THE EFFECTS OF RESPONSE REQUIREMENTS AND STIMULUS LOCATION ON BEHAVIORAL CONTRAST

by

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INTRODUCTION

Experimental investigations of behavioral contrast in pigeons have generally employed two-component multiple schedules. A multiple schedule is one in which two or more reinforcement schedules are alternated, with environmental stimuli signalling which schedule is in effect. In most investigations of behavioral contrast, after the subjects have been trained on one multiple schedule the reinforcement schedule in one of the two components is changed. If the subject's rate of responding changes in opposite directions in the two components, behavioral contrast is said to occur. If response rate decreases in the changed component and increases in the component with the same schedule throughout, this change is an instance of positive contrast. Negative contrast is obtained when there is a rate increase in the changed component while rate decreases in the constant component.

It may be preferable to define positive and negative behavioral contrast with reference to a baseline condition in which the components of the multiple schedule have the same reinforcement schedule. For example, a change from a multiple variable-interval 30-sec variable-interval 30-sec schedule (mult VI 30-sec VI 30-sec) to a multiple variable-interval 30-sec extinction schedule (mult VI 30-sec EXT) produces an increase in response rate in the constant VI 30-sec component and a decrease in response rate in the changed component; i.e. positive contrast. A change from the mult VI 30-sec EXT schedule back to the original mult VI 30-sec VI 30-sec schedule produces a

decrease in response rate in the constant VI 30-sec component and an increase in response rate in the changed component. This has sometimes been referred to as an instance of negative contrast rather than as a return to the baseline condition. There has been some question (e.g. Schwartz, 1975) about whether the same interpretation is appropriate for this type of "negative contrast" and that obtained when one component of an equal VI multiple schedule is changed to a richer schedule. Because the present experiment includes numerous shifts between an equal VI multiple schedule and a multiple schedule containing VI and EXT components, it is felt that a clearer and more consistent interpretation of the data may be made if the results are described as positive contrast with return to baseline rather than alternation of positive and negative contrast.

Many investigations of behavioral contrast were designed to test two theories which were developed as explanations of contrast. Reynolds (1961) hypothesized that contrast is due to the change in the frequency of reinforcement in the changed component. Terrace (1966) hypothesized that contrast is caused by emotional responses which occur when the change in schedule produces response suppression in one component of the multiple schedule. In her review of experiments designed to test these two hypotheses, Freeman (1971) concluded that neither the reinforcement frequency nor the response suppression explanation of contrast had been shown to be superior. She did not consider any of the experiments an adequate test between these two explanations because reinforcement frequency and response suppres-

sion were confounded in most of the experiments and none had controls for systematic changes in response rate over extended periods of time.

Brown and Jenkins (1968) found that pigeons will peck a response key which is illuminated briefly just before response-independent food presentations. Because the procedure "automatically" shapes the pigeons to keypeck, they called this phenomenon "autoshaping." This behavior has also been called "autopecking," (e.g. Redford and Perkins, 1974) and "sign-tracking" (Hearst and Jenkins, 1974). The term sign-tracking actually designates a broader class of behaviors which includes autoshaping. Hearst and Jenkins (1974, p. 4) define sign-tracking as "behavior that is directed toward or away from a stimulus as a result of the relation between that stimulus and the reinforcer, or between that stimulus and the absence of the reinforcer." In other words, these behaviors are conditioned as a result of the response-independent stimulus-reinforcer (S-S*) contingencies of the schedules, rather than the response-reinforcer (R-S*) contingencies which occur with response-dependent procedures.

Studies of autoshaping have led to an alternative interpretation of behavioral contrast, which has been called the "additivity theory" of contrast (Schwartz, 1975). According to the additivity hypothesis, contrast occurs because S-S* and R-S* relationships are superimposed in the multiple schedules used to study behavioral contrast. Investigations of behavioral contrast using pigeons, the keypeck response, and discriminative

stimuli located on the response key have obtained positive contrast as the schedule was changed from mult VI VI to mult VI EXT. The R-S* effects in the VI components (keypecking for contingent food) are assumed to be equal in both multiple schedules. Gamzu and Schwartz (1973) reported that autopecking is obtained only if keylight stimuli are differentially correlated with food presentations. Therefore, the mult VI EXT schedule is assumed to contain the S-S* relationships which elicit autopecking, while the multiple schedule with equal VI components is not. The additivity theory of contrast implies that since the behaviors produced by the R-S* contingency and the S-S* contingencies of the mult VI EXT schedule are topographically similar, and both behaviors are directed toward the response key, the result of the superimposition of the two effects is the increment in keypecking in the constant VI component which we call positive behavioral contrast.

Several recent studies have provided evidence which supports this additivity hypothesis. Gamzu and Schwartz (1973) employed multiple schedules similar to those used in studies of behavioral contrast except that food presentations were not response contingent. When the schedule was multiple variable-time 33-sec extinction (mult VT 33-sec EXT), pigeons pecked the key when its color signalled the VT component. When the schedule was changed to mult VT 33-sec VT 33-sec, rate of pecking declined. Because these changes in response rates resemble those found in studies of behavioral contrast using VI schedules, Gamzu and Schwartz suggested that positive behavioral contrast

may result from keypecking elicited by the S-S* relationships present in the mult VI EXT schedule.

Redford and Perkins (1974) used a similar procedure for their VT subjects except that each bird with VT schedules was yoked with a VI bird. All stimuli were presented simultaneously to both birds, with food presentations contingent upon the VI bird's keypecking on mult VI VI and mult VI EXT schedules. The yoked subjects' changes in rate of keypecking were quite similar to the VI subjects' changes in response rate in the constant component of the multiple schedules; i.e. VI and VT birds showed a similar contrast effect. This further supports the notion that contrast is due to the sign-tracking behavior elicited by the differential S-S* relationships of the mult VI EXT schedule.

Keller (1974) devised a method for experimentally separating behavior due to S-S* effects and R-S* effects of multiple schedules. In his experiment, responses on one of two keys produced food occasionally, while responses on the other key had no scheduled effect. The food key was illuminated with the same color throughout all conditions, while the color of the stimulus key changed when the components of the multiple schedules changed. When the components of the multiple schedule were the same VI schedule, subjects responded only to the food key. When the schedule was changed to a mult VI EXT schedule, although no contrast was shown on the food key, the birds began to peck the stimulus key when it signalled that the VI component was in force. The sum of the pecks to the two keys was similar to

contrast. This suggests that the increase in pecking normally found in the constant component when the schedule components are signalled on the food key is due to the addition of S-S* effects to the R-S* effects when the multiple schedule is changed to mult VI EXT. Although Schwartz (1975) replicated Keller's results, other experimenters (Beavers, Note 1; Edmon and Grisham, Note 2) did not obtain pecking on the signal key with a similar procedure. The difference in results may be due to the more extensive training Keller's and Schwartz's subjects had received prior to the initiation of this procedure. Keller did not specify the complete experimental histories of his subjects. Schwartz's subjects had previously received training on multiple schedules in which the components were signalled by the color of the food key; the same colors were then used as the stimuli which were located on the stimulus key. This type of training may have increased pecking to the signal key.

Further support for the additivity theory comes from studies in which responses other than the keypeck did not show contrast. Hemmes (1973) and Westbrook (1973) obtained positive contrast with pigeons using a keypeck response, but did not obtain contrast when the response used was a treadle press or a bar press, respectively. With the treadle press contingency, the S-S* contingencies and R-S* contingency result in responses which are topographically dissimilar and which are not directed toward the same stimulus; one would not expect the combination of these effects to be contrast.

The present study was designed to test the implications of the additivity theory of contrast for two opposing response classes. Previous studies of behavioral contrast have used responses compatible with sign-tracking (keypeck) or orthogonal to sign-tracking (bar press or treadle press). One purpose of the present study is to further test the additivity theory of contrast by making food contingent on a response incompatible with the autopecking tendency. The response used in this experiment may be termed "other behavior" or "nonpecking;" it is defined as a five-second period in which the key is not pecked. A differential reinforcement of other behavior (DRO) schedule is one in which reinforcement is delivered only when the subject does not make a certain response (for example, does not keypeck) for a specified time interval. A DRO schedule has sometimes been used in the changed component in behavioral contrast experiments in attempts to hold either reinforcement frequency or response rate constant in the changed component in order to distinguish between the reinforcement frequency and response suppression theories of behavioral contrast. However, the present experiment appears to be the first in which a schedule similar to a DRO schedule was used in a constant component.

Positive contrast of a nonpeck ($\overline{P}$) response would be obtained where there is an increase in nonpecking in the constant component as the schedule is changed from mult VI VI to mult VI EXT. Reynolds' reinforcement frequency theory of contrast does not make differential predictions depending upon the response used; he seems to imply that changing the reinforcement sched-

ule from mult VI VI to mult VI EXT should produce positive contrast for any instrumental response chosen. Terrace's response suppression hypothesis seems to imply that no change in rate of nonpecking should occur in the constant component, since nonpecking presumably would not be suppressed in the EXT component. The additivity theory of contrast implies a change in nonpecking rate opposite to positive behavioral contrast. There should be a decrease in nonpecking in the unchanged component as the schedule is changed from mult VI VI to mult VI EXT because keypecking is elicited by the S-S* relationships in the mult VI EXT schedule but not the mult VI VI schedule. This effect is referred to as "opposite to positive contrast" rather than as induction for three reasons. The first is that the decrease in response rate in the constant component is produced by the same schedules which produce positive contrast when a keypeck response is used. Second, use of the term induction implies that an effect is produced by generalization across multiple schedule components. Since the effect here is assumed to result from effects other than generalization, a term other than induction is preferred. Finally, because one would not expect any change in nonpeck rate in the changed component, the expected effect does not fit a precise definition of induction.

Studies of positive contrast using off-key discriminative stimuli with the keypeck response have not produced consistent findings. Hemmes (1973) obtained positive contrast using houselight stimuli and Westbrook (1973) obtained positive contrast using auditory stimuli. However, Redford and Perkins

(1974) reported no positive contrast using houselight stimuli, and Schwartz (1974, 1975) did not obtain positive contrast using either houselight or auditory stimuli.

Schwartz (1973) examined different conditions under which autopecking would develop or be maintained. Keylight and/or auditory stimuli were used to signal the components of mult VT EXT schedules. When an auditory signal was used, autopecking was not acquired. However, after autopecking had been elicited using a combination of a keylight stimulus and an auditory stimulus, the auditory stimulus alone maintained autopecking. This suggests that if some type of training directs the subject's pecking toward the response key, nonlocalized stimuli may maintain that response on the key. Therefore, when the subject is trained to peck the key for food, pecking elicited by S-S* relationships should be directed toward the response key with nonlocalized stimuli as well as when the stimuli are located on the key. One would expect, therefore, that contrast would be obtained using nonlocalized stimuli.

The present experiment was designed to further investigate the effect of stimulus location on behavioral contrast and to determine whether contrast would be obtained using a nonpeck response. The reinforcement schedules used in the experiment are summarized in Figure 1.

