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Behavioral contrast and the development of inhibitory stimulus control.

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BEHAVIORAL CONTRAST AND THE DEVELOPMENT
OF INHIBITORY STIMULUS CONTROL

A Dissertation Presented

By

James Vance Couch

Submitted to the Graduate School of the
University of Massachusetts in
partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

May, 1972

Major Subject: Psychology

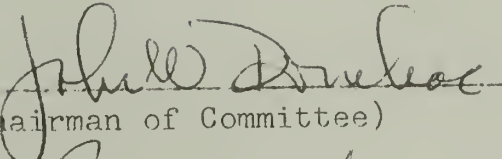
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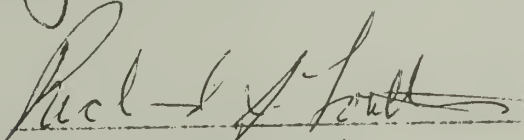
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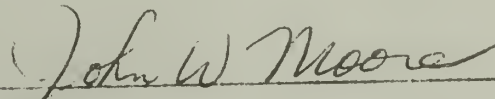
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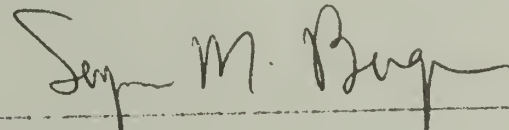
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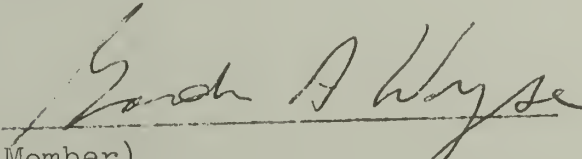
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Behavioral Contrast and the Development
of Inhibitory Stimulus Control

(May, 1972)

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Two experiments were conducted to determine if a necessary relationship exists between the occurrence of behavioral contrast during successive discrimination training and the development of inhibitory stimulus control. In both experiments, pigeons were used as subjects with a green stimulus projected onto the response key serving as the positive discriminative stimulus and a white vertical line imposed on a green background serving as the negative discriminative stimulus.

In Experiment I, an attempt was made to investigate the findings reported by Weisman (1969) indicating inhibitory control for only those subjects displaying behavioral contrast during discrimination training. Specifically, during Experiment I, groups of four pigeons were given one of the following baseline-discrimination sequences: (a) MULT VI-1 VI-1 \longrightarrow MULT VI-1 VI-5, (b) MULT VI-1 VI-1 TO \longrightarrow MULT VI-1 VI-5, (c) MULT VI-5 VI-5 \longrightarrow MULT VI-1 VI-5, or (d) MULT VI-5 VI-5 TO \longrightarrow MULT VI-1 VI-5. The time-out (TO) was employed so as to attenuate the degree of behavioral contrast that

normally occurs with the initiation of discrimination training. The results indicated that the degree of behavioral contrast was attenuated in those conditions receiving the TO. However, when a postdiscrimination generalization test along the line tilt dimension was conducted, the resulting gradients exhibited the characteristics of excitatory gradients rather than the characteristics of inhibitory gradients.

In Experiment II, in order to increase the probability of observing inhibitory generalization gradients, all generalization test stimuli were presented during baseline sessions (VI-1). As in Experiment I, eight subjects also received the TO stimulus. Following VI-1 baseline training four subjects received single stimulus training in the presence of the vertical line imposed on the green background. During single stimulus training, these four subjects received reinforcement according to a VI-5 schedule. The remaining subjects received discrimination training with either a MULT VI-1 EXT or a MULT VI-1 VI-5 schedule. Half of the subjects comprising each discrimination condition had previously received the TO stimulus during the baseline phase. The results of Experiment II were as follows:

(a) the TO did not significantly affect the terminal baseline response rate or the occurrence of behavioral contrast during discrimination training, (b) for the subjects receiving single stimulus VI-5 training, there was no significant

modification of the generalization gradient obtained following baseline training, and (c) the majority of the remaining subjects exhibited inhibitory stimulus control independent of the occurrence of behavioral contrast during discrimination training.

The results of the two experiments indicate that behavioral contrast is neither a necessary nor a sufficient condition for the development of inhibitory stimulus control. Furthermore, an argument was made that the results of the present investigation along with the results of previously reported investigations might be more parsimoniously interpreted in terms of a reduction in the response rate (excitation) in the presence of the negative stimulus rather than in terms of an inhibitory mechanism.

CHAPTER I

General Introduction

As an integral part of the learning process, the analysis of the control exerted by external stimulus events over a subject's behavior has become increasingly more prominent. The emphasis on the stimulus control of behavior has been most fruitfully examined within the paradigm of discrimination learning. Basically this paradigm involves either the simultaneous or successive presentation of different stimuli with the condition that each stimulus be correlated with a different schedule of reinforcement. For example, the simplest case of successive discrimination requires that the responses made in the presence of one discriminative stimulus (S+) are reinforced while responses which are made in the presence of another discriminative stimulus (S-) are non-reinforced. Institution of contingencies between stimulus - response - and reinforcing events leads to a gradual increase in the emission of responses in the presence of the S+ and a gradual decrease in the emission of responses in the presence of the S-. When different rates of responding are evident following the above, or similar, training procedures, a discrimination is said to have been formed between the two stimuli (S+ and S-) and further, that the stimuli have gained control of the subject's behavior (Terrace, 1966).

Excitation and inhibition. While the empirical

observation of differential response rates in the presence of the two discriminative stimuli is easily arrived at, the theoretical analysis of the underlying process is not such a simple matter.

One of the first investigators to attempt an analysis of discrimination learning was Pavlov (1927). While Pavlov's analysis was based upon physiological processes, his terminology is still current. Basically, Pavlov reasoned that through the interaction of two fundamental processes, excitation and inhibition, an animal comes to respond differentially to the two discriminative stimuli. In essence, Pavlov's analysis is that excitatory nervous activity generated by the conditioned stimulus sets the subject to respond due to the past associations of the positive conditioned stimulus with the unconditioned stimulus (reinforcement). Coupled with the excitatory process was an inhibitory process which acted to diminish the irradiation of excitation from the cortical locus of the positive conditioned stimulus and aided in the concentration of the excitation at the cortical center representative of the positive conditioned stimulus.

While Pavlov's analysis in terms of cerebral processes is most likely in error, the use of excitatory and inhibitory processes as explanatory concepts can still be found in most current literature of discrimination learning.

Spence's analysis. In terms of research generated, the most influential theoretical analysis to account for

discrimination learning was put forth by K. W. Spence (1936). While the terminology of Spence's analysis is similar to that of Pavlov, excitation and inhibition were viewed by Spence, as hypothetical concepts to be used primarily for prediction and explanation.

In the Spencian analysis, the reinforcement of a response in the presence of a discriminative stimulus (S+) leads to an increase in the tendency to respond (excitation) when that discriminative stimulus is later presented. Likewise, if a response, while in the presence of a different discriminative stimulus (S-), leads to nonreinforcement, then the tendency to respond on later occurrences of that stimulus will be reduced, i.e. inhibition is developed. These two processes (excitation and inhibition) set the condition for the gradual strengthening of a response in the presence of the stimulus during which reinforcement is scheduled and the gradual weakening of the response tendency to the stimulus during which responses are nonreinforced. Furthermore, since these excitatory and inhibitory tendencies generalize to surrounding stimuli, a gradient of decreasing response tendency (excitatory gradient) should be evident over the S+ dimension and a gradient of increasing response tendency (inhibitory gradient) should be observable when values from the S- stimulus dimension are presented.

Experimental procedures. In order to observe excitatory and inhibitory generalization gradients as

proposed by Spence, one crucial experimental condition must be arranged. This condition demands that the stimulus dimension of which the S+ is a member be independent of (orthogonal to) the stimulus dimension of which S- is a member. That is, the spread of excitation from the S+ dimension must be equal at all points on the S- dimension so that variations along the S- dimension remain at equal distances from the S+.

A procedure, termed the orthogonal training procedure, which meets the above conditions has been used to investigate inhibitory effects with pigeons as subjects by Jenkins and Harrison (1962) where a successive discrimination was formed between white noise as the S+ and a 1000 Hz tone as S-. Honig, Boneau, Burstein, and Pennypacker (1963) and Hearst (1968, 1969) also employed the same procedure but used a blank white stimulus projected onto a response key as the S+ and a white stimulus together with a black vertical line as the S-. In all of these investigations, postdiscrimination presentations of values along the S- dimension (tones or line orientations) led to an incremental gradient of response tendency with the minimum at the S- value. The occurrence of such an incremental (U-shaped) generalization gradient is taken as indicative of inhibitory stimulus (dimensional) control. However, as Hearst, Besley, and Farthing (1970) make clear, before the S- stimulus may be considered inhibitory in and of itself, one or more of the following experimental

tests must be completed. First, the S- stimulus could be paired with another stimulus of known response strength and if a reduction in response tendency is noted, the S- can then be considered inhibitory. Secondly, if the acquisition rate of some operant response is retarded when reinforcement is now scheduled in the presence of the former S-, then the former S- could be considered to have had inhibitory effects. Finally, if a subject selects a neutral stimulus over a concurrently presented S-, the S- can likewise be considered inhibitory.

While the use of the above ancillary experimental tests will indeed reduce some theoretical debates concerning the presence of inhibitory effects (Deutsch, 1967 vs Terrace, 1966, for instance), for the present, only inhibitory dimensional control will be considered.

While all of the aforementioned research involved intermittent reinforcement [variable interval (VI) reinforcement] for responses emitted in the presence of the S+ and no reinforcement [extinction (EXT)] for S- responses, there are indications that the complete omission of reinforcement during S- is not a necessary condition for the generation of inhibitory like effects. Specifically, Guttman (1959) and Terrace (1968) have shown that the alternation of a stimulus correlated with VI-1 min scheduled reinforcement and a stimulus that is associated with a VI-5 min schedule produced results suggestive of inhibitory control by the stimulus associated

with a VI-5 min schedule. Similiarly, Weisman (1969), by using the orthogonal training procedure, was able to show an incremental U-shaped gradient around a stimulus associated with a VI-5 min schedule following discrimination training between this stimulus and a stimulus correlated with a VI-1 min reinforcement schedule. These results would, therefore, be taken as indications that a stimulus can gain inhibitory control even though reinforcement is occasionally forthcoming for responses made in the presence of the stimulus.

Baseline training. While the investigations of Guttman (1959), Terrace (1968) and Weisman (1969) indicate that a stimulus may gain inhibitory control even though reinforcements are occasionally obtained for responses emitted in the presence of the stimulus, a closer examination of the Weisman (1969) investigation shows that at least two other variables seem crucial for the development of inhibitory stimulus control.

For Weisman (1969), groups of naive pigeons were initially given twenty days of non-differential training in the presence of either of two stimuli on the key --- a green stimulus or a 0° white line superimposed upon the green background. During baseline training, the subjects received reinforcement according to either one of the following reinforcement schedules: MULT VI-1 VI-1 or MULT VI-5 VI-5. Following baseline training, both groups were given discrimination training during which a VI-1 schedule was in effect for

presentations of the blank (green) stimulus and a VI-5 schedule was in effect during stimulus presentations of the line tilt + green background stimulus. Following fourteen days of MULT VI-1 VI-5 discrimination training, all birds received a generalization test consisting of values from the line tilt dimension. The generalization results indicated U-shaped gradient (inhibitory stimulus control) for all birds who had previously received MULT VI-1 VI-1 baseline training while only one of the previously trained MULT VI-5 VI-5 pigeons exhibited inhibitory control. Therefore even though all birds received identical discrimination training, the factor seemingly responsible for the development of inhibitory control was the pre-discrimination reinforcement history: The S2 always developed inhibitory control for those subjects who encountered a reduced rate of reinforcement (MULT VI-1 VI-1 \longrightarrow MULT VI-1 VI-5 condition) in the presence of the green + line tilt stimulus. From the foregoing it would appear that a statement could be made relating the reduction in reinforcement density as a necessary condition for the development of inhibitory control.

Behavioral contrast and inhibitory control. The above general statement is, however, complicated by the occurrence of inhibitory stimulus control for one bird in Weisman's investigation who received no reduction in reinforcement density to the S2 when discrimination training was instituted (MULT VI-5 VI-5 \longrightarrow MULT VI-1 VI-5 condition). The one aspect of this subject's performance which differentiated it from

other subjects receiving identical training was the occurrence of behavioral contrast during discrimination training. Behavioral contrast, as defined by Reynolds (1961), refers to the concurrent increase in the response rate during the positive stimulus and a decrease in response rate during presentations of the negative stimulus. Furthermore, all subjects in the MULT VI-1 VI-1 pretrained condition showed evidence of contrast.

If the Weisman investigation is considered alone, it could be concluded that a sufficient condition for the development of inhibitory control is either a reduction of reinforcement density in the presence of a discriminative stimulus or the occurrence of behavioral contrast upon the initiation of discrimination training. What is unclear from the Weisman investigation, however, is the necessary relationship between inhibitory control development and behavioral contrast. Indeed, several investigators (Farthing and Hearst, 1968; Terrace, 1966, 1968; Yarcozwer, 1970) have either suggested or presented evidence indicating that the occurrence of behavioral contrast is a necessary antecedent for the development of inhibitory stimulus control. It was therefore the aim of the initial experiment in the present investigation to examine further the presumed relationship between behavioral contrast and inhibitory control.

