)	401 (45)	670 (72)	741 (32)	857 (26)	0.38	0.42	0.47
	R	346 (47)	395 (45)	279 (64)	828 (30)	847 (27)	663 (27)	0.42	0.47	0.43
S26	L	350 (63)	404 (48)	423 (45)	800 (39)	794 (38)	838 (68)	0.44	0.51	0.51
	R	343 (76)	371 (43)	252 (62)	741 (66)	851 (15)	682 (55)	0.46	0.44	0.37
Group	L	290	330	345	748	768	838	0.38	0.42	0.41
Mean	R	292	360	243	722	800	631	0.40	0.45	0.38

by three subjects in the first group (Table 1). While Subject 22's response frequency in differential training exceeded the initial baseline level, it continued to increase in the subsequent nondifferential condition (Table 1).

There was at best, weak positive contrast for three of four subjects in the second group (Table 1), reflected in a very slight (and unreliable) increase for the averaged data in the differential condition (Figure 1).

Time allocation. A noticeable feature of the time-allocation data (Figure 2) was that there was far less variability, both within and between subjects, than for the corresponding response-frequency data. Reliable contrast effects occurred for both groups. Mean time allocated in the unaltered component was greater in the *mult* VI 30-sec VI 90-sec condition than in *mult* VI 30-sec VI 30-sec, for both within-group and between-group comparisons (Figure 2). Positive contrast of time allocation was exhibited by all subjects in both groups (Table 1). The magnitude of the contrast effect is not great, due to the ceiling effect produced by the 900-sec upper bound on time allocation, but it is nevertheless reliable, because it occurred for all subjects.

Mean local response rate. Positive contrast did not occur for response frequency per time allocated to responding in either the averaged data (Figure 3) or the data for individual subjects (Table 1). Interestingly, the mean local response rates in the altered (VI 90-sec) component did not show a marked decrease, compared with the original response-frequency and time-allocation data. For subjects in the first group, there appeared to be a gradual increase in mean local rates across sessions (Figure 3).

Changeover responses. Changeover responses from left to right during the left component and from right to left during the right component were recorded during each session, and are presented in Table 2 averaged over 15 sessions of the nondifferential and differential conditions for individual subjects. Mean changeovers per session in each component were always much greater than the number of components (5) scheduled in a session. This result confirms the informal observation that the subjects did not remain on the side of the component in effect during the component, but often crossed to the other side. Table 2 shows that the frequency of changeover re-

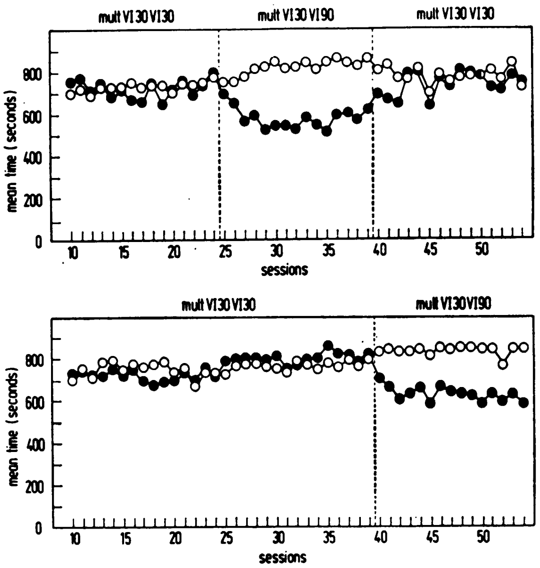

Fig. 2. Mean time on the left during the left component (unfilled circles) and mean time on the right during the right component (filled circles) per session in Experiment I. The top panel shows data for subjects in the first group, the bottom panel data for the second group.

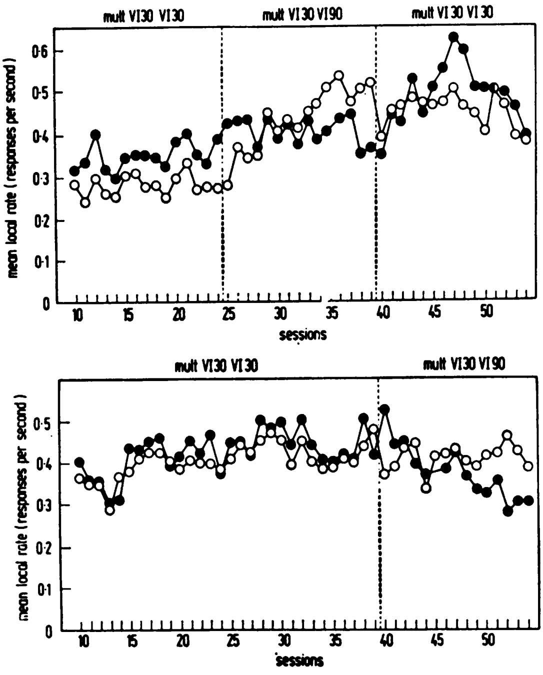

Fig. 3. Mean local response rate (response frequency per time allocated to a component) in left (unfilled circles) and right components (filled circles) per session in Experiment I, averaged for subjects in the first group (top panel) and second group (bottom panel).