In order to further investigate the effects of stimulus location on behavioral contrast, in the present experiment keylight stimuli were employed for half the subjects and houselight stimuli for the other half. In each of these stimulus

Figure Caption

Figure 1. Multiple schedules used in training. Stimulus C signalled a VI 30-sec (P) component for Groups KL-VI and HL-VI. For Groups KL-VT and HL-VT, stimulus C signalled a VT 30-sec component. Groups KL-VI and KL-VT had keylight stimuli; Groups HL-VI and HL-VT had houselight stimuli.

Component Schedule	EXT	VI 30-sec ($\overline{P}$)	EXT	VI 30-sec (P) (VT 30-sec)
Time	: 2 min	: 33 sec	: 2 min	: 33 sec :
Stimulus	A	B	A	C

EXT Schedule

Component Schedule	VI 30-sec ($\overline{P}$)	VI 30-sec (P) (VT 30-sec)
Time	: 33 sec	: 33 sec :
Stimulus	B	C

$\overline{\text{EXT}}$ Schedule

Figure 1

conditions, half of the subjects were trained to peck the response key and obtained food on a VI schedule contingent upon keypecking in one of the components, the VI(P) component, of each of two multiple schedules. One of these multiple schedules included only VI components (the $\overline{EXT}$ schedule); the other contained VI and EXT components (the EXT schedule). The other half of the subjects in each stimulus condition did not receive keypeck training and received food on a VT schedule (i.e. obtained access to food regardless of their behavior) in one component, the VT component, of each of the two multiple schedules. As for the other subjects, one of these multiple schedules contained only components in which food was presented at variable intervals ($\overline{EXT}$ schedule); the other schedule included EXT components in addition (EXT schedule).

Training and stimuli for the experimental groups are summarized in Table 1, which illustrates that these groups result from a 2 x 2 factorial combination of stimulus location and training conditions.

In order to further assess the role of the topography of the response, every subject was also exposed to a VI component in each of the two multiple schedules in which the response on which food was contingent was a nonpeck, the VI($\overline{P}$) component.

A difference between the present experiment and most previous studies of behavioral contrast is that there is no "changed" component. The change from the $\overline{EXT}$ schedule to the EXT schedule leaves the VI and VT components unchanged, but the introduction of the EXT component produces the differential S-S* relation-

Table 1

Training and stimuli employed
for each of the four experimental groups

	Training	
	Pigeons Trained to Direct Pecks Toward Response Key	Pigeons Not Trained to Direct Pecks Toward Response Key
Stimulus Location		
On-key (Keylight)	Group KL-VI	Group KL-VT
Off-key (Houselight)	Group HL-VI	Group HL-VT

ships which are assumed to affect keypecking tendencies. Thus, although the results of the present procedure may not quite fit the traditional definition of positive behavioral contrast, this procedure contains the elements which, according to the additivity theory of contrast, are assumed to produce contrast in the more traditional procedures. An advantage of the design used in the present study is that it allows the alternation of the two multiple schedules, thus providing a "return-to-baseline" control throughout the experiment. Any long term systematic changes in response rates should appear equally in both schedules, making it less crucial to insure that measures are taken at asymptote.

Specific predictions following from the additivity theory of behavioral contrast are summarized in Table 2. This table indicates for each experimental group whether a keypeck or a nonpeck response would presumably be obtained in each VI or VT component if only the R-S* relationships or the S-S* relationships of each multiple schedule were present. The righthand column of the table is a prediction of the difference in response rates across multiple schedules based on the combination of R-S* and S-S* effects; i.e. whether the response rate in each component will be higher or lower in the $\overline{EXT}$ schedule than the EXT schedule.

For Group KL-VI, the R-S* contingencies favor keypecking in the VI(P) component and nonpecking in the VI($\overline{P}$) component. The key colors are not differentially correlated with food in the $\overline{EXT}$ schedule; these nondifferential S-S* relationships do

Table 2

Predictions for each experimental group following from the additivity theory of behavioral contrast. The first four columns indicate which response (keypeck or nonpeck) would be obtained in each component of each multiple schedule if only the R-S* or S-S* contingencies were present. The final column gives predictions of the direction of differences in response rate in each component across the two multiple schedules.

Group and Component	$\overline{\text{EXT}}$ Schedule		EXT Schedule		Prediction
	R-S*	S-S*	R-S*	S-S*	
Group KL-VI					
VI(P) Component	keypeck	nonpeck	keypeck	keypeck	$P_{\overline{EXT}} < P_{EXT}$
VI($\overline{P}$) Component	nonpeck	nonpeck	nonpeck	keypeck	$\overline{P}_{\overline{EXT}} > \overline{P}_{EXT}$
Group KL-VT					
VT Component	---	nonpeck	---	keypeck	$P_{\overline{EXT}} < P_{EXT}$
VI($\overline{P}$) Component	nonpeck	nonpeck	nonpeck	keypeck	$\overline{P}_{\overline{EXT}} > \overline{P}_{EXT}$
Group HL-VI					
VI(P) Component	keypeck	nonpeck	keypeck	keypeck	$P_{\overline{EXT}} < P_{EXT}$
VI($\overline{P}$) Component	nonpeck	nonpeck	nonpeck	nonpeck	$\overline{P}_{\overline{EXT}} = \overline{P}_{EXT}$
Group HL-VT					
VT Component	---	nonpeck	---	nonpeck	$P_{\overline{EXT}} = P_{EXT}$
VI($\overline{P}$) Component	nonpeck	nonpeck	nonpeck	nonpeck	$\overline{P}_{\overline{EXT}} = \overline{P}_{EXT}$

not favor keypecking and thus pecking would not be obtained if only this factor were operative. With the EXT schedule, the introduction of the EXT component produces S-S* correlations which favor keypecking in both VI components, increasing the rate of keypecking in the VI(P) component and decreasing the nonpecking rate in the VI($\overline{P}$) component.

For Group KL-VT, there is no R-S* contingency in the VT component. The R-S* contingency in the VI($\overline{P}$) component favors nonpecking. In the $\overline{EXT}$ schedule, the nondifferential S-S* correlations do not favor keypecking. The differential S-S* contingencies of the EXT schedule should produce keypecking in both the VT and VI($\overline{P}$) components, thus increasing the keypeck rate in the VT component and decreasing the nonpeck rate in the VI($\overline{P}$) component.

For the HL-VI group, the R-S* contingencies favor keypecking in the VI(P) component and nonpecking in the VI($\overline{P}$) component. The nondifferential S-S* correlations of the $\overline{EXT}$ schedule should not favor keypecking. Prediction of the effects of introducing the EXT component is not as straightforward for this group as for the others. As noted above, results of previous experiments using off-key stimuli differed. Since birds in this group were trained to peck the key for food in the VI(P) component (i.e. the "instrumental" pecks are localized on the response key), it is predicted that pecking responses due to S-S* effects should also be directed toward the response key, thus increasing the keypeck rate in the VI(P) component. It is possible that non-symmetrical effects will be found for the

VI(P) and VI($\overline{P}$) components of the EXT schedule for this group; since nonpecking is rewarded in the VI($\overline{P}$) component and the discriminative stimuli are not localized on the key, there is no reason to expect that behavior elicited by S-S* relationships would be directed toward the response key in the VI($\overline{P}$) component.

There is no reason to expect autopecking to develop in Group HL-VT, with neither training to peck the response key nor stimuli localized on the key. Therefore, the change in schedule is not expected to produce any change in response rate.

To summarize these predictions, a positive contrast effect is expected in the VI(P) component for subjects in Groups KL-VI and HL-VI and in the VT component for subjects in the KL-VT group. An effect opposite to positive contrast is expected in the VI($\overline{P}$) component for subjects in Groups KL-VI and KL-VT.

METHOD

Subjects

Twenty-four experimentally naive pigeons obtained locally were maintained at approximately 75% of their free-feeding weights. They were housed in individual cages in a colony room kept under constant illumination. Water and grit were always available in the home cages.

Apparatus

Two identical experimental chambers 38 cm x 34 cm x 29½ cm with walls, floor, and ceiling painted flat grey were used. A transparent response key was centered in one wall 21½ cm above the floor and directly over the opening providing access to the grain feeder (Lehigh Valley). A stimulus projector (Industrial Electronics Engineers) was used to transilluminate the response key with red, blue, yellow, or white light. The response key could be operated by a minimum force of approximately 0.1 N. Each keypeck produced a feedback click from the operation of a relay located behind the panel.

Houselights were white 6 watt General Electric lamps located above a round translucent window (6.5 cm diameter) centered in the ceiling of the experimental chamber. Red, blue, and yellow houselights were produced by the insertion of color transparencies between the lamps and the window.

Masking noise was provided by a ventilating fan and by white noise presented through a loudspeaker located in the ceiling of the chamber behind the response panel. Scheduling and recording equipment located in an adjacent room consisted

of an 8-channel tape reader, standard relay and timing equipment, counters, and an event recorder.

Procedure

Subjects were randomly assigned to four groups of six birds each. Each pigeon in Groups KL-VI and HL-VI received one session of feeder habituation. Pigeons in Groups KL-VT and HL-VT were given two sessions of feeder habituation. During feeder training, the response key was covered by grey tape and the chamber was illuminated by a white houselight. For Groups KL-VI and HL-VI, two sessions of keypeck training followed on consecutive days. In the first, each pigeon was shaped to keypeck; the session then continued until the bird had earned 30 grain presentations on a continuous reinforcement schedule. Food presentations consisted of 3-second access to a mixture of 50% wheat and 50% milo. During food presentations, the only illumination in the chamber was from the feeder light. In the second session of keypeck training, grain became available at variable intervals which were gradually increased up to 30 seconds. For each bird, keypeck training was carried out under keylight and houselight conditions subsequently employed during the VI(P) component of the training schedules.

The multiple schedules employed following pretraining are summarized in Figure 1. For Groups KL-VI and HL-VI the procedure employed on the first ten sessions following keypeck training may be described as a mult EXT VI 30-sec ($\overline{P}$) EXT VI 30-sec (P) schedule. In this multiple schedule, which will be referred to as the EXT-VI schedule, grain became available on the same

schedule in both VI components, but the response contingency differed. In the VI 30-sec ($\overline{P}$) component grain was contingent on a nonpeck ($\overline{P}$); i.e. a five second period without a keypeck. Food was contingent on a keypeck (P) in the VI 30-sec (P) component. These two VI components alternated regularly, but were always separated by an EXT component in the EXT-VI schedule.

The next twenty days, the EXT-VI schedule and the $\overline{EXT}$-VI schedule, a mult VI 30-sec ($\overline{P}$) VI 30-sec (P) schedule, were presented on alternate days. In the $\overline{EXT}$-VI schedule, as in the EXT-VI schedule, a nonpeck was required to obtain food in the VI 30-sec ($\overline{P}$) component, while a keypeck was required in the VI 30-sec (P) component. The VI($\overline{P}$) and VI(P) components alternated regularly. Note that the only difference between the two multiple schedules is the inclusion of the EXT component between successive VI components in the EXT-VI schedule. In both schedules, the VI($\overline{P}$) and VI(P) components were of 33 seconds duration; the duration of the EXT component was two minutes.