Time-out (TO) effects. Previous research concerning the origins of and the procedures which can produce behavioral contrast has indicated that contrast will occur in one component

of a multiple schedule if that component is alternated with a component during which there is no illumination of the operant chamber or the response key (Sadowsky, 1970). The component during which the operant chamber and response key are darkened has been termed the time-out from reinforcement component, or simply a time-out (TO), and usually produces few if any responses to the darkened key.

Reynolds (1961), during the initial examination of behavioral contrast using multiple schedules, employed such a procedure and reported behavioral contrast during a VI-3 minute component which alternated with a TO of 3 minutes duration. In a more thorough investigation of TO effects, Taus and Hearst (1970) exposed pigeons to a MULT VI-1 TO schedule with TO values of 0, 1, 5, 10, or 30 seconds respectively for the five independent groups. The results indicated that response rates were highest for those subjects receiving the longest TOs.

It can be concluded, then, that the TO is a useful technique to increase the rate of responding in the presence of another stimulus, and since the response rate during the TO is near zero, the conditions defining behavioral contrast, as proposed by Reynolds, are satisfied.

CHAPTER II

Experiment I

Considering again the presumed relationship between the occurrence of contrast and the development of inhibitory stimulus control, it is clear that if behavioral contrast is essential to the development of inhibitory control, then if the contrast which normally occurs during discrimination training were eliminated or reduced, the development of inhibitory control should be reduced or eliminated. Since it has been shown that the addition of a TO will produce rate increases identified as behavioral contrast and since the TO stimulus (complete chamber darkness) is orthogonal to any key stimulus that would be presented, it was the purpose of the initial experiment to employ TOs during non-differential training as an attempt to reduce the magnitude of behavioral contrast when discrimination training was instituted. Through this procedure it is possible to examine the presumed relationship between behavioral contrast and inhibitory stimulus control.

Design of Experiment I. Two groups of four pigeons were given training identical to that reported by Weisman (1969). That is, one group received initial MULT VI-1 VI-1 non-differential training while the other group experienced MULT VI-5 VI-5 training in the presence of the two discriminative stimuli. Furthermore, two additional groups received identical reinforcement schedules as the above conditions but with the addition of TOs. Following non-differential training, all subjects were

given discrimination training using a MULT VI-1 VI-5 reinforcement schedule. At the termination of discrimination training, a generalization test, consisting of test values from the S- dimension, was administered. Through this procedure it was possible to compare the generalization gradients following the two conditions of baseline training, either with or without the TOs. If no necessary relationship exists between the occurrence of behavioral contrast and the development of inhibitory control, then existing formulations suggesting such a relationship must be reconsidered.

Method

Subjects. Sixteen White Carneaux pigeons, at least six months old, were used as subjects. After introduction into the laboratory, the subjects were housed individually and given several days of free food in order to obtain stabilized body weights. All subjects were then deprived of food and reduced to 75% of their free-feeding weight. Each subject was maintained at this deprivation level throughout the experiment. If necessary, supplemental feedings were given approximately fifteen minutes after the completion of the daily session so as to maintain the appropriate deprivation level.

Apparatus. Four identical Lehigh Valley Electronics pigeon operant chambers and accompanying sound attenuating hulls were used. Only the right most of two keys mounted on the

front wall was operative. Reinforcement consisted of 4 seconds access to a grain hopper through an aperture located to the left of the right response key. White noise at a sound level of 85 db was delivered through a speaker also mounted on the front wall and to the left of the feeder aperture.

The different stimuli that transilluminated the response key were generated by an Industrial Electronics Engineers display cell located behind the response key. Six orientations of a white line ($\pm 90^\circ$, -60° , -30° , 0° , $+30^\circ$, and $+60^\circ$ from vertical) and a green background were projected by the display cell. Line orientations superimposed upon a green background were obtained by illuminating a lamp behind a green Kodak Wratten filter and a lamp for the specific line orientation. Brightness differences due to the illumination of two lamps (line orientation and surround) as compared to illumination of only one lamp for the green surround were eliminated by the addition of neutral density filters between each line orientation and its light source.

Preliminary training. On the first day, subjects were habituated to the operant chamber for approximately 15 minutes. On the following two days, the subjects were feeder trained with 30 feeder presentations given daily. The house light provided the only illumination during these three sessions. On the fourth day, the subjects were trained to peck the S1 stimulus by the method of successive approximations. Following key peck training, the subjects were given one day of continuous

reinforcement with 25 reinforcements given for responses to the blank green stimulus (S1) and 25 reinforcements for responses to the green + 0° line tilt stimulus (S2). On the following two days, a fixed ratio of increasing length (maximum FR 33) was in effect and approximately 40 reinforcements, equally divided between the two stimuli, were obtained.

Baseline training. On the next day, non-differential reinforcement to the green background stimulus and the white vertical line imposed on the green background was begun with the introduction of VI reinforcement schedules during presentations of each stimulus. The eight subjects who were to receive MULT VI-1 VI-1 training were given two MULT VI-30 VI-30 sessions before the introduction of the VI-1 schedules. Subjects (n=8) who were to receive MULT VI-5 VI-5 baseline training received preliminary training on a progressive series of VI schedules [VI-30 sec (2 sessions), VI-1 min (2 sessions), VI-3 min (3 sessions)]. All subjects were then given 20 sessions of baseline training on the appropriate multiple schedule. Half of the subjects (n=4) from each of the above conditions, in addition to the random order of green and green + line tilt stimuli, were presented with a third stimulus, the T0. The T0 consisted of darkening the response key and the chamber for a 1 minute duration. In other words, these latter subjects received a randomized order of three stimuli with the appropriate schedule of rein-

forcement present in each. In all conditions a stimulus was presented for one minute with a 5 second TO separating the successive stimuli presentations.

Inter-reinforcement intervals of both the VI-1 and VI-5 schedules were controlled by a continuous loop of film. The inter-reinforcement intervals were obtained from the Fleshler and Hoffman (1962) series with the range of intervals being from 3 seconds to 184 seconds for the VI-1 schedule and from 43 seconds to 751 seconds for the VI-5 schedule.

Discrimination training. After baseline training, all groups received 14 days of discrimination training with a MULT VI-1 VI-5 schedule of reinforcement. The VI-1 schedule was correlated with the green stimulus while the VI-5 schedule was correlated with the 0° line on the green background.

Following discrimination training, all birds received a generalization test in extinction during which the six orientations of the white line, each on a green background, were presented along with the green background alone. The stimuli were each presented 10 times in randomized blocks of seven, 30 second trials each separated by a 5 second TO. Four reinforced (VI-1) presentations of the green stimulus preceded the generalization test.

Table 1 gives a summary of the reinforcement schedules operative during each phase of Experiment I. The number of responses per stimulus period for each subject was recorded on printing counters and was used in the data analysis.

TABLE 1

SUMMARY OF PROCEDURE: EXPERIMENT I

Groups	Number of Sessions in Each Phase		
	(Baseline)	(Discrimination)	(Generalization)
MULT VI-1 VI-1 \blackrightarrow MULT VI-1 VI-5	20 MULT VI-1 VI-1	14 MULT VI-1 VI-5	1 Line Orientation Generalization Test
MULT VI-1 VI-1 TO \blackrightarrow MULT VI-1 VI-5	MULT VI-1 VI-1 TO	MULT VI-1 VI-5	Line Orientation Generalization Test
MULT VI-5 VI-5 \blackrightarrow MULT VI-1 VI-5	MULT VI-5 VI-5	MULT VI-1 VI-5	Line Orientation Generalization Test
MULT VI-5 VI-5 TO \blackrightarrow MULT VI-1 VI-5	MULT VI-5 VI-5 TO	MULT VI-1 VI-5	Line Orientation Generalization Test

Results

Over the two days of VI-30 second baseline training the response rate did not significantly differ between the four groups ($F < 1$). This analysis indicates that prior to the introduction of the MULT VI-1 VI-1 or MULT VI-5 VI-5 reinforcement schedules, the response rates of the subjects comprising the four conditions were highly similar.

Baseline Training

VI-1 conditions. The response rate per stimulus on each day of baseline training for each subject in the MULT VI-1 VI-1 baseline condition is shown to the left of the vertical line in Figure 1. Similarly, Figure 2 indicates the response rates for each subject of the MULT VI-1 VI-1 TO condition. It should be noted that while the rate of responding had stabilized at the end of the 20 training days, the response rate for those birds receiving the TO was, on the average, higher than the response rate of the MULT VI-1 VI-1 subjects. The mean response rate averaged across both the S1 and S2 components was 58.50, 36.67, 39.83, and 18.50 responses per minute for the four MULT VI-1 VI-1 subjects while for the four MULT VI-1 VI-1 TO birds, the response rates were 74.83, 45.33, 68.33, and 98.83 responses per minute respectively.

VI-5 condition. The rate of responding per stimulus on each day for each subject in the MULT VI-5 VI-5 baseline condition is shown in Figure 3 with similar data being indicated

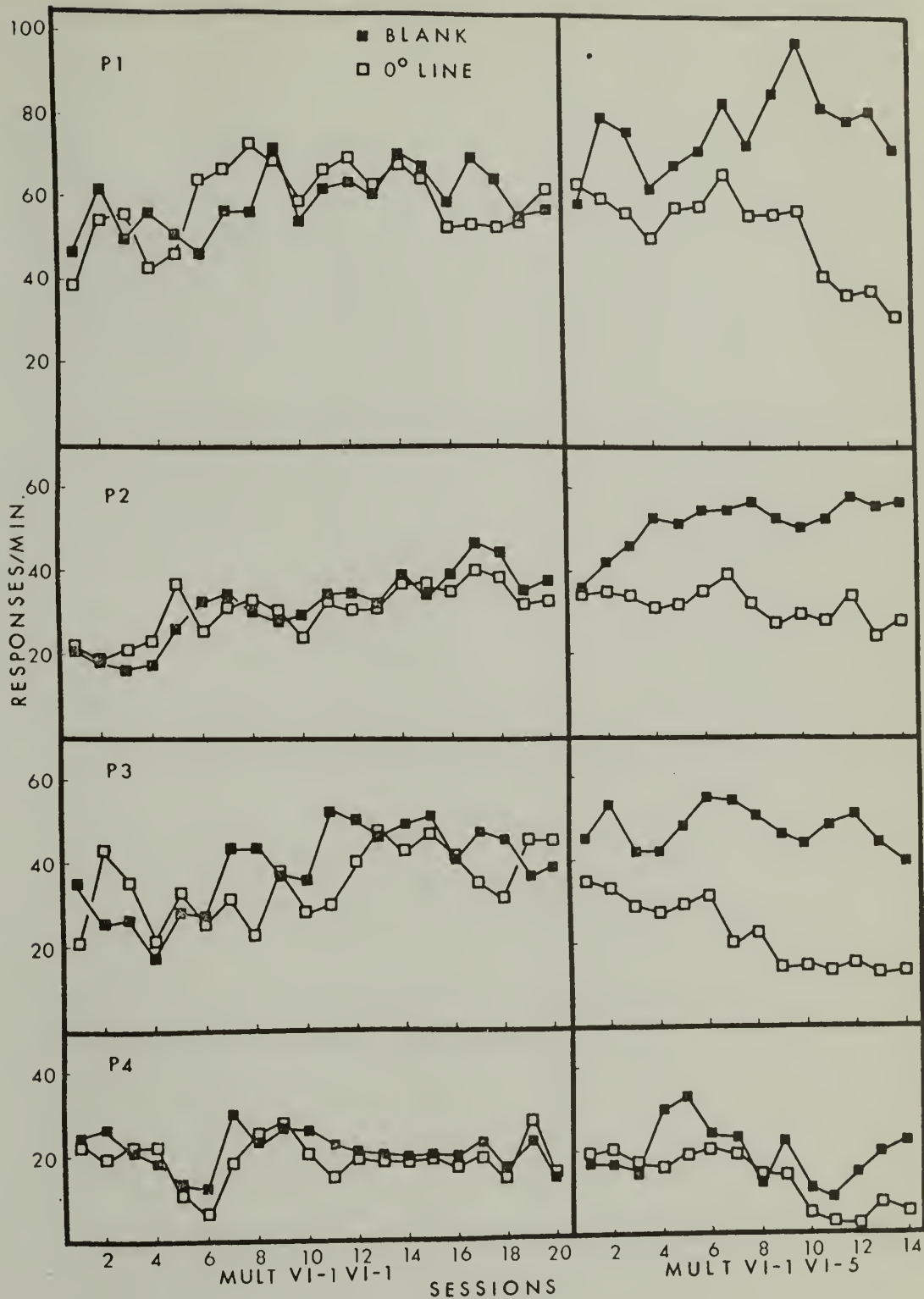


Fig. 1. Mean Rate of Responding Per Subject for the S1 and S2 Stimuli on Each Session of MULT VI-1 VI-1 Base-line Training and on Each Session of MULT VI-1 VI-5 Discrimination Training.