Table 2

Mean frequencies of changeover response from left to right during the left (L) component and from right to left during the right (R) component averaged over 15 sessions for each condition for individual subjects. Standard deviations are given in parentheses. Condition A was *mult* VI 30-sec VI 30-sec and Condition B was *mult* VI 30-sec VI 90-sec.

Subject	*Component*	*Changeover Frequency*		
		A	*B*	*A*
S19	L	21.6 (9)	13.9 (9)	38.9 (24)
	R	21.3 (11)	33.2 (6)	33.7 (14)
S20	L	30.2 (11)	17.5 (12)	25.7 (17)
	R	40.1 (17)	52.1 (15)	21.3 (12)
S21	L	31.9 (12)	2.9 (2)	11.1 (11)
	R	16.3 (10)	34.1 (11)	25.7 (11)
S22	L	26.7 (6)	12.0 (8)	25.1 (17)
	R	23.7 (10)	44.3 (10)	31.3 (19)
Group	L	27.6	11.6	25.2
Mean	R	25.3	40.9	28.0
		A	*A*	*B*
S23	L	23.5 (8)	21.4 (15)	3.7 (3)
	R	46.2 (13)	21.3 (15)	36.4 (16)
S24	L	23.9 (7)	25.9 (7)	17.1 (8)
	R	28.2 (4)	30.3 (14)	38.0 (9)
S25	L	37.9 (11)	41.9 (9)	10.4 (9)
	R	15.3 (5)	14.7 (10)	45.9 (8)
S26	L	20.3 (12)	22.1 (9)	7.3 (7)
	R	28.1 (10)	8.1 (5)	31.9 (8)
Group	L	26.4	27.8	9.6
Mean	R	29.4	18.6	38.0

sponses decreased markedly in the unaltered component in the differential condition, compared with nondifferential training, whereas the frequency of changeovers in the altered component (where reinforcement density was reduced) showed a general increase.

DISCUSSION

The present study extends the demonstration of positive behavioral contrast in rats (Gutman and Minor, 1976; Gutman, Sutterer, and Brush, 1975; Pear and Wilkie, 1971) to a differential training procedure, where the reinforcement density in the altered component was reduced to a nonzero level. The weak contrast effect for response frequency in the second group of subjects may have been the result of their extended period of nondifferential training (*cf.* Gutman *et al.,* 1975).

In particular, Experiment I demonstrated positive behavioral contrast for both response-frequency and time-allocation measures, but not for mean local response rate. This result indicates that positive contrast derives partly from an increase in the time allocated to responding in the unaltered component, rather than from an increase in response rate. That is, the increase in response frequency in the unaltered component may partly be a result of the allocation of more time to responding at an otherwise near-constant rate. The increase in time allocation in the unaltered component of the differential condition cannot be accounted for in terms of a reduction in the latency of crossing to that component, since the changeover rate during a component was fairly high. Comparison of Tables 1 and 2 indicates, however, that when the time allocated to a component was high, the frequency of changeovers during the component was low (and *vice versa*). That is, increased time allocation in a component appears to correspond to a decrease in the frequency of occasions on which the subject crosses to the other side. Whether this relation reflects a contrast effect for approach-withdrawal behaviors (*cf.* Hearst and Franklin, 1977) in the present context is speculative.

Bouzas and Baum (1976) studied behavioral contrast of time allocation in pigeons. Grain was delivered according to a VI schedule in one component when the pigeon stood on a platform near the magazine. Extinction was in effect in the other component. Bouzas and Baum measured the percentage of time spent on the platform in each component and found an increase in the time spent on the platform in the VI component, compared with nondifferential training. While their result is consistent with the present data for hooded rats, the two experiments are not strictly comparable. In the present experiment, a discrete response (lever pressing) was employed; in Bouzas and Baum's study, platform depression was a continuous response.