For Groups KL-VT and HL-VT, following feeder habituation, two multiple schedules were presented in the same manner as for Groups KL-VI and HL-VI. The EXT-VT schedule, a mult EXT VI 30-sec ($\overline{P}$) EXT VT 30-sec schedule, was presented on the first ten days of training. The next twenty days, the EXT-VT schedule was alternated with the $\overline{EXT}$-VT schedule, a mult VI 30-sec ($\overline{P}$) VT 30-sec schedule. The EXT-VT schedule differed from the $\overline{EXT}$-VT schedule only in the inclusion of an EXT component between the VI and VT components of the EXT-VT schedule. The

only difference between the EXT-VT schedule and the EXT-VI schedule and between the $\overline{\text{EXT}}$-VT schedule and the $\overline{\text{EXT}}$-VI schedule was in one component which was VT 30-sec in the VT schedules and VI 30-sec (P) in the VI schedules.

Red, blue, and yellow keylight stimuli signalled the three components of the two schedules for Groups KL-VI and KL-VT. Schedule-color combinations were counterbalanced across pigeons. The houselight was white for these birds. Group HL-VI and Group HL-VT had houselight stimuli which were 1) a constant white light, 2) lights flashing from yellow to white with the color changing every half-second, and 3) lights flashing from red to blue with the color changing every half-second. Schedules associated with each houselight stimulus were counterbalanced across pigeons. The keylight remained white throughout all conditions for these birds. For each bird, the VI 30-sec ($\overline{\text{P}}$) component was signalled by the same stimulus in both multiple schedules; the same was true of the VI 30-sec (P) component for the VI birds and of the VT 30-sec component for the VT birds.

RESULTS

Figures 2-4 show mean response rates in each VI (or VT) component for each session for Groups KL-VI, KL-VT, and HL-VI. Rate of pecking in the VI(P) component (or VT component) and rate of nonpecking in the VI($\overline{P}$) component are plotted separately for the $\overline{EXT}$ and EXT schedules. Table 3 gives individual subject and group mean rates of responding in each component of each schedule, averaged over the last ten sessions of each schedule (the final twenty sessions).

Figure 2 indicates that for Group KL-VI, rate of pecking in the VI(P) component was consistently higher in the EXT schedule than in the $\overline{EXT}$ schedule. Rates of nonpecking in the VI($\overline{P}$) component were lower in the EXT schedule than the $\overline{EXT}$ schedule. In other words, positive behavioral contrast was obtained in the VI(P) component, but an opposite effect was obtained in the VI($\overline{P}$) component. All six of the birds in Group KL-VI had higher mean rates of pecking in the VI(P) component of the EXT schedule than in that component of the $\overline{EXT}$ schedule; five of the six had lower nonpecking rates (i.e. pecked more) in the VI($\overline{P}$) component of the EXT schedule than the $\overline{EXT}$ schedule. Individual subject plots are included in the appendix. The group mean pecking rate in the VI(P) component was significantly higher in the EXT schedule than the $\overline{EXT}$ schedule; $F(1,5) = 19.4$, $p < .01$. The difference in nonpecking rate in the VI($\overline{P}$) components of the two schedules fell short of significance at the 5% level; $F(1,5) = 6.4$, $.05 < p < .10$. However, a comparison of the pecking rates in the VI($\overline{P}$) components of the two schedules

Figure Caption

Figure 2. Group KL-VI mean nonpeck rate in the VI($\overline{P}$) component and mean keypeck rate in the VI(P) component in each session. Rates are plotted separately for the $\overline{EXT}$ schedule and the EXT schedule.

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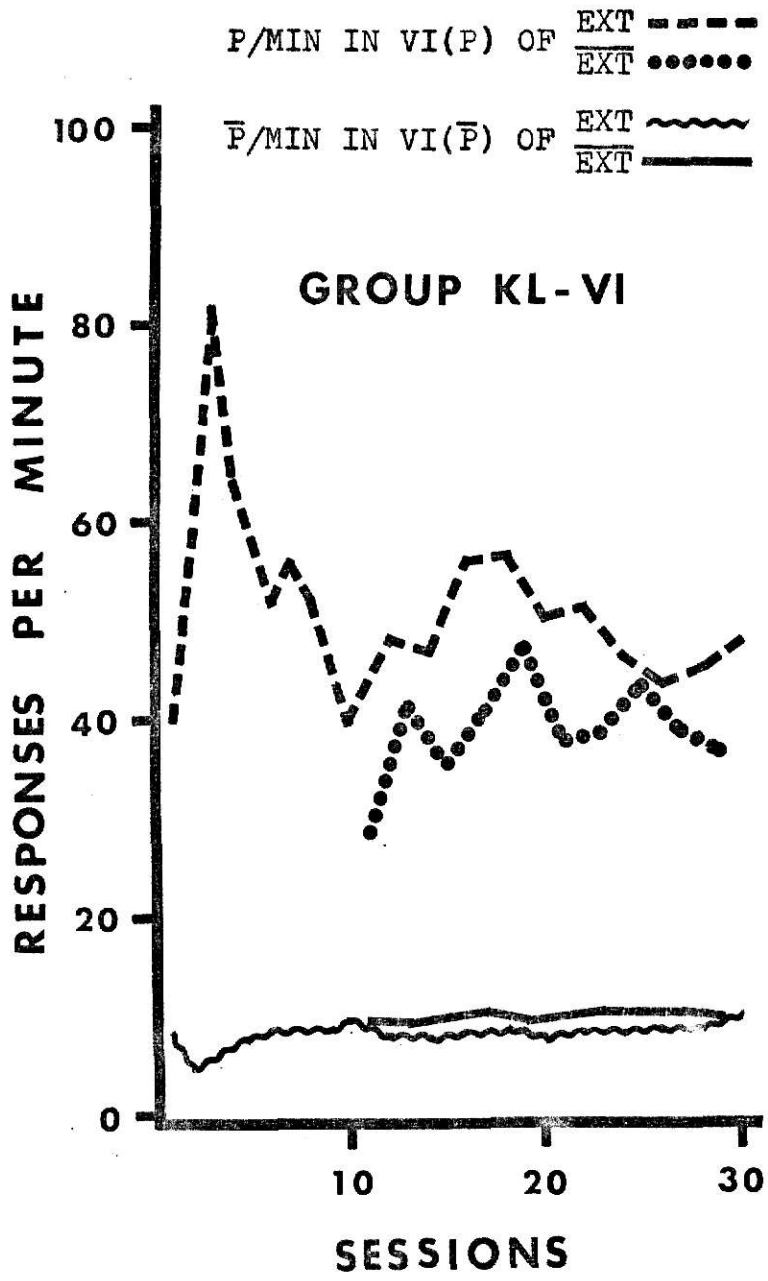

P/MIN IN VI(P) OF EXT
P/MIN IN VI(P) OF EXT
P/MIN IN VI(P) OF EXT
P/MIN IN VI(P) OF EXT
GROUP KL-VI
RESPONSES PER MINUTE
100
80
60
40
20
0
10
20
30
SESSIONS

Figure Caption

Figure 3. Group KL-VT mean nonpeck rate in the VI($\overline{P}$) component and mean keypeck rate in the VT component in each session. Rates are plotted separately for the $\overline{EXT}$ schedule and the EXT schedule.

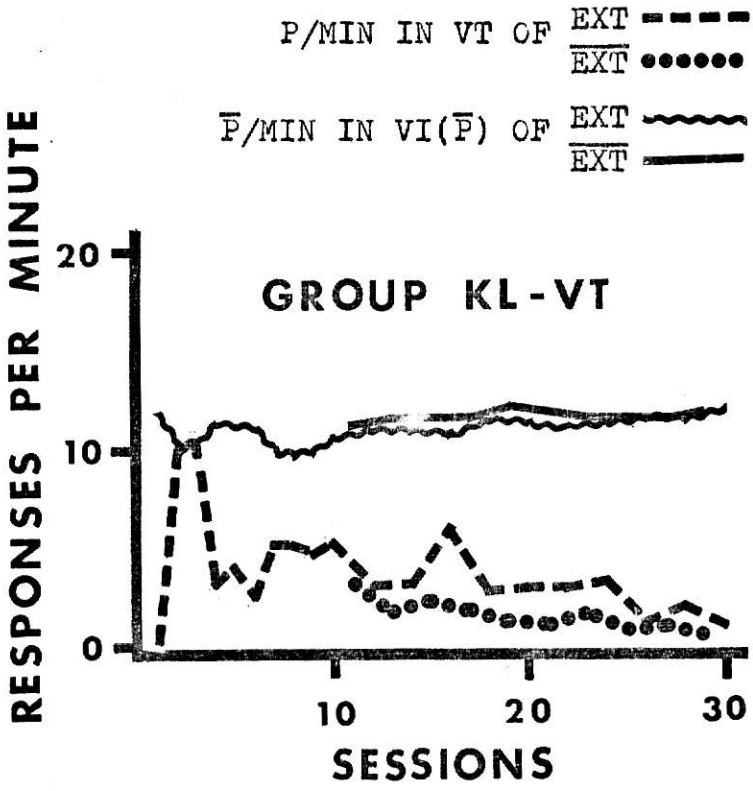

P/MIN IN VT OF EXT
EXT
P/MIN IN VI(P) OF EXT
EXT
GROUP KL-VT
RESPONSES PER MINUTE
20
10
0
10
20
30
SESSIONS

Figure Caption

Figure 4. Group HL-VI mean nonpeck rate in the VI($\overline{P}$) component and mean keypeck rate in the VI(P) component in each session. Rates are plotted separately for the $\overline{EXT}$ schedule and the EXT schedule.