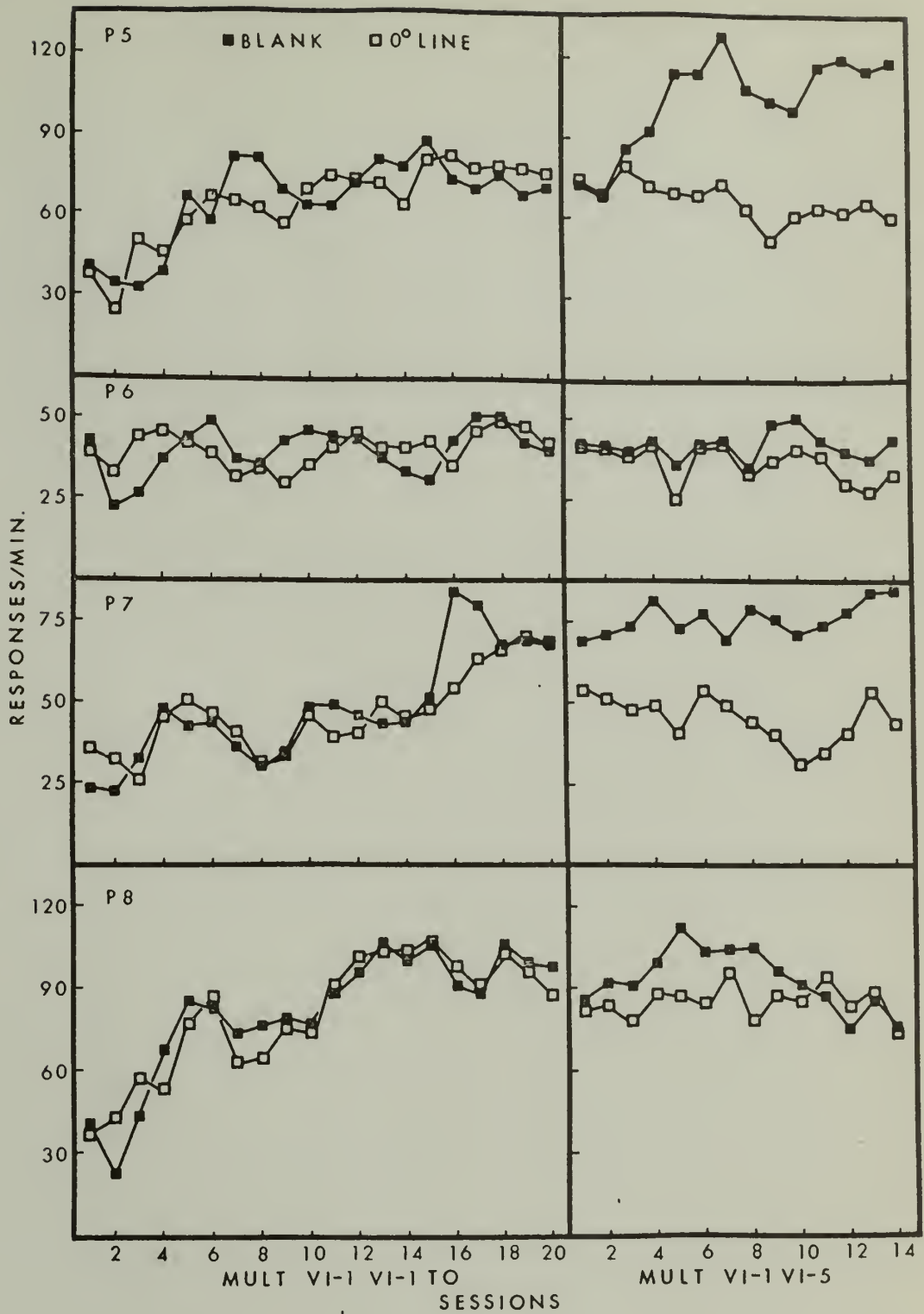


Fig. 2. Mean Rate of Responding Per Subject for the S1 and S2 Stimuli on Each Session of MULT VI-1 VI-1 TO Baseline Training and on Each Session of MULT VI-1 VI-5 Discrimination Training.

in Figure 4 for each MULT VI-5 VI-5 TO trained subject. A similar spectrum of results was obtained for the VI-5 trained subjects as for the VI-1 trained birds. That is, the mean rate over the last three training days for the MULT VI-5 VI-5 TO subjects was higher than the rate for the MULT VI-5 VI-5 subjects. The mean response rate for each subject of the MULT VI-5 VI-5 condition was 52.67, 58.33, 36.67, and 42.17 responses per minute while for the MULT VI-5 VI-5 TO condition, the response rate means were 113.33, 84.67, 74.00, and 58.00 responses per minute.

An analysis of variance performed on the response rates over the final three baseline training days indicated a reliable Groups effect, $F(3,12) = 4.95$, $p < .025$. Simple effects tests indicated that the subjects receiving a TO during training differed significantly from subjects not receiving the TO, $F(1,12) = 13.63$, $p < .005$ while the two schedule conditions did not differ ($F < 1$). The lack of a significant Days effect ($F < 1$) indicates response rate stability among the various conditions. Likewise, the lack of a reliable Stimulus effect ($F < 1$) indicates that there was no consistent preferences for either stimulus at the termination of baseline training.

Discrimination Training

The data plotted to the right of the vertical line in Figures 1, 2, 3, and 4 indicates the response rate in the presence of the S1 stimulus (VI-1 schedule) and the S2 stimulus

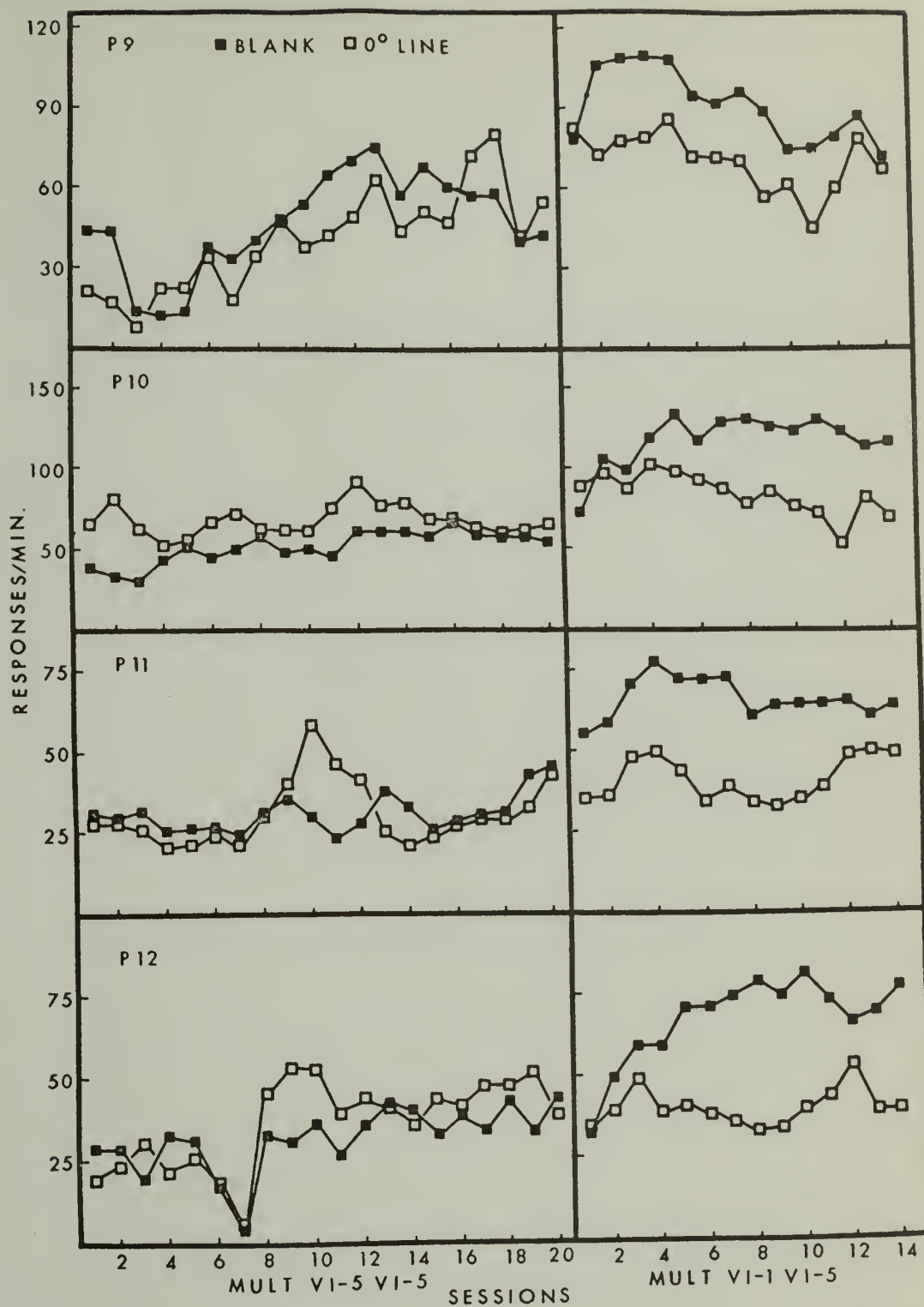


Fig. 3. Mean Rate of Responding Per Subject for the S1 and S2 Stimuli on Each Session of MULT VI-5 VI-5 Baseline Training and Each Session of MULT VI-1 VI-5 Discrimination Training.

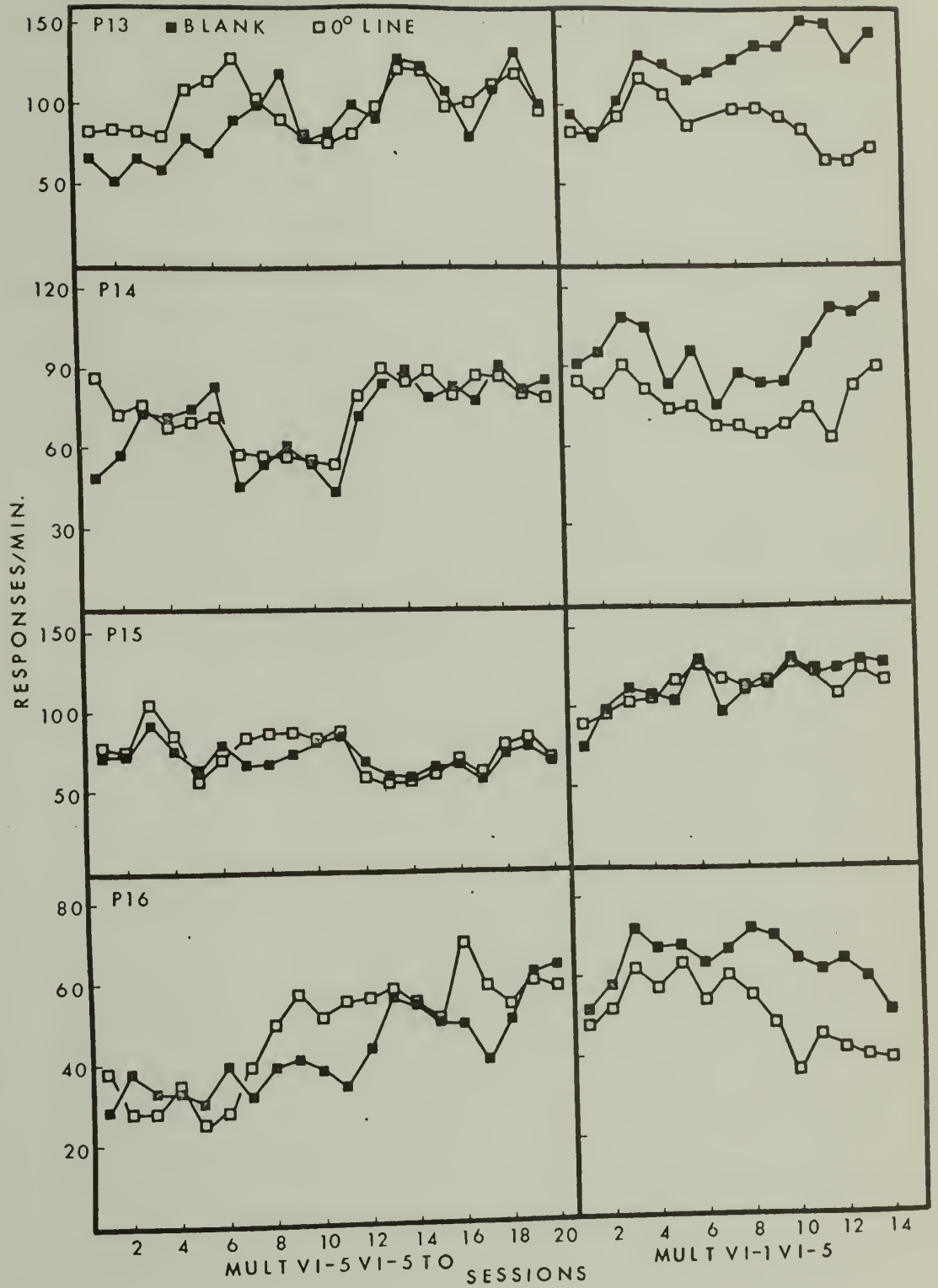


Fig. 4. Mean Rate of Responding Per Subject for the S1 and S2 Stimuli on Each Session of MULT VI-5 VI-5 TO Baseline Training and on Each Session of MULT VI-1 VI-5 Discrimination Training.

(VI-5 schedule) for each subject in each group during each discrimination training session.