The suggestion that behavioral contrast reflects changes in time allocation, rather than in mean local response rate, is not inconsistent with the transient effects observed when local rate is recorded for segments of a component for pigeons (Arnett, 1973; Nevin and Shettleworth, 1966) and rats (Gutman and Minor, 1976). Indeed, differences in local response rate in component segments might be a consequence of differential time allocation, although this possibility requires empirical verification. Support for this notion comes from Menlove's (1975) study of contrast in pigeons. He found that for 5-sec component durations, the local pattern of responding (assessed in terms of interresponse-time distributions) was less important than time spent responding (assessed in terms of response latencies) in determining transient contrast.

EXPERIMENT II

The result of Experiment I indicated that behavioral contrast in rats is at least partly determined by differential time allocation to the different components of the multiple schedule. The data point to the possibility that allocation of time to responding is sensitive to the relative rate of reinforcement in the components. That is, time allocation is sensitive to reinforcement value (*cf.* Baum and Rachlin, 1969; Bouzas and Baum, 1976). If this is so, then behavioral contrast should occur for time allocation when there is no response requirement. Experiment II examined behavioral contrast of time allocation in multiple variable-time (VT) schedules, where reinforcement was delivered independently of the subject's behavior. The general design and procedure for Experiment II was much the same as for Experiment I, except for the use of VT instead of VI schedules.

METHOD

Subjects

Eight experimentally naive female hooded rats, approximately seven months old at the beginning of the experiment, were maintained at 80 to 85% of their free-feeding body weights under conditions similar to those in the preceding experiment.

Apparatus

The experimental chamber was identical to that used in Experiment I. Both retractable levers were retracted at all times during Experiment II. Components were signalled by the stimulus lights on the right of the dippers.

Procedure

Sessions were conducted daily. Because there was no response requirement, conditions of nondifferential training were in effect from Session 1. Three-minute components alternated in direct succession through each 30-min session. In the left component, the left stimulus light was on and the left dipper was presented at intervals averaging 30 sec (VT 30-sec). In the right component, the right stimulus light was on and right dipper presentations were also governed by a VT 30-sec schedule. Thus, the schedule in nondifferential training was *mult* VT 30-sec VT 30-sec. The VT schedules delivered condensed milk independently of the subject's behavior or position in the chamber. Nondifferential training continued until Session 24 for four subjects in the first group and until Session 39 for the four subjects in the second group.

The general conditions of differential training were the same as in nondifferential training, except that the reinforcement density in the right component was decreased (*mult* VT 30-sec VT 90-sec). The differential condition was in effect for 15 sessions from Session 25 to 39 for the first group and from Session 40 to 54 for the second group. Following differential training, subjects in the first group were returned to the *mult* VT 30-sec VT 30-sec condition for Sessions 40 to 54.

RESULTS

Time in seconds spent on the left side of the chamber during the left component, and on the right side during the right component, was recorded for each session. The time measures were independent and had an upper bound of 900 sec. Frequencies of changeover response from left to right during the left component, and from right to left during the right component, were also recorded. Figure 4 presents the average times allocated to each component over sessions separately for the four subjects in the first group and for the four subjects in the second group. For each subject, times allocated to each component were averaged over 15 sessions for Sessions 10 to 24, Sessions 25 to 34, and Sessions 40 to 54 (Table 3). The data for individual subjects were accurately reflected by the averaged data in Figure 4.

Reliable positive behavioral contrast occurred for both the first group and the second group in two respects. First, mean time allocated to the unaltered component was greater