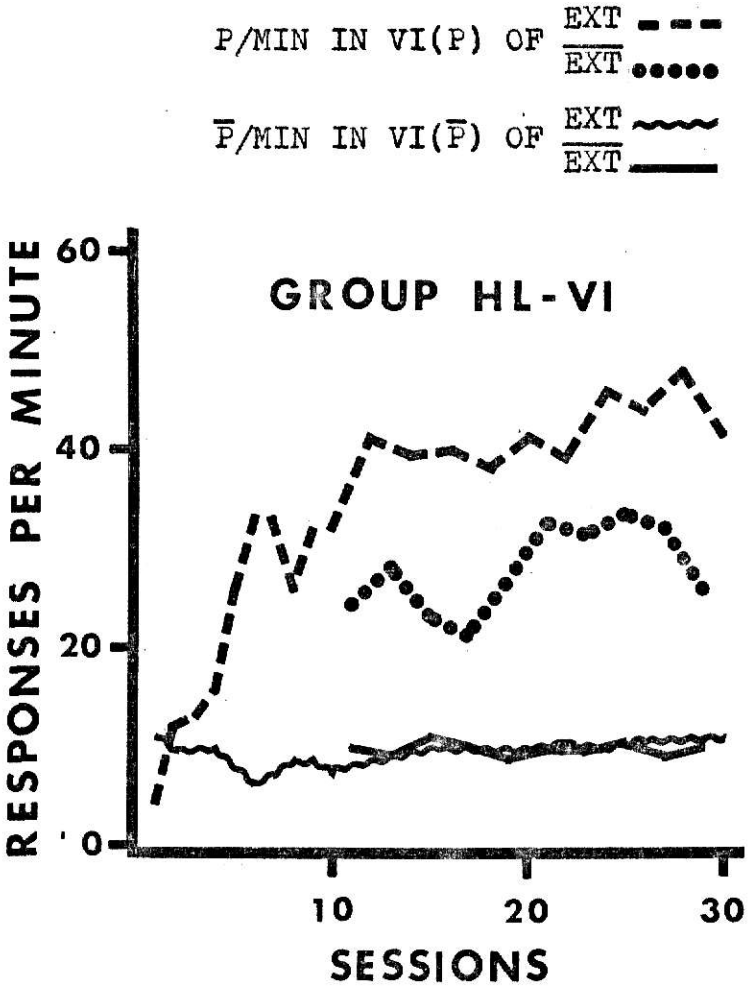

P/MIN IN VI(P) OF EXT
EXT
P̄/MIN IN VI(P̄) OF EXT
EXT
GROUP HL-VI
RESPONSES PER MINUTE
60
40
20
0
10
20
30
SESSIONS

Table 3

Subject and group mean response rates in each component of each multiple schedule, averaged over the last ten sessions of each schedule (the final twenty sessions).

	$\overline{\text{EXT}}$ Schedule		EXT Schedule		
Group KL-VI Pigeon	VI($\overline{P}$) ($\overline{P}$/min)	VI(P) (P/min)	VI($\overline{P}$) ($\overline{P}$/min)	VI(P) (P/min)	EXT (P/min)
523	11.60	32.81	9.50	39.71	0.06
682	11.71	23.88	11.15	34.68	0.08
570	9.65	54.54	7.03	71.50	0.94
74	8.49	12.57	9.46	13.38	0.65
24	10.38	46.06	8.50	60.15	0.54
63	8.53	63.36	6.38	75.82	4.21
Mean	10.06	38.87	8.67	49.21	1.08
Group KL-VT Pigeon	VI($\overline{P}$) ($\overline{P}$/min)	VT (P/min)	VI($\overline{P}$) ($\overline{P}$/min)	VT (P/min)	EXT (P/min)
8098	11.98	0.10	11.87	0.01	0.00
502	11.73	3.84	11.07	6.49	0.51
526	10.64	3.61	8.78	9.56	25.27
50	12.00	0.00	12.00	0.01	0.00
27	11.40	1.34	11.86	0.48	0.14
43	11.95	0.22	11.77	0.46	0.01
Mean	11.62	1.52	11.22	2.84	4.32
Group HL-VI Pigeon	VI($\overline{P}$) ($\overline{P}$/min)	VI(P) (P/min)	VI($\overline{P}$) ($\overline{P}$/min)	VI(P) (P/min)	EXT (P/min)
NB	7.89	23.48	5.95	46.12	2.20
419	9.61	19.39	10.82	29.67	16.31
56	11.44	15.88	11.42	29.83	2.68
33	8.39	64.31	7.22	71.51	4.21
577	10.70	22.19	11.47	34.85	2.94
547	9.78	21.28	11.28	38.59	1.07
Mean	9.64	27.76	9.69	41.76	4.91
Group HL-VT Pigeon	VI($\overline{P}$) ($\overline{P}$/min)	VT (P/min)	VI($\overline{P}$) ($\overline{P}$/min)	VT (P/min)	EXT (P/min)
397	12.00	0.00	12.00	0.00	0.00
8082	12.00	0.00	12.00	0.00	0.00
30	12.00	0.00	12.00	0.00	0.00
58	12.00	0.00	12.00	0.00	0.00
8090	12.00	0.00	12.00	0.00	0.01
404	12.00	0.00	12.00	0.00	0.00
Mean	12.00	0.00	12.00	0.00	0.00

showed that the rate of pecking in this component was significantly higher with the EXT schedule than the $\overline{EXT}$ schedule, $F(1,5) = 6.86$, $p < .05$. The failure to reach statistical significance with the nonpeck measure may be due to a lower sensitivity of that measure to changes in responding.

The group plot for Group KL-VT, Figure 3, shows a slightly but consistently higher pecking rate in the VT component of the EXT schedule than the $\overline{EXT}$ schedule. This difference was not statistically significant; $F(1,5) = 1.6$, $p > .05$. No difference was found between the nonpecking rates in the VI($\overline{P}$) components of the two schedules; $F(1,5) = 1.4$, $p > .05$. Although all birds in this group began keypecking early in training, only two maintained pecking throughout training. Plots for these two birds, pigeons 526 and 502 (included in the appendix), show that pecking rates in the VT component were generally higher in the EXT-VT schedule than the $\overline{EXT}$-VT schedule for both birds. Rate of nonpecking was slightly lower for these birds in the VI($\overline{P}$) component of the EXT schedule than the VI($\overline{P}$) component of the $\overline{EXT}$ schedule. The direction of the effects is the same as for Group KL-VI, although the effects are not as large.

Daily mean response rates for Group HL-VI in each VI component of each schedule are shown in Figure 4. Keypecking rate during the VI(P) component was clearly higher in the EXT schedule than with the $\overline{EXT}$ schedule. This difference is also apparent on individual subject plots, shown in the appendix. All six birds in Group HL-VI had higher mean pecking rates in the VI(P) component of the EXT schedule than the VI($\overline{P}$) component of

the $\overline{EXT}$ schedule (see Table 3). This difference was significant; $F(1,5) = 39.9$, $p < .01$. There was no systematic difference between the nonpecking rates in the VI($\overline{P}$) components of the two schedules for Group HL-VI; $F(1,5) = .01$, $p > .05$. Although these birds did show positive contrast in the VI(P) component, the schedule change did not produce any difference in nonpeck rate in the VI($\overline{P}$) component.

Birds in Group HL-VT did very little keypecking, as indicated in Table 3.

Two measures were used to compare the amount of "contrast" obtained in Groups KL-VI and HL-VI. If the measure of contrast used for each bird is the simple difference between response rates in the two schedules, then differences in the amount of contrast for the two groups are not statistically significant for either the VI(P) component, $F(1,10) = 1.3$, $p > .05$, or the VI($\overline{P}$) component, $F(1,10) = 3.4$, $p > .05$. A ratio measure of contrast based on differences in rate between the two schedules relative to the overall response rate was also calculated for each bird. This contrast ratio (CR) was the number of pecks in the VI(P) component of the EXT schedule (P_{EXT}) relative to total pecks in the VI(P) components of both schedules; i.e.

$$CR(P) = \frac{P_{EXT}}{P_{EXT} + P_{\overline{EXT}}}.$$

With this measure, a ratio of .5 indicates no difference in rate between the two schedules; a ratio greater than .5 indicates a positive contrast effect, and a ratio less than .5 indicates an effect opposite to positive contrast. All pigeons in both groups had ratios above .5.

$CR_{(P)}$ was significantly greater for Group HL-VI than Group KL-VI; $F\ (1,10) = 7.1$, $p < .025$. The discrepancy in the results for the VI(P) component using the two measures of contrast occurs because the ratio measure reflects relative response rate while the simple difference measure reflects only the absolute difference in response rate across schedules. Since pigeons in Group HL-VI generally had lower keypeck rates than those in Group KL-VI but showed approximately the same absolute differences across schedules, higher ratio scores were obtained for Group HL-VI.

Similar ratios were calculated for each bird for nonpeck rates in the VI($\overline{P}$) components: $CR_{(\overline{P})} = \frac{\overline{P}_{EXT}}{\overline{P}_{EXT} + \overline{P}_{\overline{EXT}}}$. With this measure, differences between the two groups were not significant at the 5% level, $F\ (1,10) = 2.2$.

DISCUSSION

The nonpeck response was used in the present experiment in order to test the hypothesis that behavioral contrast depends upon the response on which reward is contingent. More generally, the relationship between the topography of the response maintained by the R-S* contingency and the topography of the response maintained by the S-S* relationships of the schedules will determine what effect will be produced when the R-S* and S-S* effects are superimposed. The additivity theory of contrast implies an effect opposite to positive contrast when food is dependent upon a nonpeck response because the R-S* effects and S-S* effects are opposing in the VI($\overline{P}$) component of the EXT schedule. Group KL-VI did show the expected effect; rate of nonpecking was higher in the VI($\overline{P}$) component in the $\overline{EXT}$ schedule than the EXT schedule. Group HL-VI did not show this effect, presumably because neither the instrumental response nor the discriminative stimuli were localized on the response key.

For Group KL-VI use of both the VI($\overline{P}$) and VI(P) components in both multiple schedules makes possible the within-subject comparison of contrast behavior with the two opposing response classes. For each subject within Group KL-VI, a comparison was made of the difference in pecking rates between the two multiple schedules for each of the VI components. In the EXT-VI schedule, the S-S* effect should presumably be about equal in the VI($\overline{P}$) and VI(P) components, since the relationship of each to food presentations is approximately the same. (Although the same number of food presentations were available in both VI

components, they were not always collected. Records were kept of the number of food presentations in each component in each session. Because of equipment failure, these data are not available for two of the last twenty sessions for three of the birds in the KL-VI group. Based on the available data, over the last twenty sessions the group mean number of food presentations per session was 18.0 in the VI($\overline{P}$) component and 18.1 in the VI(P) component.) Because both discriminative stimuli are located on the response key, there should be the same tendency to direct behavior toward it. Therefore the increase in tendency to keypeck should be approximately the same in both components, producing an increase in the instrumental response in the VI(P) component and a decrease in the instrumental response in the VI($\overline{P}$) component.

Table 4 shows the difference in rate of keypecking across schedules for each VI component for birds in Group KL-VI. Five of the six birds had a higher rate of pecking with the EXT schedule than the $\overline{EXT}$ schedule in both the VI($\overline{P}$) component and the VI(P) component. This indicates that the direction of the S-S* effect is consistent across VI components. For every bird, however, this difference was greater in the VI(P) component than the VI($\overline{P}$) component. This difference between the two components is difficult to interpret. It could be due to a response scale nonlinearity; i.e. the same increase in response tendency may effect a different increase in response rate, depending upon the initial response rate. Alternatively, the difference in the size of the effect in the two components could indicate an

Table 4

Differences in mean keypecking rates across multiple schedules for each VI component for birds in Group KL-VI.