Behavioral contrast: VI-1 conditions. Considering first the subjects comprising the MULT VI-1 VI-1 baseline training condition, it is clear that the response rate in the presence of the S1 stimulus increased, in varying degrees, for all subjects during discrimination training. As an index of the response rate increase, the mean rate over the last three baseline days was subtracted from the mean rate from the last three discrimination training sessions. This response rate comparison indicated that the four MULT VI-1 VI-1 → MULT VI-1 VI-5 subjects increased their response rate 19.00, 18.33, 5.00, and 1.33 responses per minute during the stimulus (S1) which was correlated with the VI-1 reinforcement schedule. A similar index for the response rate changes during the stimulus associated with the VI-5 schedule (S2 stimulus) indicated a decrease of 22.66, 5.33, 26.67, and 14.66 responses per minute for each subject respectively of the MULT VI-1 VI-1 baseline condition.

Since the response rate for each subject of the MULT VI-1 VI-1 baseline condition both increased during the S1 stimulus and decreased during presentations of the S2 stimulus over the course of discrimination training, Reynolds (1961) definition of behavioral contrast is satisfied.

When the baseline and discrimination training response rates during the S1 stimulus for the MULT VI-1 VI-1 TO con-

dition were compared (see Figure 2), it was found that Birds 5 and 7 increased their response rates 46.00 and 17.67 responses per minute respectively while Birds 6 and 8 decreased their S1 rates of responding 4.01 and 23.33 responses per minute. Considering the S2 response rates, all four subjects showed a decline in response rate, the decline, for each subject, being 14.67, 16.66, 23.34, and 11.67 responses per minute respectively. It should also be noted that the decrease in rate during the S2 stimulus which was associated with the VI-5 reinforcement schedule is comparable in the two VI-1 baseline conditions. That is, the mean response rate decrease for the MULT VI-1 VI-1 groups was 17.31 responses per minute while the mean decrease for the MULT VI-1 VI-1 TO conditions was 16.58 responses per minute.

VI-5 baseline conditions. With a five-fold increase in the reinforcement density occurring during presentations of the S1 stimulus, the rate of responding increased initially for all eight subjects. The rate remained elevated for all subjects in the MULT VI-5 VI-5 pretrained condition and for three of the four subjects comprising the MULT VI-5 VI-5 TO baseline group. The response rate for the remaining subject (Bird 16) of the later group declined and was slightly below the terminal baseline training level by the end of discrimination training.

Considering the S2 response rates during discrimination training, an increase (10.33, 8.67, and 14.67 responses per

minute) relative to baseline training, was found for three of the four subjects (Birds 9, 10, and 11) who had previously been given MULT VI-5 VI-5 baseline training. For these three subjects, the concurrent increase in response rate during the S1 and S2 stimuli is a result characteristic of positive induction as reported by Reynolds (1963). The S2 rate of responding for the remaining bird (Bird 12) decreased only slightly with the introduction of discrimination training. In contrast, one subject (Bird 13) from the MULT VI-5 VI-5 TO condition showed a decreased S2 response rate (decrease of 39.67 responses per minute) while concurrently increasing the S1 rate, e.g. exhibited behavioral contrast. The S2 response rate for Bird 14 of this condition remained unchanged from baseline training while the rate during the S2 stimulus for Bird 15 increased 39.67 responses per minute and the rate for Bird 16 decreased 17.66 responses per minute.

In summary then, behavioral contrast was evident for all subjects given MULT VI-1 VI-1 baseline training while only two of the MULT VI-1 VI-1 TO trained subjects exhibited contrast during the course of discrimination training. Likewise, one of the MULT VI-5 VI-5 TO subjects (Bird 13) exhibited behavioral contrast with the remaining birds (Birds 15 and 16) either increasing their S1 and S2 rates of responding or increasing the rate during one stimulus while the rate during the other stimulus remained relatively unchanged (Bird 14). For the MULT VI-5 VI-5 pretrained condition, all of the animals

increased their response rate during S1 presentations with three of the four animals also increasing their S2 response rates (positive induction). The S2 rate for the fourth subject (Bird 12) of the MULT VI-5 VI-5 \longrightarrow MULT VI-1 VI-5 condition decreased slightly in reference to the terminal baseline level.

Discrimination performance. Reference to Figure 1 will indicate that all subjects who were given MULT VI-1 VI-1 baseline training preceding the MULT VI-1 VI-5 discrimination showed reliable differences between the response rate in the presence of the S1 component and the response rate during presentations of the S2 stimulus. In contrast, only two subjects (Birds 5 and 7) of the MULT VI-1 VI-1 TO condition (see Figure 2) indicated reasonable separation of the response rates. These two birds it will be remembered are the subjects of this condition from which behavioral contrast was obtained. Bird 6 of the MULT VI-1 VI-1 TO condition indicated a reduced degree of discrimination while Bird 8 responded at nearly the same rate in the presence of the two discriminative stimuli.

Considering the MULT VI-5 VI-5 condition, it is apparent from Figure 3 that all subjects, with the possible exception of Bird 9, discriminated between the S1 and S2 stimuli. In the case of Bird 9, the S2 rate increased during the final discrimination sessions for unknown reasons thereby reducing the rate separation. For the MULT VI-5 VI-5 TO groups (Figure 4), Bird 13 showed excellent rate separation

while the remaining subjects showed only a moderate degree of discrimination between the stimuli.

In summary, the discrimination performance was retarded for most of the subjects who had received either a TO or the MULT VI-5 VI-5 schedule during baseline sessions. However, the majority of the MULT VI-1 VI-1 subjects learned the discrimination problem. In fact, the discrimination results obtained from the MULT VI-1 VI-1 \longrightarrow MULT VI-1 VI-5 condition are in exact accord with the results reported by Weisman (1969).

An analysis of variance using S1 percentage scores $[S1 \text{ responses}/(S1 + S2 \text{ responses})]$ over the last three discrimination days as data indicated a reliable Groups effect, $F(3,12) = 4.95$, $p < .025$. When the Groups effect was partitioned, it was found that subjects receiving MULT VI-1 VI-1 baseline training differed significantly from subjects receiving MULT VI-5 VI-5 training, $F(1,12) = 5.06$, $p < .05$, and that the reinforcement schedule during baseline interacted with the effect of whether or not the subjects experienced a TO, $F(1,12) = 5.42$, $p < .05$. Considering the group means, 73% of the total responses for the MULT VI-1 VI-1 condition were emitted during S1 presentations while only 59%, 59%, and 58% of the responses were during S1 periods for the MULT VI-1 VI-1 TO, MULT VI-5 VI-5 TO, and MULT VI-5 VI-5 conditions, respectively.

Generalization Test

Since the present procedures for the MULT VI-1 VI-1 and for the MULT VI-5 VI-5 experimental conditions were a

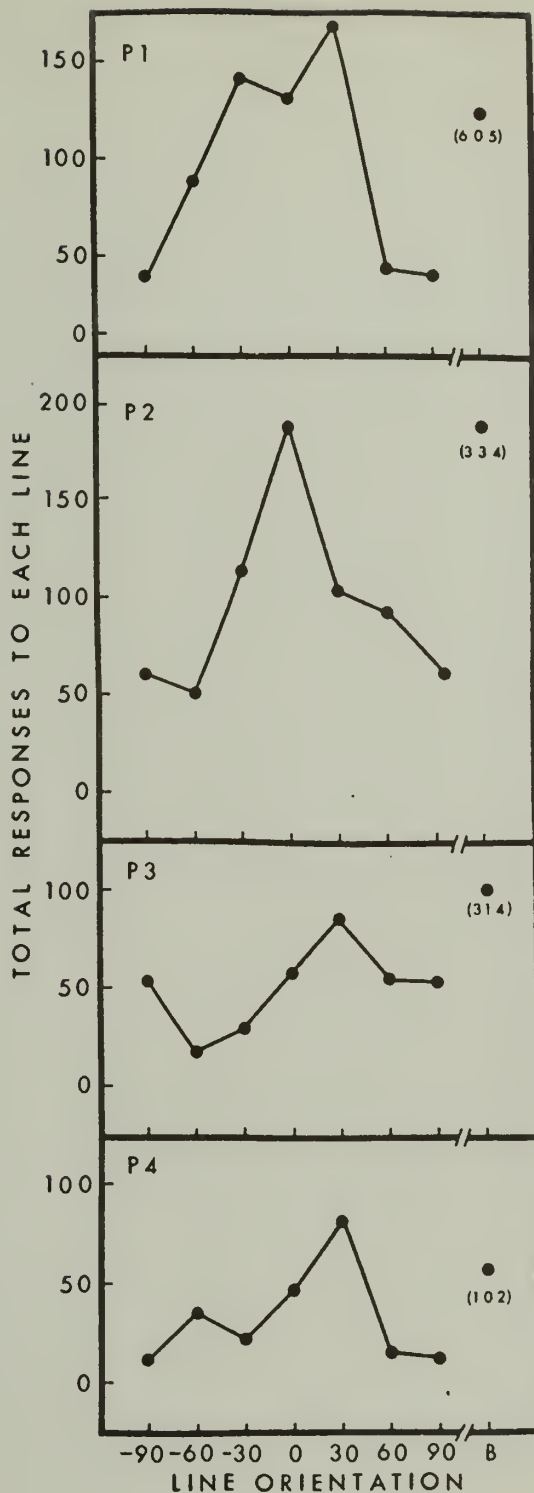


Fig. 5. Postdiscrimination Line Orientation Gradients for Each Subject of the MULT VI-1 VI-1 \rightarrow MULT VI-1 VI-5 Condition. The Total Number of Responses to the Blank Green Stimulus is Indicated by the Number in Parenthesis.

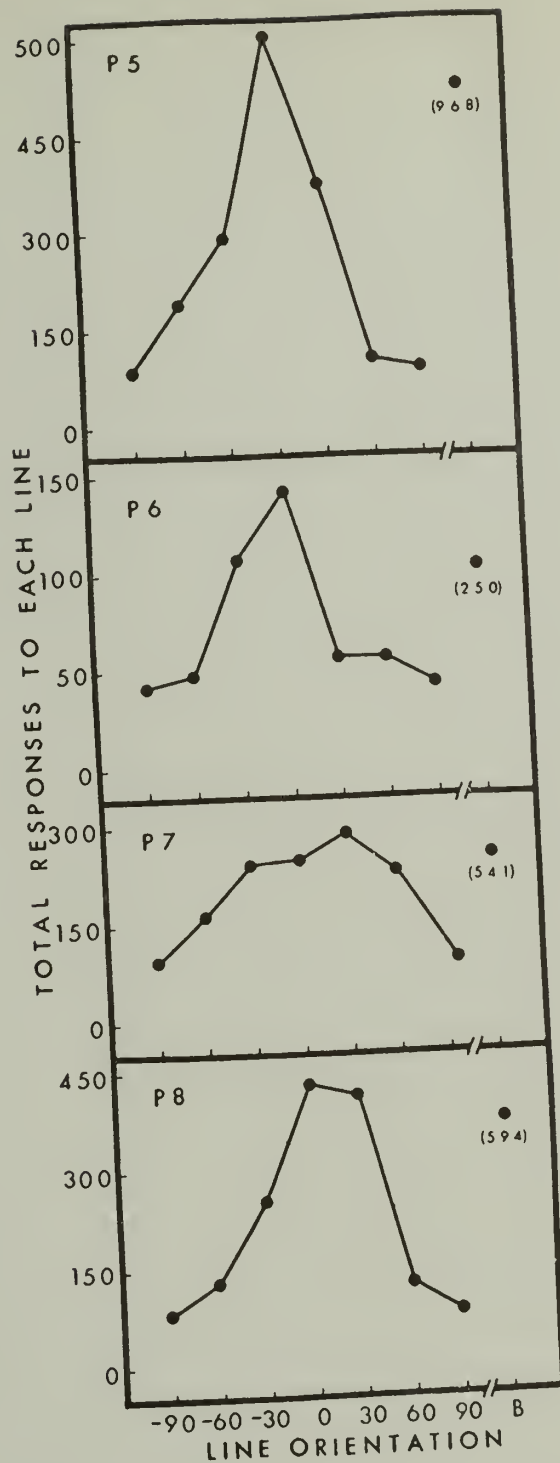


Fig. 6. Postdiscrimination Line Orientation Gradients For Each Subject of the MULT VI-1 VI-1 TO → MULT VI-1 VI-5 Condition. The Total Number of Responses to the Blank Green Stimulus is Indicated by the Number in Parenthesis.

direct replication of the procedures reported by Weisman (1969) it was expected that the MULT VI-1 VI-1 \longrightarrow MULT VI-1 VI-5 condition would yield U-shaped generalization gradients (inhibitory stimulus control) while the MULT VI-5 VI-5 \longrightarrow MULT VI-1 VI-5 condition would yield flat generalization gradients. However, as Figure 5 (MULT VI-1 VI-1 condition) and 7 (MULT VI-5 VI-5 condition) indicate, the post-discrimination generalization gradients from the present experiment were not U-shaped but were of an excitatory nature. That is, instead of the 0° line orientation controlling the lowest response rate, as in Weisman's study, the present experiment indicates that the S2 stimulus (0° line) controlled either the highest or second highest rate of response in all subjects. Even though the MULT VI-1 VI-1 gradients were flatter than the MULT VI-5 VI-5 gradients, both sets of gradients are clearly excitatory.

Considering those subjects who encountered a TO during baseline training, the same conclusions as above may be applied. That is, as shown in Figures 6 (MULT VI-1 VI-1 TO condition) and 8 (MULT VI-5 VI-5 TO condition), the generalization gradients along the line tilt dimension clearly have peaks at or near the S2 stimulus.