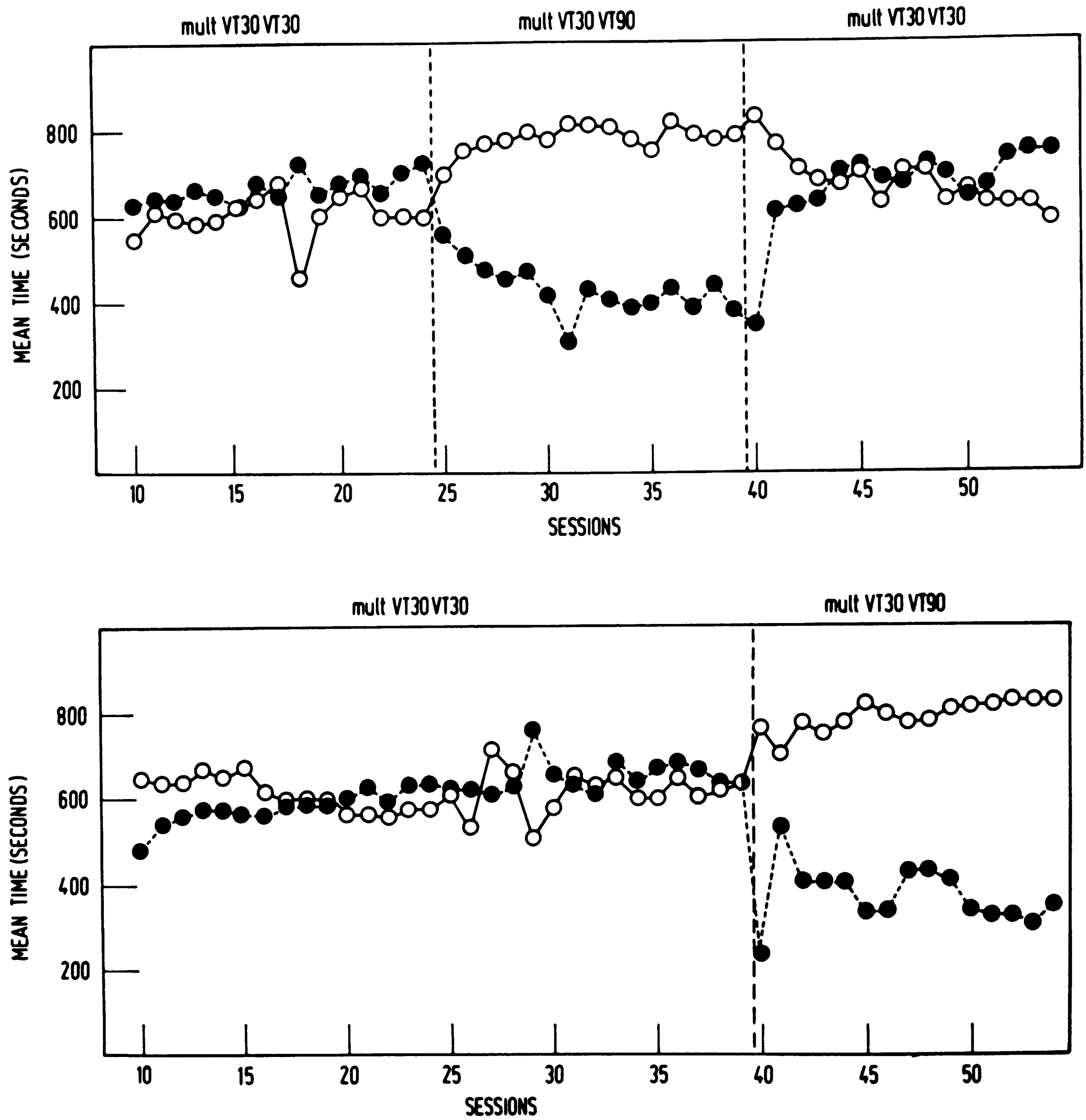

Fig. 4. Mean time allocated to the left (unfilled circles) and right (filled circles) components per session for *mult* VT VT schedules in Experiment II. The data are averages for subjects in the first group (top panel) and second group (bottom panel).

in *mult* VT 30-sec VT 90-sec than in *mult* VT 30-sec VT 30-sec for both groups. Second, mean time allocated to the unaltered component was always greater in *mult* VT 30-sec VT 90-sec for the first group than in *mult* VT 30-sec VT 30-sec for the second group over Sessions 25-39, and was greater in *mult* VT 30-sec VT 90-sec for the second group than in *mult* VT 30-sec VT 30-sec for the first group over Sessions 40 to 54.

The positive-contrast effects apparent in the averaged data were also the case for the data of individual subjects; positive contrast occurred for every subject (Table 3). Furthermore, the time allocated to the altered component (VT 90-sec) decreased to a level below that for the nondifferential condition in every subject.

The frequencies of changeover response in each component averaged over 15 sessions of

Table 3

Mean time (in seconds) allocated to the left (L) and right (R) components, and changeover frequencies during left and right components averaged over 15 sessions for each condition for individual subjects. Standard deviations are given in parentheses. Condition A was *mult* VT 30-sec VT 30-sec and Condition B was *mult* VT 30-sec VT 90-sec.