$R_{EXT} - R_{\overline{EXT}}$

Pigeon	VI($\overline{P}$) Component	VI(P) Component
523	5.86	7.90
682	2.54	10.80
570	5.92	16.66
74	-3.09	0.81
24	6.84	14.09
63	7.32	12.46
Mean	4.23	10.45

interaction between the R-S* contingencies and the S-S* effects. For example, the keypeck contingency might enhance and/or the nonpeck contingency inhibit the S-S* effects or the nonpeck contingency might cause pecks induced by S-S* effects to be directed away from the response key.

A significant contrast effect was found in the VI 30-sec (P) component for both Group KL-VI and Group HL-VI. If a simple rate difference between the two schedules is used as the measure of contrast, the contrast effect for the two groups is not significantly different. However, if a ratio measure, which relates the difference in rate in the two schedules to the overall rate of responding, is used, the contrast effect is statistically larger for the HL-VI group than the KL-VI group. It is not clear which of these measures is more appropriate. If superimposition of S-S* effects is assumed to produce the same amount of keypecking regardless of the level of responding maintained by the R-S* contingency, the simple difference measure would be more appropriate. The important point to be made here is that the contrast effect was significant for both the KL-VI group and the HL-VI group.

This finding is not consistent with those previous experiments in which no contrast was obtained using a keypeck contingency with off-key stimuli. A review of these experiments leads to a possible explanation of the inconsistent results in terms of the "localizability" of the off-key stimuli. Hearst and Jenkins (1974) point out that the localizability of a stimulus influences the amount of sign-tracking directed toward the

stimulus. For example, they point out that although pigeons will track auditory cues delivered through spatially separated loudspeakers, the effect is not as strong as with more localized cues such as keylights.

In studies of behavioral contrast using a keypeck response but off-key stimuli, one would expect that the more localizable those off-key stimuli, the more that behavior produced by the differential S-S* relationships would be directed toward the off-key stimuli and therefore away from the response key, producing an effect in the direction opposite to positive contrast of keypecking. Depending upon how much behavior was directed away from the key, this could result in a smaller contrast effect, a failure to obtain contrast, or an effect opposite to positive contrast. Conversely, the less localizable (more diffuse) the off-key stimuli, the less the behavior would be directed away from the response key, and the greater the likelihood that behavior induced by the S-S* relationships would be recorded on the response key, thereby producing positive contrast.

Reports of investigations of contrast using off-key stimuli have sometimes referred to those stimuli as nonlocalized. It seems appropriate to make a distinction between nonlocalized stimuli and stimuli localized to some degree, but localized away from the response key. Probably the most diffuse off-key stimuli used in studies of contrast were houselight colors, with the houselights located above a translucent window in the ceiling of the chamber. Of the three experiments which used this type of stimuli for some subjects, the present study and that of Hemmes

(1973) did obtain positive behavioral contrast with these conditions. The third study, Redford and Perkins (1974) did not result in contrast for birds with houselight cues. However, in the final phase of the Redford and Perkins experiment, birds in the H-VI group did not respond differentially to the VI and EXT schedules signalled by the blue and green houselights. This may explain their failure to obtain positive contrast. Schwartz (1974, 1975) failed to obtain positive contrast using houselight-on and houselight-off conditions as discriminative stimuli. The houselight used was located within the experimental chamber, directly above the continuously transilluminated response key. This houselight is presumably a more localizable cue than the houselight colors used in the other experiments.

Keller's (1974) procedure used highly localizable stimuli located off the operant (food) key; these stimuli were colors localized on a second response key. This procedure resulted in no contrast on the food key, and a considerable amount of pecking directed toward the stimulus key.

Schwartz (1974, 1975) and Westbrook (1974) used auditory stimuli delivered through loudspeakers located behind the response panel and to one side of the response key. One might expect these cues to have an intermediate level of localizability (Hearst and Jenkins, 1974). Thus findings of no contrast (Schwartz) and a small contrast effect (Westbrook) using auditory cues are consistent with the present interpretation.

To summarize, studies with localized off-key stimuli have less often obtained behavioral contrast of a keypeck response

than those with more diffuse off-key stimuli. This is presumably because the behavior induced by the differential S-S* relationships is directed toward the localized off-key stimuli rather than toward the response key. Unfortunately, of the above studies, only the Keller procedure tested whether the subjects tracked the off-key stimuli. It is difficult to predict a priori how localizable a particular stimulus is; therefore perhaps the best way to predict whether contrast will occur is to test the particular stimulus conditions with a response-independent procedure to determine whether subjects will track the stimuli.

Although all of the birds in the KL-VT group began keypecking early in training, most did not continue pecking throughout training. This unfortunately limits comparison of this group with Group KL-VI. The direction of the differences in rate in each component across multiple schedules was the same for both Group KL-VI and Group KL-VT. However, these differences were not significant in the KL-VT group. An attempt had been made in the experiment to optimize conditions for the development of autopecking, for example, making EXT components relatively long in comparison to the VI and VT components, and beginning training with the EXT schedule. Keypecking might have been maintained better by enriching the VT and VI($\overline{P}$) schedules or increasing the duration of the EXT component. It is also possible that autopecking might have been increased by using different keylight stimuli to signal the VT component of the $\overline{EXT}$ and EXT schedules.

The results for Group HL-VT were as expected; very little keypecking occurred and there were no differences in response

rates within the VT and VI($\overline{P}$) components across multiple schedules.

Investigations of autoshaping, sign-tracking, and the additivity theory of behavioral contrast have indicated that it is important to consider the response-independent, stimulus-contingent effects of experimental procedures designed to investigate response contingencies. If the effects of the S-S* relationships are ignored, misleading conclusions may be drawn, perhaps sending subsequent research down a blind alley. These studies have also shown that the choice of an instrumental response cannot be made arbitrarily because S-S* contingencies interact differently with different responses. As Hearst and Jenkins (1974) have pointed out, this research has implications for many other areas in addition to behavioral contrast.

Reference Notes

1. Beavers, W. Personal communication, March, 1974.

2. Edmon, E. L. & Grisham, M. G. Contrast with a displaced signal. Paper presented at the meeting of the Midwestern Psychological Association, Chicago, May, 1976.

References

Brown, P. L., & Jenkins, H. M. Auto-shaping of the pigeon's keypeck. Journal of the Experimental Analysis of Behavior, 1968, 11, 1-8.

Freeman, B. Behavioral contrast: reinforcement frequency or response suppression? Psychological Bulletin, 1971, 75, 347-356.

Gamzu, E., & Schwartz, B. The maintenance of keypecking by stimulus contingent and response-independent food presentation. Journal of the Experimental Analysis of Behavior, 1973, 19, 65-72.

Hearst, E., & Jenkins, H. M. Sign-tracking: The stimulus-reinforcer relation and directed action. Austin, Texas: The Psychonomic Society, 1974.

Hemmes, N. S. Behavioral contrast in pigeons depends upon the operant. Journal of Comparative and Physiological Psychology, 1973, 85, 171-178.

Keller, K. The role of elicited responding in behavioral contrast. Journal of the Experimental Analysis of Behavior, 1974, 21, 249-257.

Redford, M. E. & Perkins, C. C., Jr. The role of autopecking in behavioral contrast. Journal of the Experimental Analysis of Behavior, 1974, 21, 145-150.

Reynolds, G. S. Behavioral contrast. Journal of the Experimental Analysis of Behavior, 1961, 4, 57-71.

Schwartz, B. Maintenance of key pecking by response-independent food presentation: The role of the modality of the

signal for food. Journal of the Experimental Analysis of Behavior, 1973, 20, 17-22.

Schwartz, B. Behavioral contrast in the pigeon depends upon the location of the stimulus. The Bulletin of the Psychonomic Society, 1974, 3, 365-368.

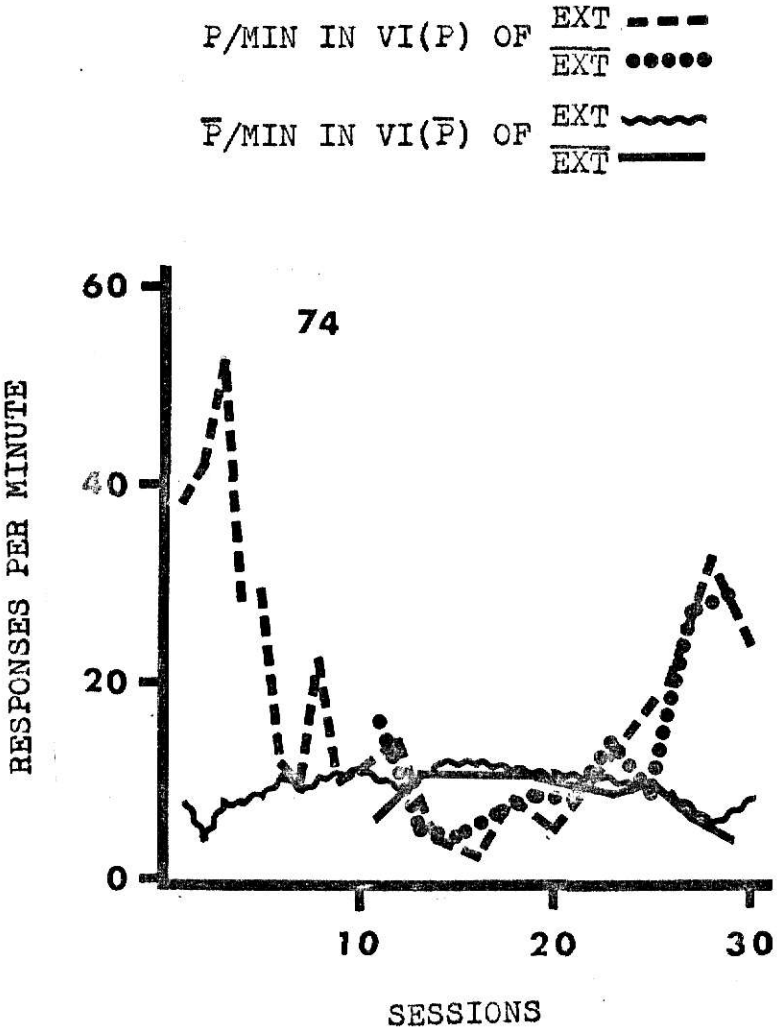
Schwartz, B. Discriminative stimulus location as a determinant of positive and negative behavioral contrast in the pigeon. Journal of the Experimental Analysis of Behavior, 1975, 23, 167-176.