The generalization gradients presented in Figures 5, 6, 7, and 8 are plotted in terms of total number of responses emitted in the presence of each generalization test stimulus. This response measure was chosen so that direct comparisons

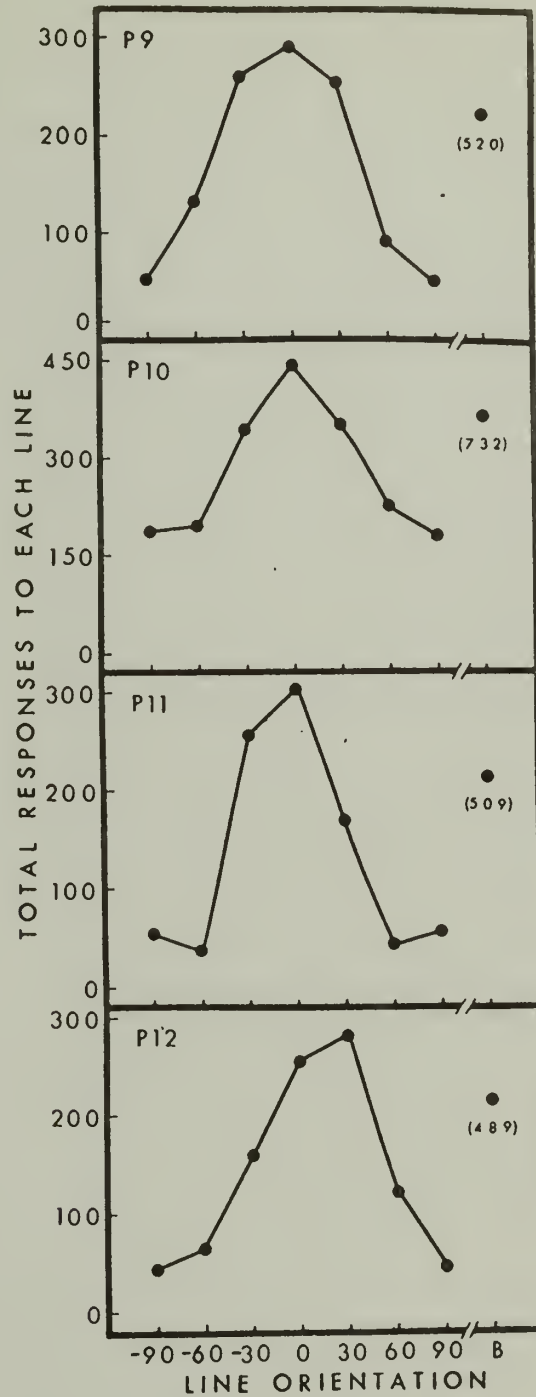


Fig. 7. Postdiscrimination Line Orientation Gradients for Each Subject of the MULT VI-5 VI-5 → MULT VI-1 VI-5 Condition. The Total Number of Responses to the Blank Green Stimulus is Indicated by the Number in Parenthesis.

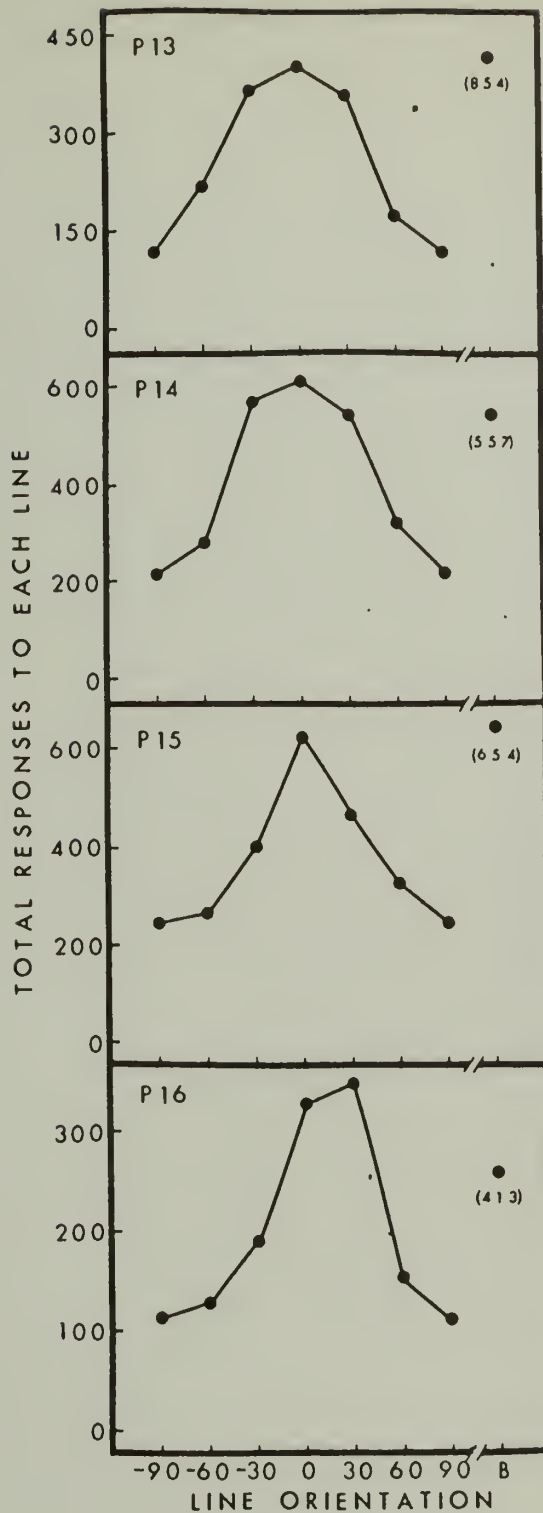


Fig. 8. Postdiscrimination Line Orientation Gradients for Each Subject of the MULT VI-5 VI-5 TO \rightarrow MULT VI-1 VI Condition. The Total Number of Responses to the Blank Green Stimulus is Indicated by the Number in Parenthesis.

of the generalization gradients could be made between the present investigation and the Weisman (1969) study. Since each stimulus was presented for a total of four minutes (four one minute stimulus presentations), response totals presented in Figures 5, 6, 7, and 8 may be transformed to response rate (responses per minute) by dividing each total by four.

Summary of Results

The results indicate that during the baseline phase of the present experiment, the response rate for those subjects who received a TO stimulus in addition to the S1 and S2 stimuli was elevated relative to the response rate of subjects who received just the S1 and S2 stimuli. When all of the subjects were then given discrimination training according to a MULT VI-1 VI-5 reinforcement schedule, the degree of behavioral contrast and the degree of response rate separation was attenuated for the subjects having previously received the TO or MULT VI-5 VI-5 schedule. Moreover, the results of the MULT VI-1 VI-1 \longrightarrow MULT VI-1 VI-5 condition agree perfectly with previously reported findings (Weisman, 1969).

Surprisingly, however, when a generalization test along the line orientation dimension was given, all of the resulting generalization gradients were peaked at or near the S2 stimulus.

Discussion

From the generalization gradients obtained from Experiment I, it is clear that none of the sequence conditions generated gradients that would be taken as indicative of inhibitory stimulus control. Rather, all of the gradients obtained were decremental with the gradient peak at or near the S2 stimulus. It is similarly clear that the gradients reported by Weisman (1969) obtained after MULT VI-1 VI-1 → MULT VI-1 VI-5 training were U-shaped, indicating inhibitory stimulus control. Since the MULT VI-1 VI-1 condition of Experiment I was replicated from Weisman's investigation and since the baseline and discrimination performance from Experiment I closely approximate comparable data from the Weisman investigation, the reason for the absence of U-shaped gradients in the present experiment is unclear.

Two possible explanations for the different results will be considered. In the first instance, it could be argued that if the inter-reinforcement intervals of the VI-5 schedule differed between the two experiments, this difference might partially account for the divergent results. That is, in the present experiment the VI-5 reinforcement schedule was composed of three random orders of four inter-reinforcement intervals (43, 150, 314, and 751 seconds). Even though the mean inter-reinforcement interval is five minutes, intervals similar to those of the VI-1 schedule were present. The inter-reinforcement intervals characteristic of the VI-1

schedule were 4, 12, 23, 35, 49, 70, 102, and 185 seconds. If the response rate was controlled by the inter-reinforcement intervals rather than by the absolute density of reinforcement, then the present VI-1 and VI-5 schedules could be considered to be highly similar. Also if the VI-5 schedule employed by Weisman contained only long intervals relative to the VI-1 schedule, that VI-5 schedule would allow for more non-reinforced responding (extinction) than a schedule which contained some relatively short inter-reinforcement intervals. The behavioral effect of adding short inter-reinforcement intervals into the VI-5 schedule would be an increase in the rate of responding (Catania and Reynolds, 1968) which would reduce the rate separation between the VI-1 and VI-5 stimulus components. With the rate separation reduced, the probability of observing a U-shaped generalization gradient around the S2 stimulus would be greatly decreased. While the above argument is plausible and worthy of further investigation, Weisman (personal communication) indicated that the VI-5 schedule employed in his investigation did contain some short inter-reinforcement intervals. While the Weisman schedule (Segal, 1964) was not derived from the Fleshler and Hoffman (1962) series as were the VI-1 and VI-5 schedules employed in Experiment I, the Weisman schedule and the present schedule are comparable. In fact, the differences between the two schedules may not be great enough to account for the differences observed between the results of the two investigations.

The other possible explanation for the present results concerns the lack of generalized response tendency to those stimuli most removed from the S2 stimulus ($\pm 60^\circ$ and $\pm 90^\circ$ line orientations). As can be seen from examination of the generalization gradients, the response output to the $\pm 90^\circ$ and, to a lesser extent, the $\pm 60^\circ$ line orientations is quite low. When the rate of responding is so low on the end points of the gradient the probability of observing further decreases in the presence of stimuli more similar to the S2 stimulus is drastically reduced.

The explanation for the reduced response strength along the S2 dimension is unclear. The answer may lie in some inherent flaw in either the orthogonal training procedure or in the stimuli that were employed in the present experiment. The latter explanation is countered, however, by the observation that the response rate did vary with presentations of different line orientations; a result indicating stimulus control by line orientation or some aspect correlated with line orientation. Whatever the explanation, the fact remains that in order to observe reliable U-shaped generalization gradients, the response strength must be elevated across the entire line tilt dimension. A procedure to increase the response tendency is available and was employed in Experiment II.

One conclusion, however, is derivable from Experiment I: The conclusion being that since behavioral contrast was observed in all of the MULT VI-1 VI-1 subjects and for other

individual subjects in the remaining conditions and since inhibitory gradients were not obtained for any of these subjects, the presence of behavioral contrast as a sufficient condition for inhibitory stimulus control must be denied. Even though a covariation between the degree of inhibitory control and the degree of behavioral contrast was not obtained, the fact remains, that in the present situation the occurrence of behavioral contrast and the development of inhibitory stimulus control were not related.

CHAPTER III

Experiment II

As was indicated in the preceding discussion, one possible explanation for the absence of U-shaped generalization gradients in Experiment I was the low degree of generalized response tendency from the green stimulus to the points on the line tilt dimension. By inference from the obtained generalization gradients, it would appear that the conditioned response tendency occasioned by the VI-5 reinforcement schedule in effect during presentations of the 0° line tilt stimulus was greater than the generalized response tendency, derived from the orthogonal green stimulus, at all of the line tilt values. Since the response tendency for the 0° line would therefore be greater than the response tendency for any other line orientation, it would be predicted that during generalization testing, a decremental gradient, peaked at the 0° line stimulus, would be observed. The results of Experiment I are consistent with the foregoing analysis.

This explanation suggests at least one possible procedure which could be employed to increase the probability of observing U-shaped generalization gradients. That is, if the response rate for each line tilt stimulus is elevated above the baseline level through the use of contingent reinforcement instead of through the weaker process of generalization from the orthogonal dimension, then the

occurrence of a decrease in the response strength for the S2 stimulus might more easily be examined.

Specifically, by administering reinforcement according to a VI-1 schedule during presentations of all line tilt stimuli together with presentations of the blank green stimulus during baseline training, the response tendency to all points of the line orientation dimension should be greater than when only the 0° line tilt and the green stimulus are presented as in Experiment I. When discrimination training is then instituted, any decrease occasioned by the reinforcement schedule associated with the S2 stimulus should be easily observed when a post-discrimination generalization test is administered.

The above technique has been used by both Honig (1961) and later by Weisman and Palmer (1968). In the latter investigation extremely steep U-shaped generalization gradients were obtained following MULT VI-1 EXT discrimination training which was preceded by non-differential VI-1 training during which all of the generalization stimuli (line tilts) were presented daily.

It was therefore the purpose of Experiment II to further examine the relationship between the occurrence of behavioral contrast and the development of inhibitory stimulus control. As in Experiment I, the T0 stimulus was employed in baseline training so as to reduce the degree of behavioral contrast during discrimination training.

Method

Subjects. Twenty White Carneaux pigeons, at least six months old, were used as subjects. The mean ad libitum weight for all subjects was 544 grams. The subjects were housed individually and were placed on a maintenance schedule (75% of ad libitum weight) that was identical to the maintenance schedule for subjects of Experiment I.

Apparatus. The programming and stimulus projection units were identical to that employed in Experiment I.

Preliminary training. As in Experiment I, the subjects were habituated to the operant chamber, feeder trained, shaped to peck the response key which was illuminated with the green stimulus, and finally given experience with a fixed ratio schedule of reinforcement. All procedural details are common with those of Experiment I.