Subject	*Component*	*Mean Time*			*Changeover Frequency*		
		A	*B*	*A*	*A*	*B*	*A*
S11	L	575 (74)	738 (53)	572 (97)	28.3 (5)	14.1 (4)	25.9 (9)
	R	737 (57)	451 (88)	706 (83)	21.4 (6)	22.3 (4)	17.3 (5)
S12	L	659 (49)	772 (46)	709 (77)	30.9 (7)	18.6 (8)	32.7 (15)
	R	637 (84)	479 (66)	620 (74)	28.4 (7)	35.8 (11)	37.1 (11)
S13	L	703 (54)	777 (43)	670 (64)	28.6 (6)	16.6 (5)	39.3 (12)
	R	522 (54)	406 (73)	672 (123)	42.7 (7)	35.7 (7)	39.8 (9)
S14	L	518 (63)	824 (59)	759 (92)	24.6 (5)	2.0 (4)	6.5 (5)
	R	768 (44)	391 (129)	696 (79)	13.3 (5)	12.3 (5)	9.8 (6)
Group Mean	L	614	778	677	28.1	12.8	26.1
	R	666	432	673	26.4	26.5	26.0
		A	*A*	*B*	*A*	*A*	*B*
S15	L	494 (100)	574 (114)	818 (48)	70.2 (10)	51.3 (14)	15.7 (9)
	R	686 (114)	700 (103)	326 (92)	41.5 (10)	37.5 (9)	40.3 (8)
S16	L	716 (53)	684 (66)	812 (28)	37.6 (8)	38.6 (6)	18.9 (4)
	R	433 (70)	664 (74)	336 (70)	48.1 (8)	38.3 (5)	41.3 (11)
S17	L	600 (50)	623 (47)	772 (52)	41.1 (9)	39.1 (7)	20.9 (6)
	R	620 (38)	583 (51)	384 (88)	39.5 (8)	33.9 (6)	36.8 (5)
S18	L	646 (65)	602 (71)	755 (52)	35.1 (8)	53.0 (15)	50.0 (12)
	R	584 (64)	664 (84)	431 (112)	42.3 (10)	45.9 (9)	65.4 (13)
Group Mean	L	614	621	789	46.0	45.5	26.4
	R	581	653	369	42.8	38.9	45.9

the differential and nondifferential conditions for individual subjects are presented in Table 3. Changeover frequency in the unaltered component decreased in the *mult* VT 30-sec VT 90-sec condition.

DISCUSSION

Strong and unequivocal positive behavioral contrast was exhibited in Experiment II for multiple variable-time schedules where reinforcement was delivered independently of behavior in both components. Time allocated to a component is therefore sensitive to changes in reinforcement density.

The contrast effect in *mult* VT VT schedules in Experiment II might have been mediated by discrete behaviors maintained by an adventitious response-reinforcer contingency (Herrnstein, 1966), or elicited by the stimulus-reinforcer contingency (Gamzu and Schwartz, 1973; Hearst and Jenkins, 1974; Rachlin, 1973). For example, Gamzu and Schwartz (1973), Spealman (1976), and Williams (1976) have reported positive contrast for pigeons' key pecking elicited by stimulus-reinforcer contingencies in *mult* VT EXT schedules where reinforcement was always response-independent. Occasional observation by the experimenter during the present experiments did not reveal any particular discrete responses. The most frequently observed activities were licking the dipper housing and running from side to side. But even if performance of a specifiable discrete activity (such as licking) "mediated" the contrast effect, it remains the case that the time allocated to that activity or any other during a component was sensitive to the differential probability of response-independent reinforcement.

GENERAL DISCUSSION

The present experiments confirm the importance of differential time allocation in the production of behavioral contrast in multiple schedules. In Experiment I, positive contrast occurred for response-frequency and time-allocation measures, but not for mean local response rate. Differential time allocation might therefore contribute to determining the contrast effect for overall response rate. In Experiment II, positive contrast of time allocation was exhibited in multiple variable-time schedules. Time allocation was therefore sensitive to changes in reinforcement value and was subject to contrast effects.

Positive contrast for time allocation was stronger for VT schedules in Experiment II than for VI schedules in Experiment I. Notwithstanding the possible influence of ceiling effects on time allocation, the factors contributing to contrast in VT schedules may be different from those determining contrast in VI schedules. For example, presence of the lever in *mult* VI VI provided an opportunity for lever presses elicited by the stimulus-reinforcer contingency (*cf.* Stiers and Silberberg, 1974). Elicited responding could therefore contribute to the contrast effect for response frequency in VI schedule. In the *mult* VT VT conditions of Experiment II, the stimuli signalling the components may have controlled approach-withdrawal behavior in the manner described by Hearst and Franklin (1977). Thus, the contrast effect for time allocation may have resulted from the subject "approaching" the signal associated with the greater reinforcement density. These questions must remain unanswered, however, until further research can specify the conditions under which behavioral contrast of time allocation occurs in schedules of response-independent reinforcement. Such research would complement recent studies of behavioral contrast for elicited responding in response-independent schedules of reinforcement (Spealman, 1976; Williams, 1976).

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