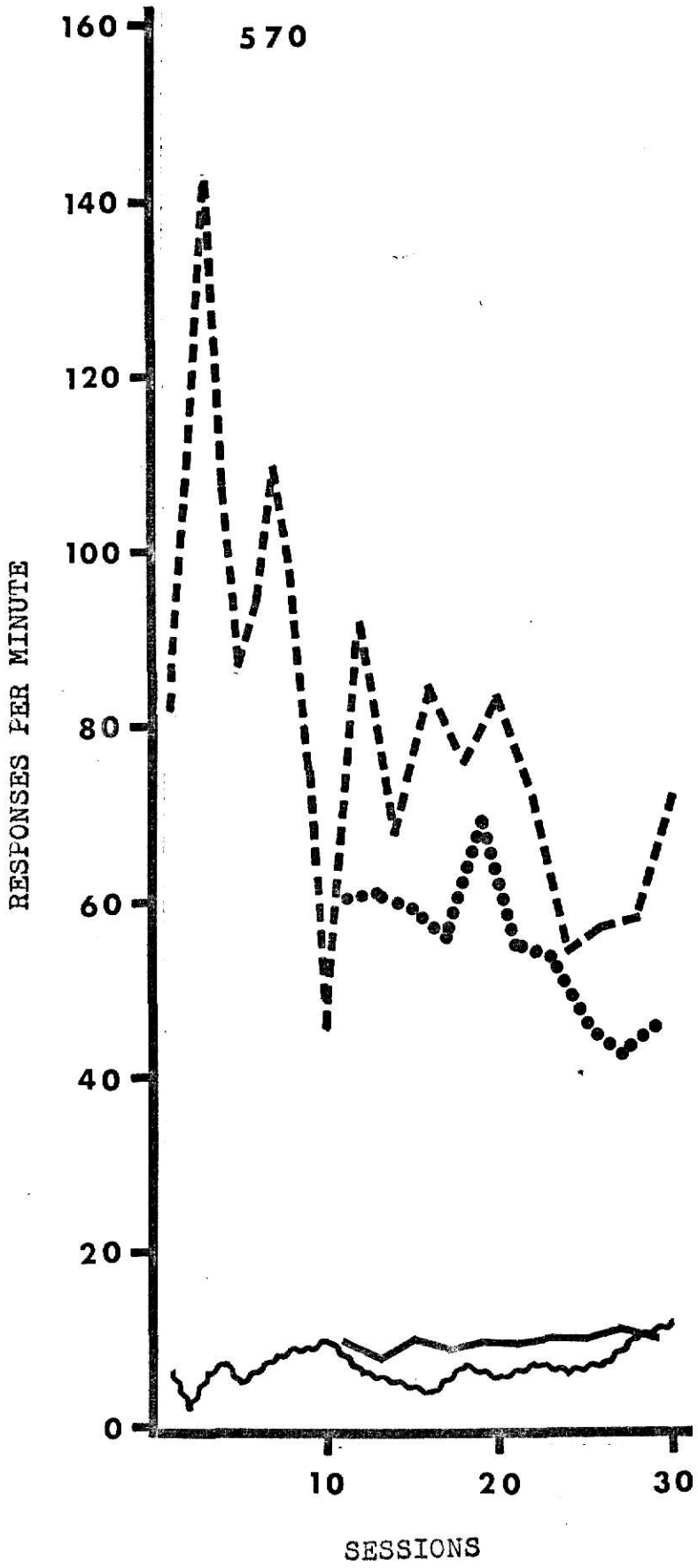
Terrace, H. S. Behavioral contrast and the peak shift; effects of extended discrimination training. Journal of the Experimental Analysis of Behavior, 1966, 9, 613-617.

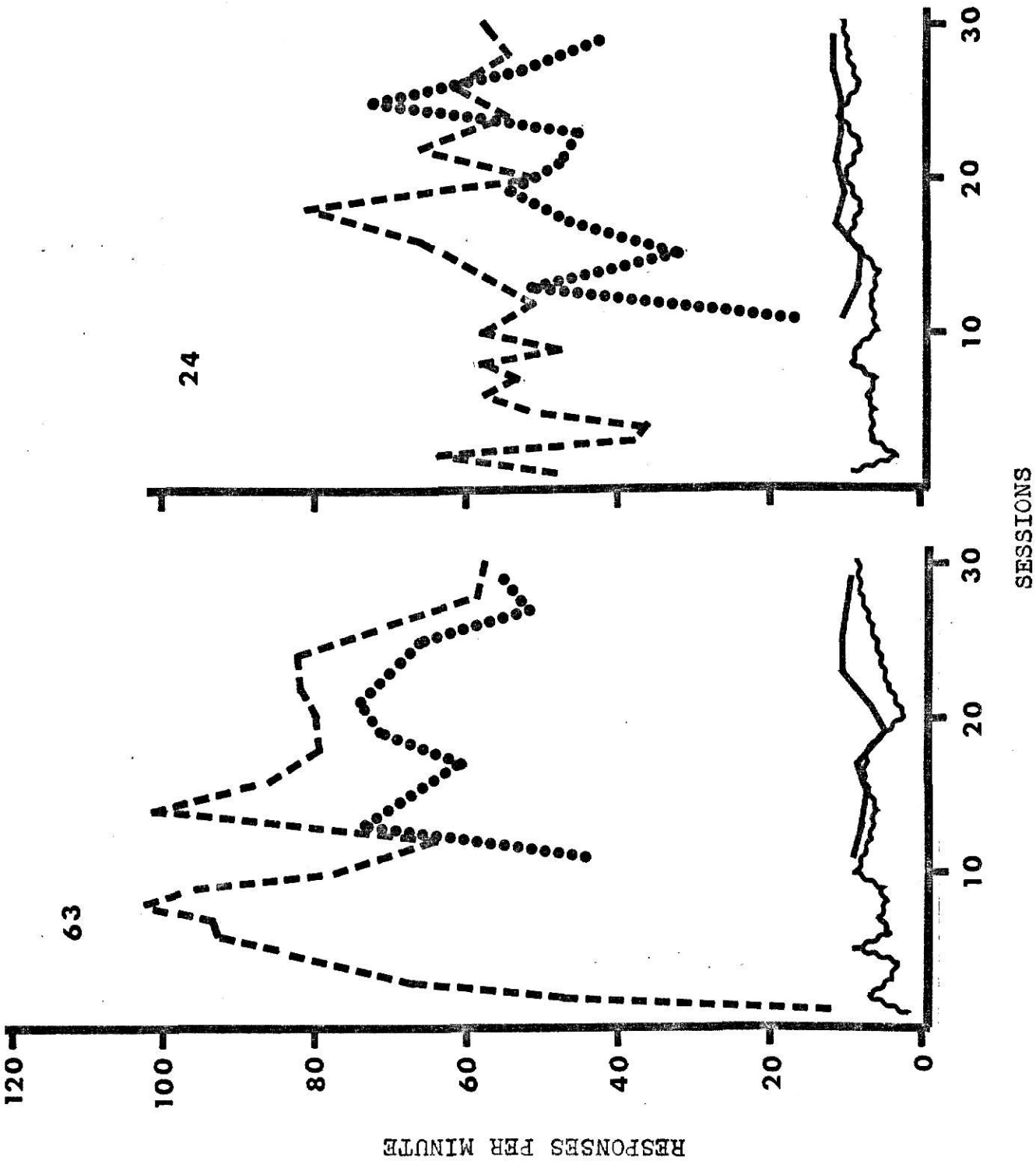
Westbrook, R. F. Failure to obtain positive contrast when pigeons press a bar. Journal of the Experimental Analysis of Behavior, 1973, 20, 499-510.

Figure Caption

Appendix A. Nonpeck rate in the VI($\overline{P}$) component and keypeck rate in the VI(P) component of each session for individual birds in Group KL-VI.