Baseline training. Following two VI-30 sec sessions, all subjects were given twenty daily VI-1 baseline sessions during which four presentations of each of the seven stimulus were scheduled. During VI-1 baseline training, a VI-1 reinforcement schedule, identical to the VI-1 schedule of Experiment I, was employed for all subjects. Similarly, all subjects were exposed to a random order of the seven generalization test stimuli (six line tilts on a green background plus the green background) each day. Two random orders of stimuli presentations were used. The first stimuli was identical to the initial twenty-eight stimuli presentations

of the generalization test while the second stimulus order was identical to the next twenty-eight stimuli presentations of the generalization test. In addition, eight subjects (TO trained subjects) also received fourteen TO stimuli which were inserted in the same ordinal position of the daily sessions as in Experiment I.

Discrimination training. Following baseline training, four subjects which had experienced the VI-1 baseline training were given fourteen sessions of single stimulus training in the presence of the 0° line imposed on the green background. Each daily session consisted of 14 one minute stimulus presentations during which the VI-5 reinforcement schedule was operative.

The remaining sixteen subjects were given discrimination training with either a MULT VI-1 EXT or a MULT VI-1 VI-5 schedule. Of the eight subjects who received VI-1 baseline training, four subjects were assigned to the MULT VI-1 EXT discrimination condition while four subjects were assigned to the MULT VI-1 VI-5 condition. Similarly, four of the previously trained VI-1 TO subjects experienced the MULT VI-1 EXT discrimination while the remaining four subjects from the VI-1 TO baseline condition received the MULT VI-1 VI-5 discrimination. Discrimination training was conducted for fourteen sessions with the same daily stimulus order as employed in Experiment I.

Following discrimination training, all subjects received a generalization test which was in all ways identical to the generalization test administered at the termination of Experiment I. That is, each of the six line orientations plus the green background were presented 10 times each in randomized blocks of seven, 30 sec stimulus periods. A 5 sec TO separated each stimulus-on period. Four reinforced (VI-1) presentations of the green stimulus preceded the generalization test.

Results

To test for similarity among the five conditions prior to the introduction of the baseline conditions, the response rates in the presence of the seven stimuli from the two VI-30 sessions were submitted to an analysis of variance. The variance analysis indicated that the five groups did not differ ($F < 1$).

Baseline Training

The mean daily response rate in the presence of the blank green stimulus (S1) and the 0° line on the green surround (S2) for each subject of the five conditions is shown to the left of the vertical line in Figures 9, 10, 11, 12, and 13.

An analysis of variance of the mean response rate during each of the seven stimuli across the final two VI-1 baseline sessions indicated that the response rate had stabilized, i.e., Days effect ($F < 1$).

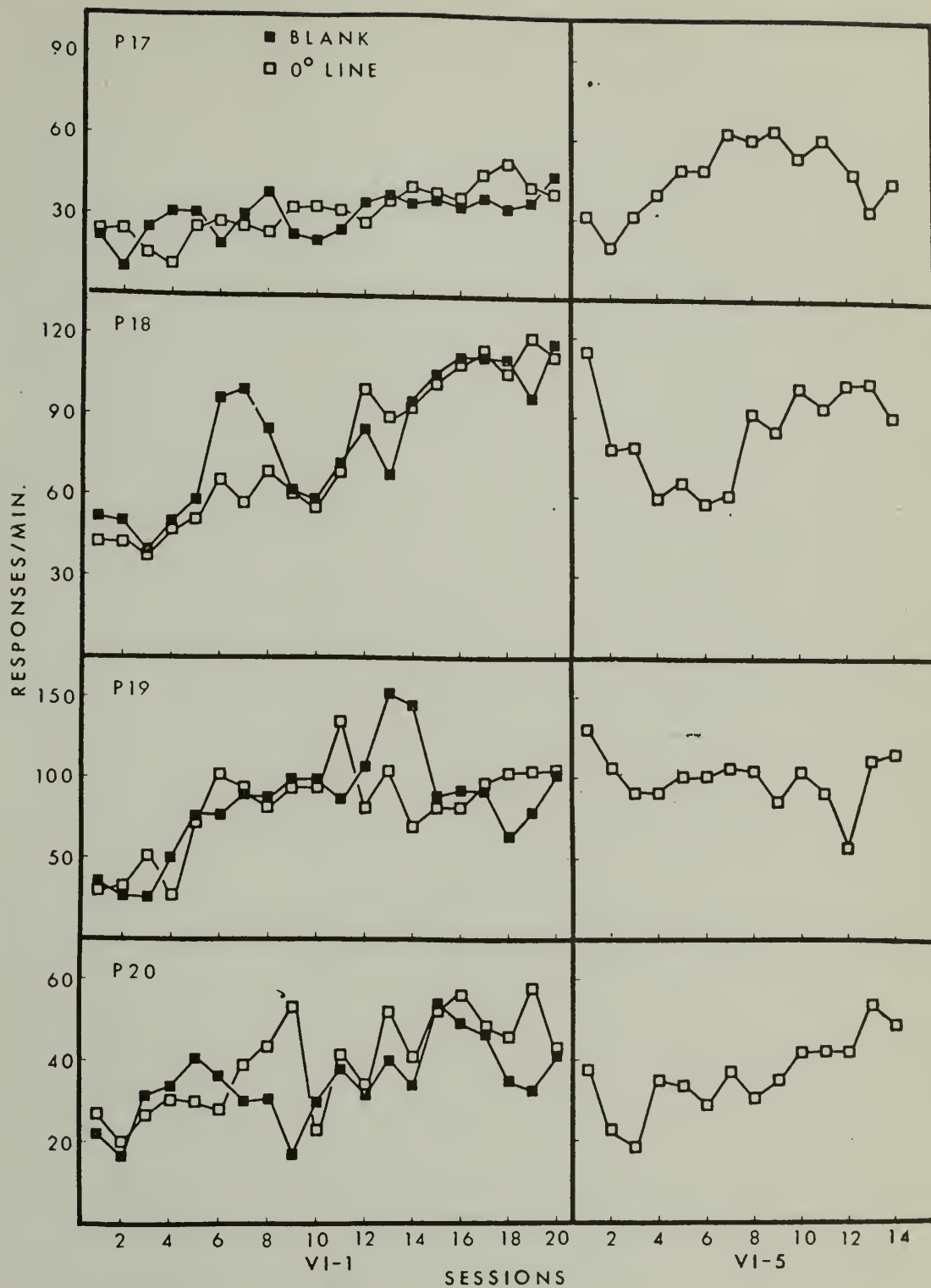


Fig. 9. Mean Rate of Responding Per Subject for the S1 and S2 Stimuli on Each Session of VI-1 Baseline Training and for the S2 on Each Session of VI-5 Single Stimulus Training.

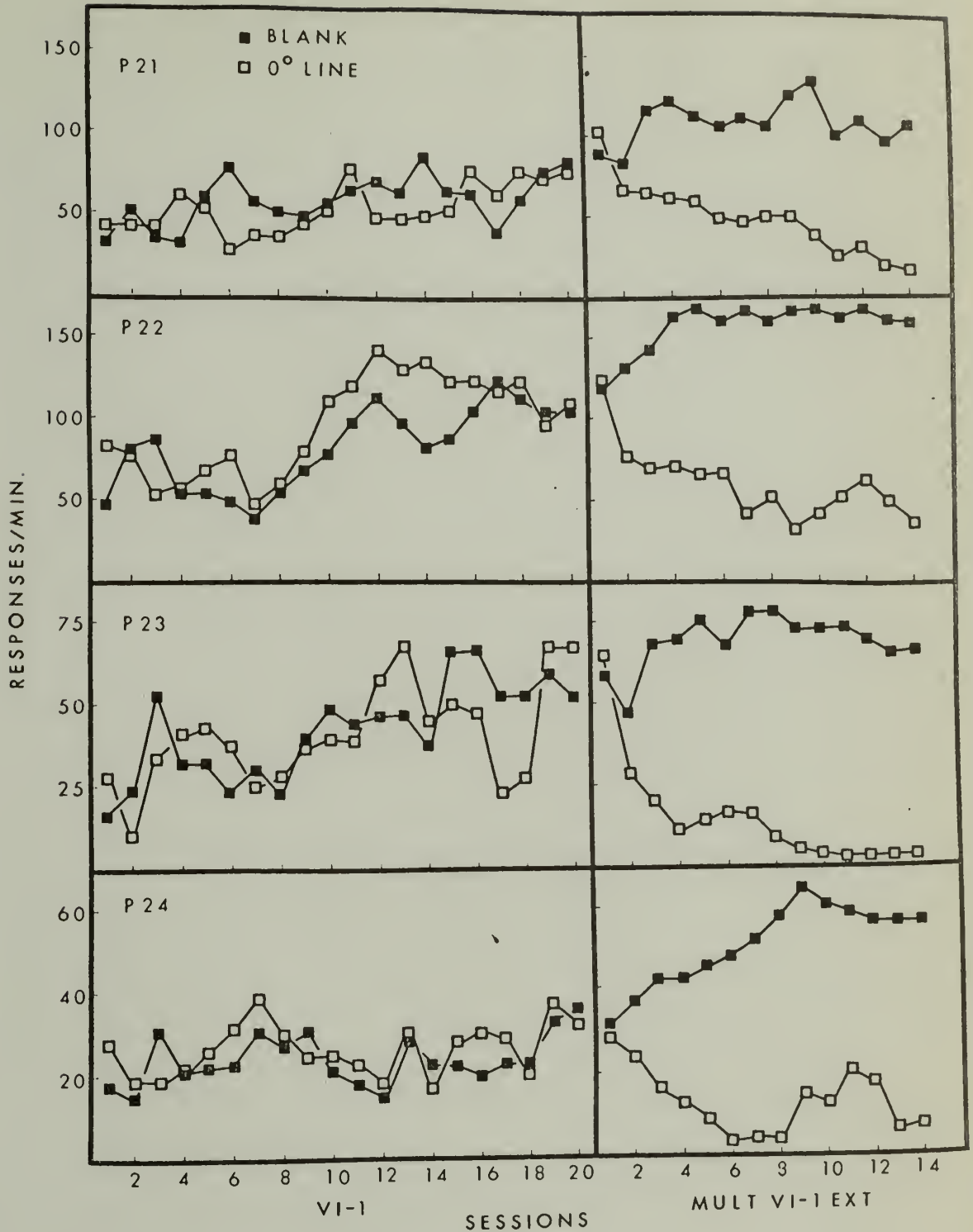


Fig. 10. Mean Rate of Responding Per Subject for the S1 and S2 Stimuli on Each Session of VI-1 Baseline Training and on Each Session of MULT VI-1 EXT Discrimination Training.

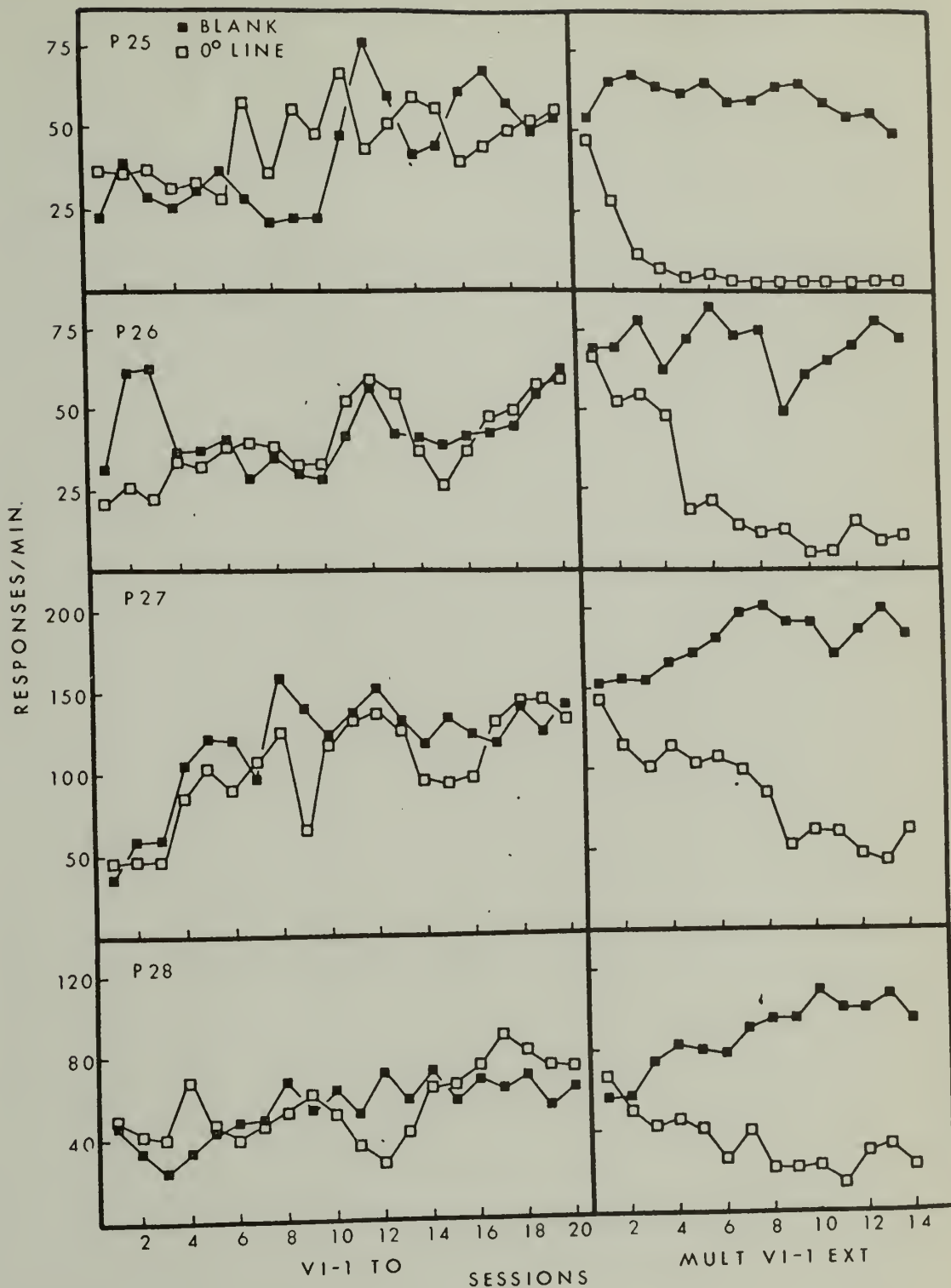


Fig. 11. Mean Rate of Responding Per Subject for the S1 and S2 Stimuli on Each Session of VI-1 TO Baseline Training, and on Each Session of MULT VI-1 EXT Discrimination Training.