P/MIN IN VI(P) OF EXT
EXT
P̄/MIN IN VI(P̄) OF EXT
EXT
74
60
40
20
0
RESPONSES PER MINUTE
10
20
30
SESSIONS


570
160
140
120
100
80
60
40
20
0
RESPONSES PER MINUTE
10
20
30
SESSIONS


63
24
120
100
80
60
40
20
0
10
20
30
RESPONSES PER MINUTE
SESSIONS

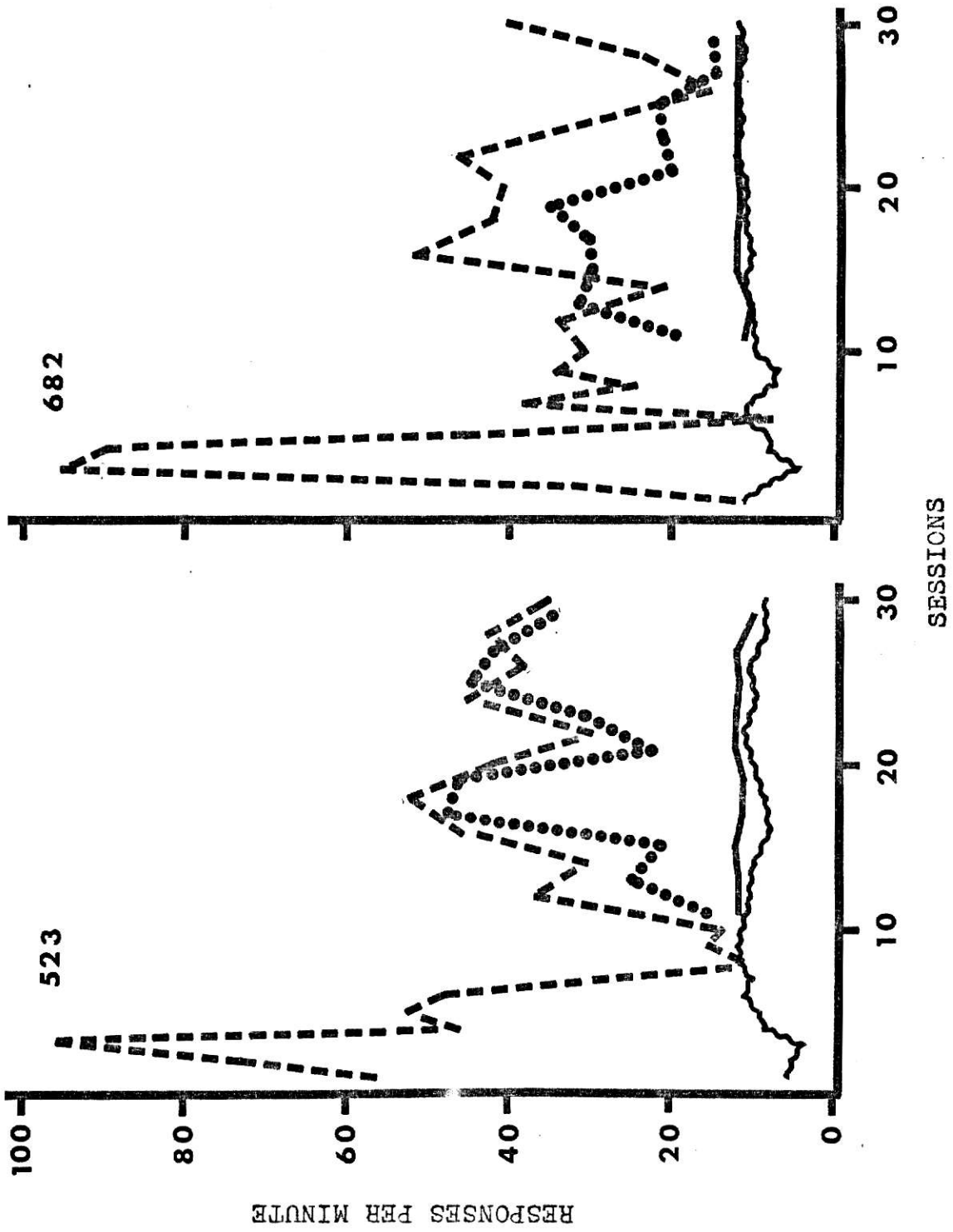
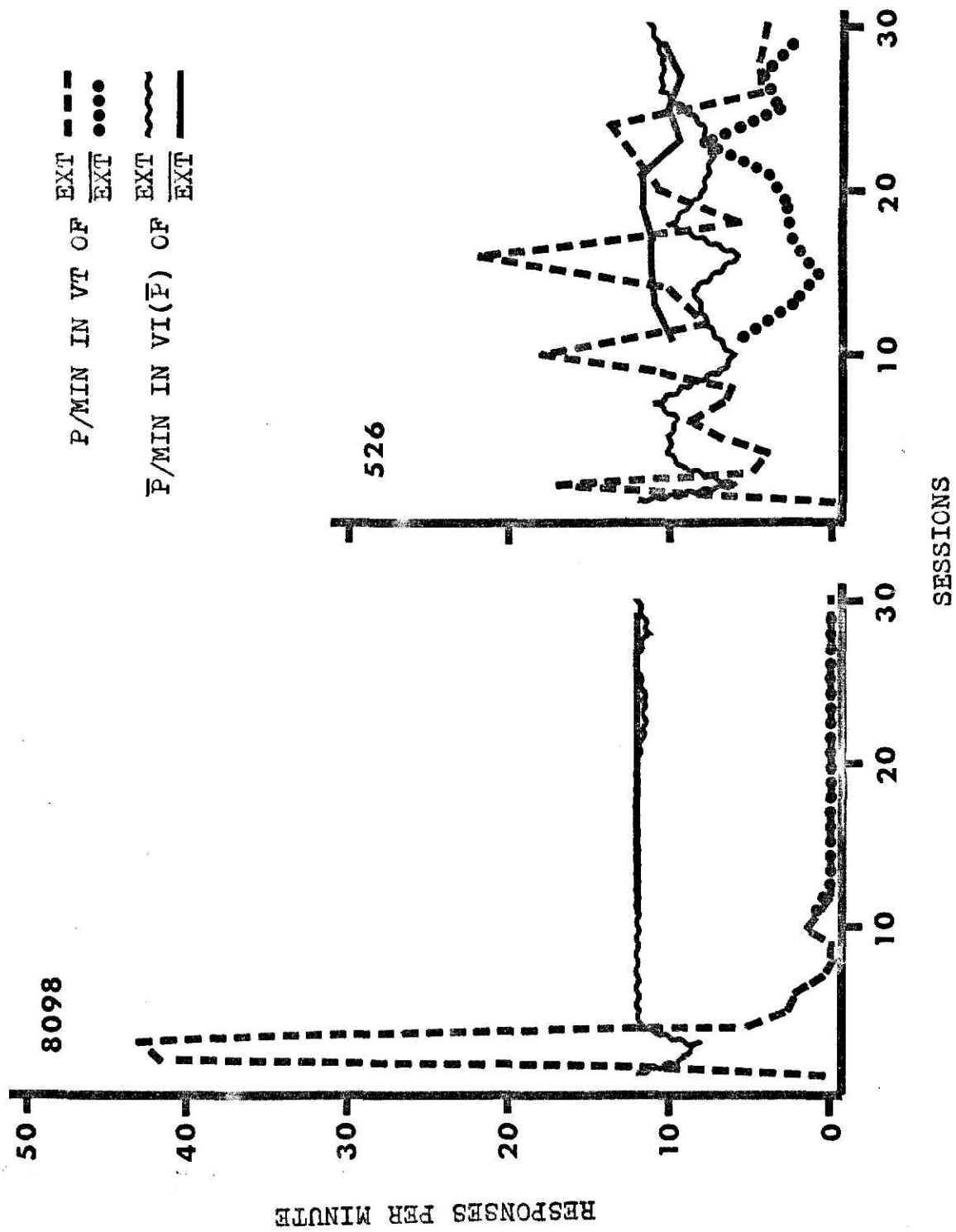

523
682
100
80
60
40
20
0
10
20
30
SESSIONS
RESPONSES PER MINUTE

Figure Caption

Appendix B. Nonpeck rate in the VI($\overline{P}$) component and keypeck rate in the VT component of each session for individual birds in Group KL-VT.


P/MIN IN VT OF EXT
P/MIN IN VT OF EXT
P/MIN IN VI(P̄) OF EXT
P/MIN IN VI(P̄) OF EXT
8098
526
RESPONSES PER MINUTE
SESSIONS
0
10
20
30
40
50
10
20
30
10
20
30