In contrast to the finding of Experiment I, however, the terminal response rate for the subjects receiving a TO was not significantly elevated relative to the non-TO trained subjects. The difference between the TO and non-TO conditions did not approach statistical reliability, although the mean response rate for the three conditions without the TO (70.92, 65.21, and 58.55 responses per minute) was lower, in each case, than the mean response rate for the two TO conditions (75.36 and 71.14 responses per minute).

When the mean response rate of the two VI-1 TO conditions from Experiment I was compared with the response rate of the two TO conditions of Experiment II, it was found that the mean rates were comparable, i.e. 71.33 responses per minute (Experiment I) and 73.25 responses per minute (Experiment II). It would seem, therefore, that the effect of the TO stimulus is to increase the response rate emitted to stimuli projected on the response key in both Experiment I and II. When a similar comparison of the mean response rates for the non-TO trained subjects (VI-1 conditions) of the two Experiments was made, it was found that the mean response rate from Experiment I (38.37 responses per minute) was drastically lower than the rate observed in Experiment II (66.87 responses per minute). The conclusion becomes, then, that with the addition of either the TO stimulus or the occurrence of multiple stimuli during baseline training, the response rate is elevated above that level exhibited by subjects in

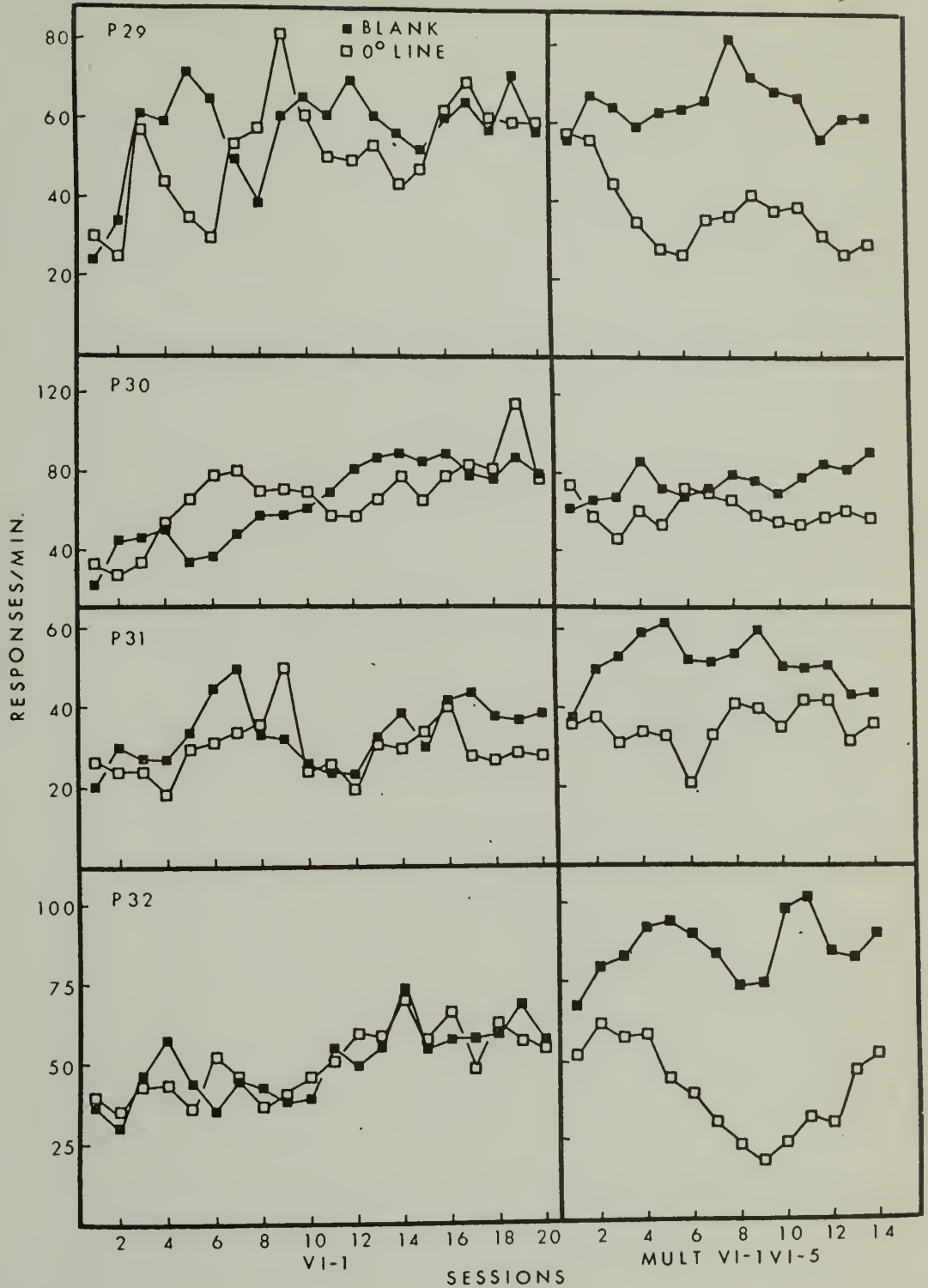


Fig. 12. Mean Rate of Responding Per Subject for the S1 and S2 Stimuli on Each Session of VI-1 Baseline Training and on Each Session of MULT VI-1 VI-5 Discrimination Training.

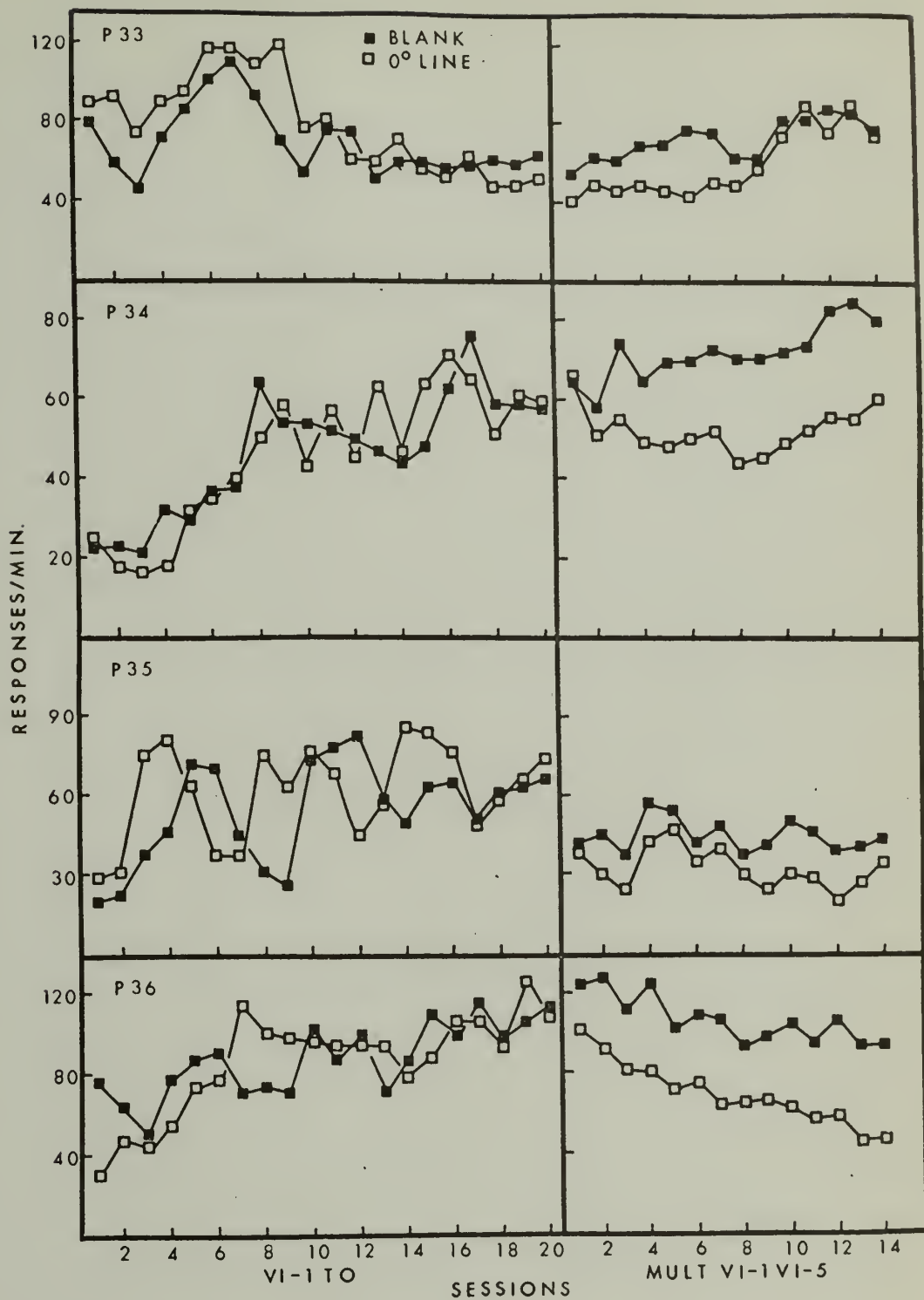


Fig. 13. Mean Rate of Responding Per Subject for the S1 and S2 Stimuli on Each Session of VI-1 TO Baseline Training and on Each Session of MULT VI-1 VI-5 Discrimination Training.

a condition of Experiment I which received only the S1 and S2 stimuli (MULT VI-1 VI-1 or MULT VI-5 VI-5).

Discrimination Training

Single stimulus VI-5 condition. The right hand panel of Figure 9 indicates the daily response rate in the presence of the 0° line tilt following the reduction in reinforcement density from VI-1 to VI-5. By inspection of Figure 9, it is evident that over the first several VI-5 sessions, the effect of the reinforcement reduction was a lowering of the response rate. However, by the end of the fourteen daily sessions, the response rate for each subject had increased to a level similar to that displayed during the VI-1 baseline condition. Specifically, the mean response rate over the last three VI-5 sessions had increased 2.00 responses per minute for Bird 17 and decreased 16.00, 13.50, and 2.50 responses per minute for Birds 18, 19, and 20, respectively. The mean response rate decrease for the VI-5 single stimulus condition, then, was 7.50 responses per minute. This decrease relative to the baseline level was not statistically significant, $t(3) = 1.74$.

Effect of extinction during S2 presentations. The mean daily response rates during each discriminative stimulus for the VI-1 \rightarrow MULT VI-1 EXT condition are depicted to the right of the vertical line in Figure 10. From inspection of Figure 10 it can be seen that relative to the VI-1 baseline level, the response rate increased during discrimination

training for all subjects during presentations of the S1 stimulus and decreased during presentations of the S2 stimulus when responses were non-reinforced. The response rate increase for each subject was 28.50, 69.50, 13.50, and 22.50 responses per minute while the response rate decrease was 52.50, 53.00, 67.50, and 24.50 responses per minute, respectively. It is apparent, then, that behavioral contrast was obtained for each subject of the VI-1 \longrightarrow MULT VI-1 EXT condition.

Considering Figure 11 in which the response rates for each subject of the VI-1 TO \longrightarrow MULT VI-1 EXT condition are shown, a similar --- through not identical --- spectrum of results was observed. The response rate during the S2 stimulus decreased for all subjects of this condition (55.99, 46.83, 86.00, and 48.17 responses per minute for the four subjects) while only three of the four subjects (Birds 26, 27, and 28) showed an S1 increase in the response rate (12.83, 58.17, 41.67 responses per minute, respectively). For the remaining subject (Bird 25), the mean S1 rate of responding across the last three discrimination days had decreased 2.67 responses per minute relative to the terminal baseline level. Therefore, for Bird 25, the occurrence of a TO during baseline training abolished the S1 rate increase that was evident during discrimination training for the other three subjects. Similarly, when the mean increase in response rate for the VI-1 TO condition was compared to the increase

in response rate for the non-TO subjects, it was found that the increase in response rate was essentially the same for the non-TO trained subjects (33.25 response per minute) and for the VI-1 TO trained subjects (27.50 responses per minute). Therefore, it may be concluded that the TO during baseline training, unlike Experiment I, had little effect on the degree of behavioral contrast that occurred following the initiation of discrimination training.