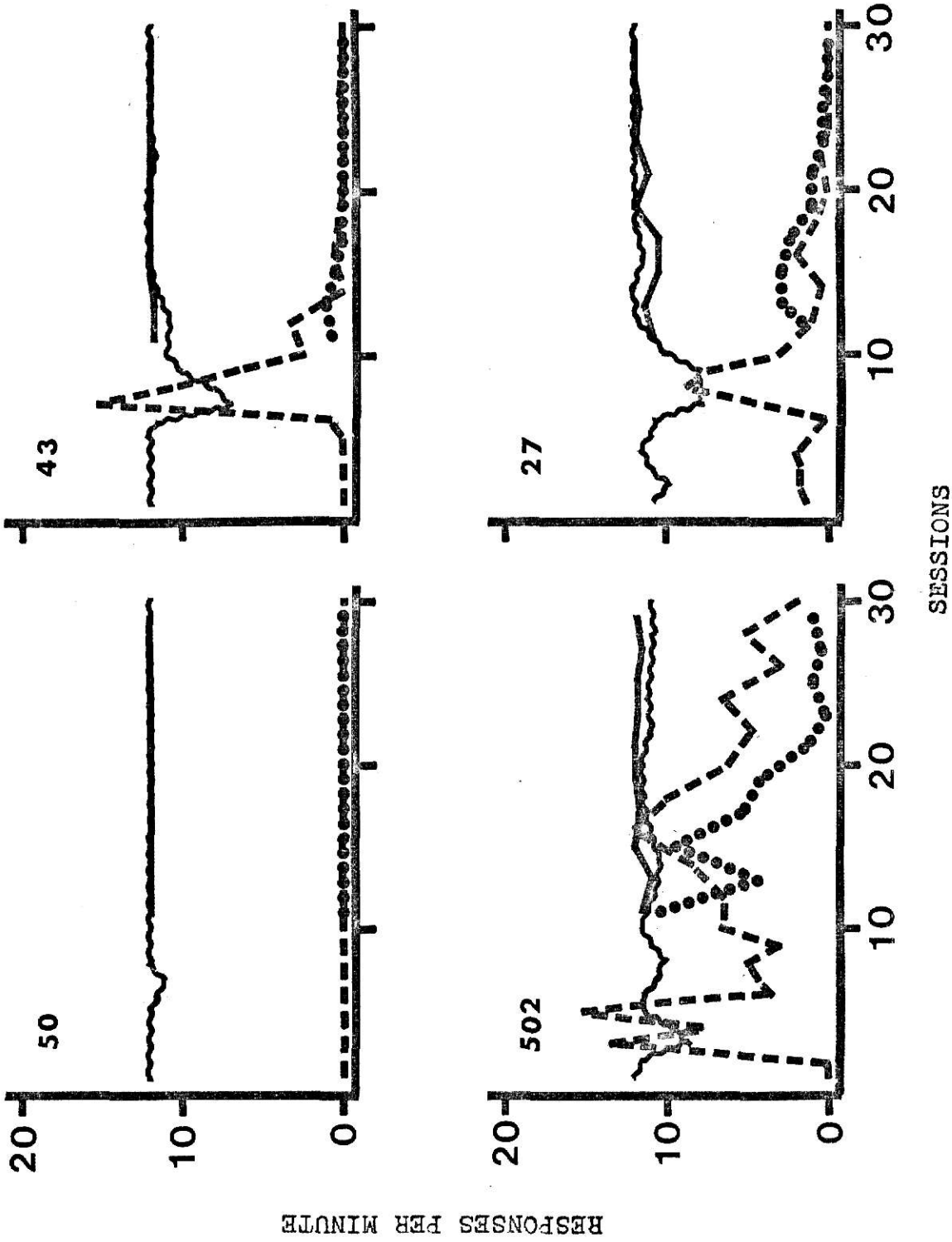
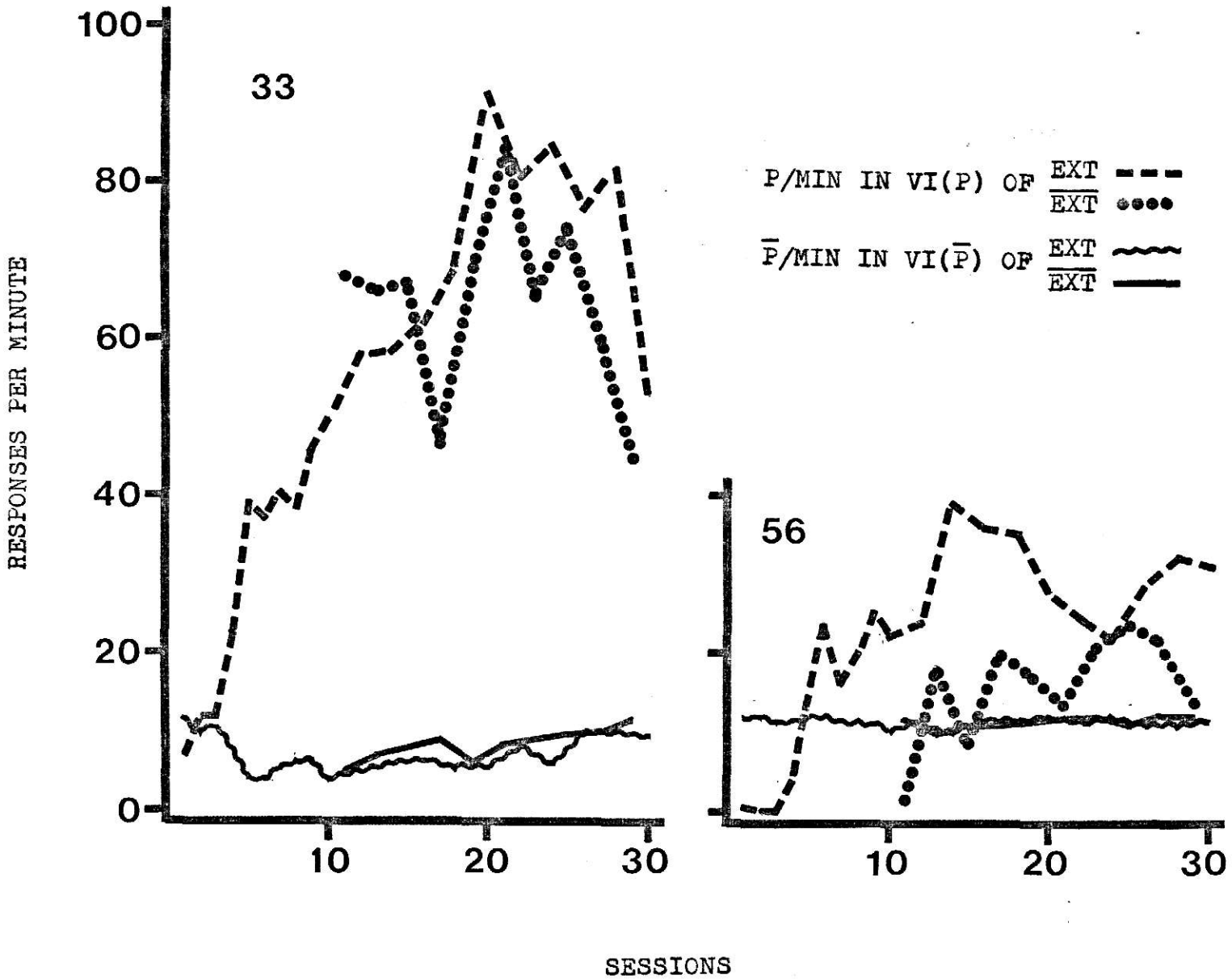
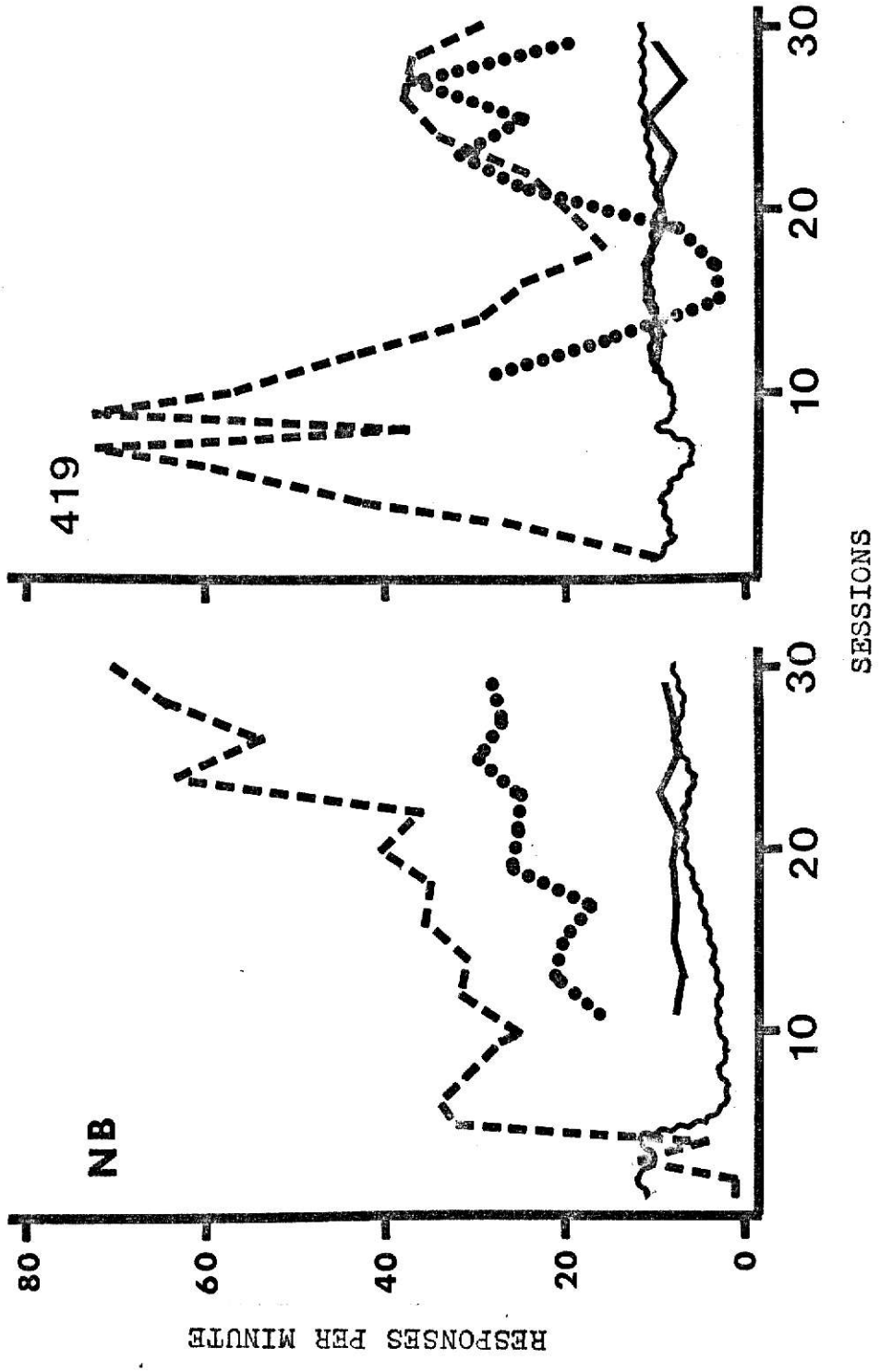
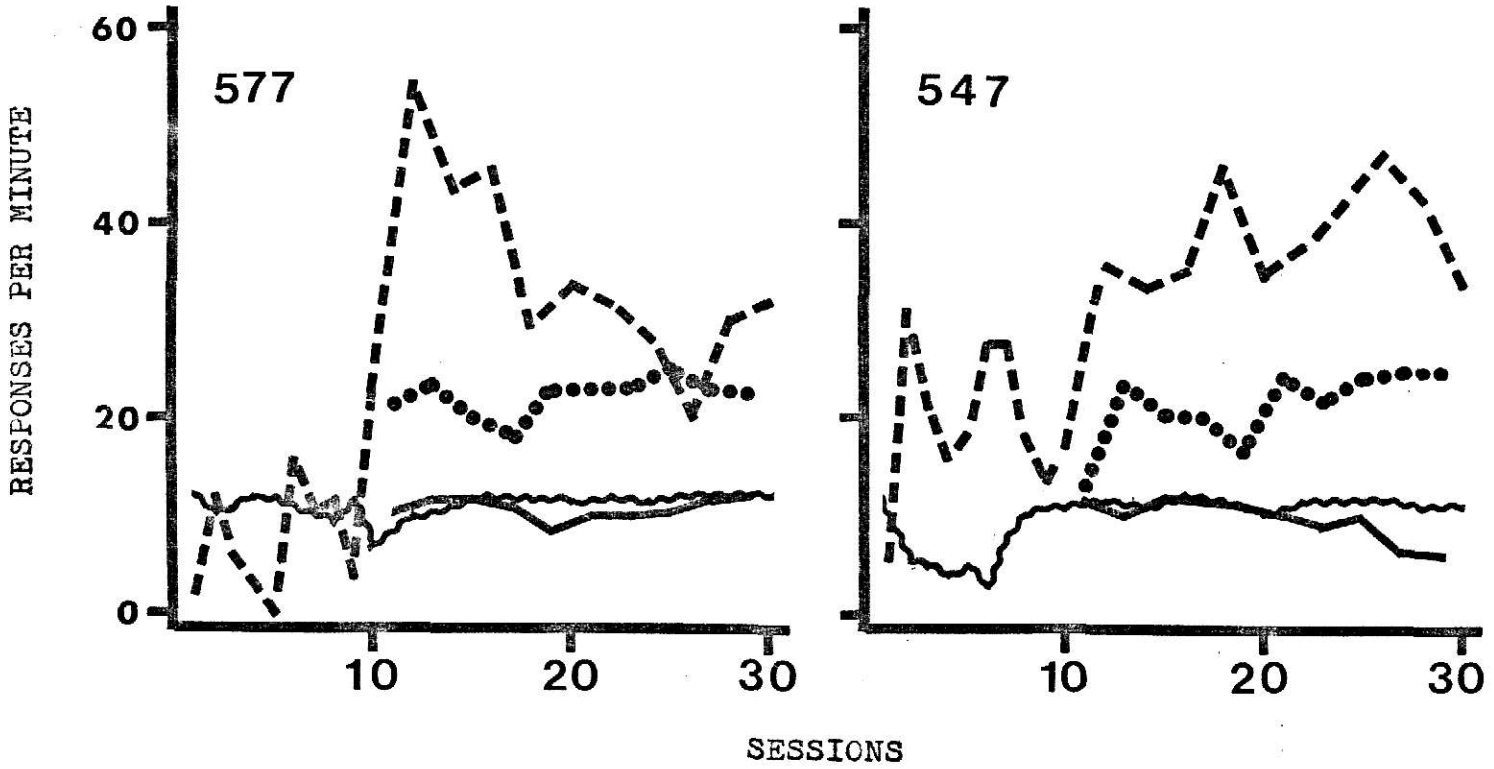

43
27
50
502
20
10
0
10
20
30
RESPONSES PER MINUTE
SESSIONS

Figure Caption

Appendix C. *Nonpeck* rate in the VI($\overline{P}$) component and keypeck rate in the VI(P) component of each session for individual birds in Group HL-VI.


100
80
60
40
20
0
33
56
10
20
30
RESPONSES PER MINUTE
SESSIONS
P/MIN IN VI(P) OF EXT
EXT
P̄/MIN IN VI(P̄) OF EXT
EXT


NB
419
RESPONSES PER MINUTE
0
20
40
60
80
10
20
30
SESSIONS


RESPONSES PER MINUTE
60
40
20
0
577
547
10
20
30
10
20
30
SESSIONS

THE EFFECTS OF RESPONSE REQUIREMENTS AND STIMULUS LOCATION ON BEHAVIORAL CONTRAST

by

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ABSTRACT

An experiment was conducted to test the additivity theory of behavioral contrast by investigating the effects of stimulus location and the topography of the response upon which food is contingent on behavioral contrast. Four groups of six pigeons each were trained on two multiple schedules each. Stimuli were response key colors for two groups and houselight colors for the other two groups. For one keylight group and one houselight group, food was available on a variable-interval schedule contingent upon a keypeck in one component and a nonpeck in a second component of both multiple schedules. Birds in the other two groups received response-independent variable-time food presentations in one component and nonpeck-contingent variable-interval food presentations in a second component of both multiple schedules. For each subject, the only difference between the two multiple schedules was that one contained an extinction component in addition to the components already described. Positive behavioral contrast was obtained in the keypeck-contingent variable-interval component with both keylight and houselight groups. An effect opposite to positive contrast was obtained in the nonpeck-contingent variable-interval schedule with keylight birds but not with houselight birds. These results support the additivity theory of behavioral contrast.