Taken together, the subjects receiving the MULT VI-1 Ext discrimination training increased their response rate during S1 presentations significantly above the terminal baseline level, $t(7) = 3.50$, $p < .005$ while concurrently decreasing their response rate during S2 presentations significantly below the terminal baseline level, $t(7) = 8.72$, $p < .001$. The actual response rate increase during S1 presentations was 30.37 responses per minute while the response rate decrease during S2 presentations was 54.18 responses per minute. The concurrent response rate changes indicate that behavioral contrast was evident for a majority of the subjects receiving the MULT VI-1 EXT discrimination schedule.

Effect of VI-5 during S2 presentations. The right hand panel of Figure 12 indicates the mean response rate during MULT VI-1 VI-5 discrimination training for the subjects who had received VI-1 training to all stimuli during baseline training sessions. As an index of behavioral contrast, the

response rate over the last three discrimination sessions for the S1 and S2 stimuli was compared to the response rate emitted during these stimuli at the termination of baseline training. Using Reynold's (1961) definition of behavioral contrast (an increase in the rate of response during S1 accompanied by a decrease during S2), it was found that two of the four subjects of this condition (Birds 30 and 32) showed evidence of behavioral contrast. For Bird 30, the S1 response rate increased, relative to baseline, 3.17 responses per minute along with a concurrent S2 response rate decrease of 40.17 responses per minute while for Bird 31, the response rate increase during S1 presentations was 22.50 responses per minute and the response rate decrease during S2 presentations was 12.17 response per minute. Of the remaining two subjects, Bird 29 showed a decrease in both the S1 and S2 response rate; 5.00 responses per minute decrease for S1 and 30.67 response per minute decrease for S2, while Bird 32 increased both the S1 and S2 response rate; 7.67 responses per minute increase for S1 and 8.17 responses per minute increase for S2. Therefore when these VI-1 baseline trained subjects were subjected to the MULT VI-1 VI-5 discrimination schedule, only two of the four subjects showed behavioral contrast.

In regard to the development of behavioral contrast for the VI-1 TO \rightarrow MULT VI-1 VI-5 subjects (see Figure 13), only one subject (Bird 34) showed behavioral contrast (23.67

responses per minute S1 increase and 2.17 response per minute S2 decrease). Bird 33 increased both the S1 and S2 response rate (increase of 21.50 response per minute for S1 and an increase of 30.67 responses per minute for S2) while Birds 35 and 36 decreased both their S1 and S2 response rate (decrease of 25.17 and 42.50 response per minute for S1 and S2 respectively for Bird 35 and 11.83 and 67.11 response per minute for S1 and S2 respectively for Bird 36).

Therefore, for the MULT VI-1 VI-5 discrimination subjects, two of the non-TO trained subjects and one of the TO trained subjects developed a moderate degree of behavioral contrast while the remaining subjects either increased or decreased their response rate during both the S1 and S2 stimuli.

Due to the degree of between subject variability and the lack of separation in response rate for Bird 33, the results of t-tests performed on the S1 response rate increases and the S2 response rate decreases were not statistically reliable. However, the mean decrease in S2 response rate (19.63 responses per minute) was considerably greater than the mean S2 response rate decrease (7.50 response per minute) observed for the VI-1 \longrightarrow VI-5 condition. When the response rate on S2 trials following S1 stimuli presentations was compared to the S2 response rate on trial following other S2 stimuli presentations, it was found that the S2 response rate was significantly depressed following S1 stimuli pre-

sentations relative to the S2 response rate following other S2 stimuli presentations, $F(1,7) = 9.27$, $p < .025$. That is, the response rate on S2 trials following S1 trials was 37.24 response per minute as compared to 50.38 response per minute for S2 trials following other S2 trials. It would appear, then, that the difference in S2 response rate decrease between the MULT VI-1 VI-5 conditions as compared to the VI-5 single stimulus condition was partially accounted for by a depression in the S2 response rate due to preceding S1 stimuli presentations for the subjects receiving the MULT VI-1 VI-5 discrimination schedule.

By comparing the subjects who received the MULT VI-1 EXT discrimination with the MULT VI-1 VI-5 discrimination subjects it was observed that the MULT VI-1 EXT subjects has a larger S1 - S2 rate separation than was evident for the MULT VI-1 VI-5 subjects. In order to ascertain the magnitude of the difference in S1 - S2 rate separation as a function of the reinforcement schedule operative during S2, an analysis of variance was performed on the mean response rates for the S1 and S2 stimuli in the two discrimination conditions over the last three discrimination sessions. The results of the analysis indicated a Stimuli X S2 Schedule effect which was highly reliable, $F(1,12) = 18.99$, $p < .001$. In order to determine the exact relationship which produced the significant Stimuli X S2 Schedule interaction, the mean response rates comprising this interaction were examined.

This examination of the mean response rates indicated that the MULT VI-1 EXT schedule produced a higher S1 response rate and a lower S2 response rate than did the MULT VI-1 VI-5 discrimination schedule. That is, the S1 response rate for the MULT VI-1 VI-5 condition (73.33 responses per minute) was lower than the S1 response rate obtained from the MULT VI-1 EXT subjects (102.87 responses per minute). Concurrent with this difference, it was found that the S2 response rate for the MULT VI-1 VI-5 condition was higher than the S2 response rate for the MULT VI-1 EXT condition (48.00 vs 22.00 response per minute). Therefore, by employing a MULT VI-1 VI-5 reinforcement schedule during discrimination training, the degree of response rate separation for the two discriminative stimuli was reduced as compared to the results from the MULT VI-1 EXT condition.

When the percentage of total responses emitted during S1 presentations was considered, the above conclusion was further substantiated. That is, the subjects of the MULT VI-1 EXT condition emitted 85.54% of their responses in the presence of the S1 stimulus while the subjects of the MULT VI-1 VI-5 condition emitted only 60.54% of their responses to the S1 stimulus. This difference is highly reliable, $F(1,12) = 37.20$, $p < .001$.

Generalization Test

The generalization gradients for each subject which received single stimulus VI-5 training following VI-1

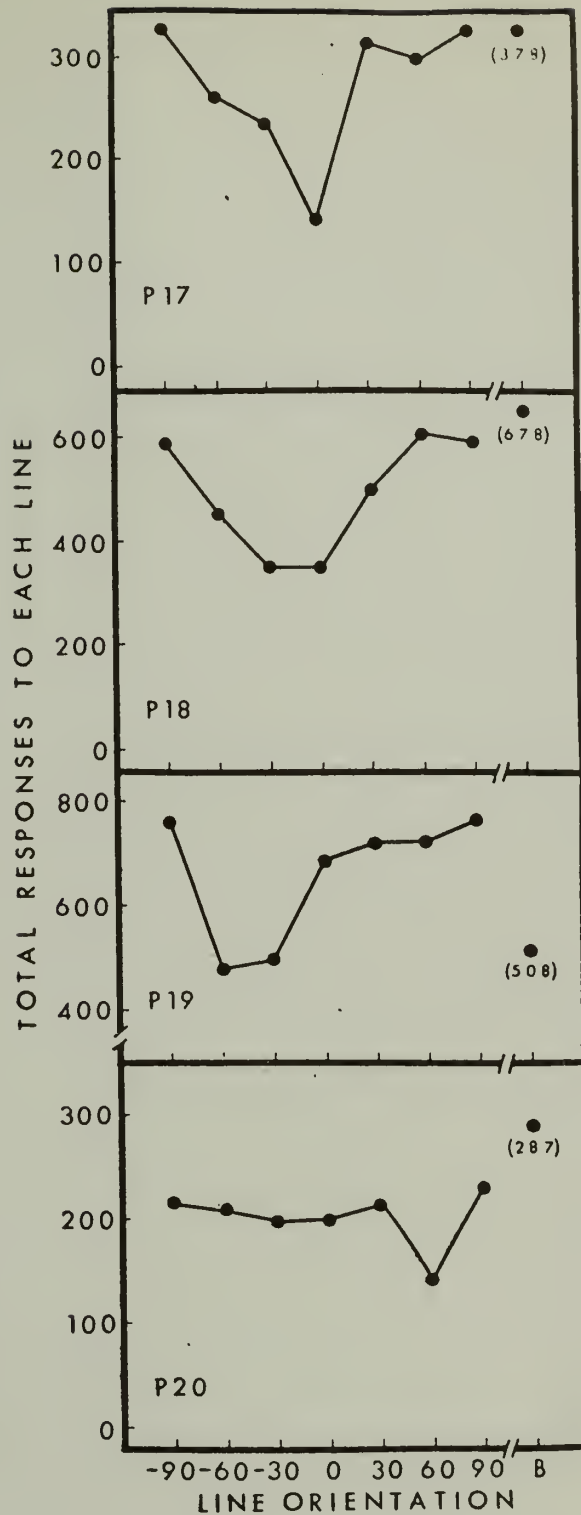


Fig. 14. Postdiscrimination Line Orientation Gradients for Each Subject of the VI-1 \rightarrow VI-5 Condition. The Total Number of Responses to the Blank Green Stimulus is Indicated by the Number in Parenthesis.

baseline experience are presented in Figure 14. The gradients, while presented in terms of the total number of responses emitted during presentations of the generalization test stimuli, may be transformed to rate of responding gradients by the method indicated in Experiment I. It is evident from inspection of Figure 14 that three of the subjects produced U-shaped generalization gradients following single stimulus training. The gradients were centered at the 0° line orientation for two of the subjects (Birds 17 and 18) while for Bird 19 the gradient minimum was at the -60° line value. The fourth subject of this condition (Bird 20) produced a relatively flat generalization gradient possibly indicating a lack of specific line tilt stimulus control.

Considering the subjects who received discrimination training according to the MULT VI-1 EXT schedule, the generalization gradients depicted in Figure 15 (VI-1 baseline subjects) and Figure 16 (VI-1 TO subjects) are clearly U-shaped and could be taken as indicative of inhibitory stimulus control. In all cases the gradients are quite steep and exhibit a minimum at the S2 stimulus value.

In regard to the relationship between behavioral contrast and inhibitory stimulus control, it is of particular interest to note the generalization gradient exhibited by Bird 25. During discrimination training, Bird 25 did not show a response rate increase during presentations of the S1 stimulus but did exhibit a greatly reduced response rate

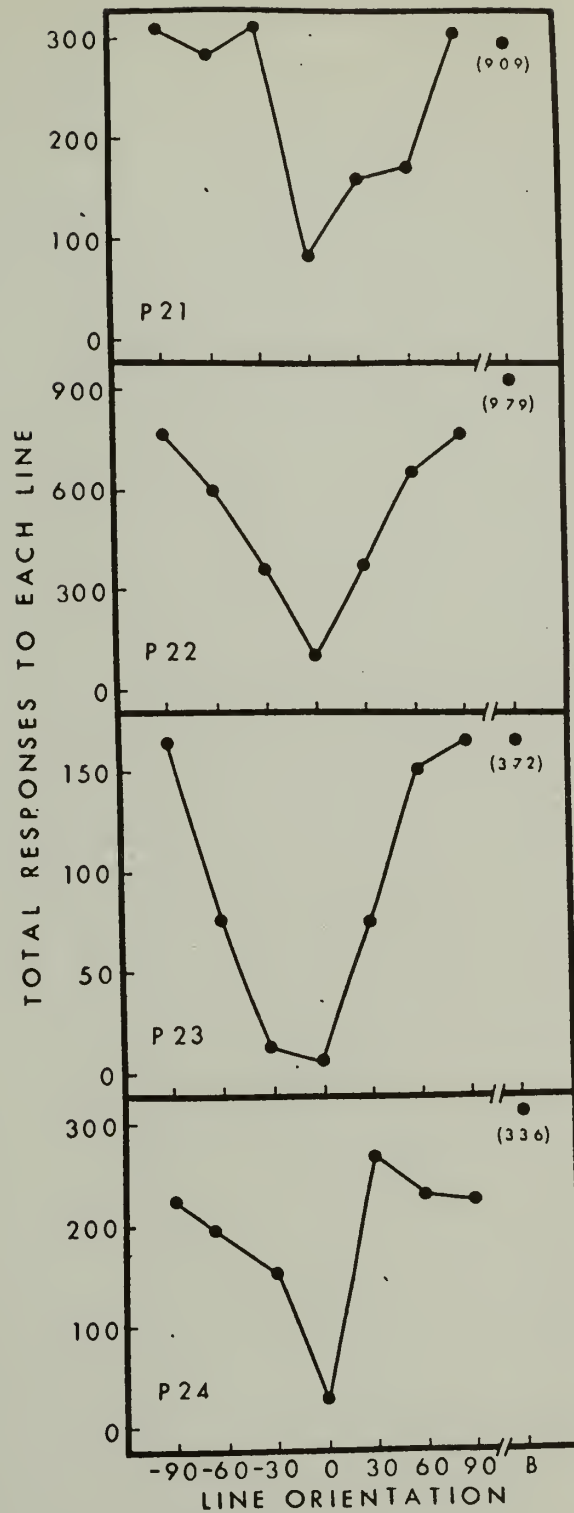


Fig. 15. Postdiscrimination Line Orientation Gradients For Each Subject of the VI-1 → MULT VI-1 EXT Condition. The Total Number of Responses to the Blank Green Stimulus is Indicated by the Number in Parenthesis.

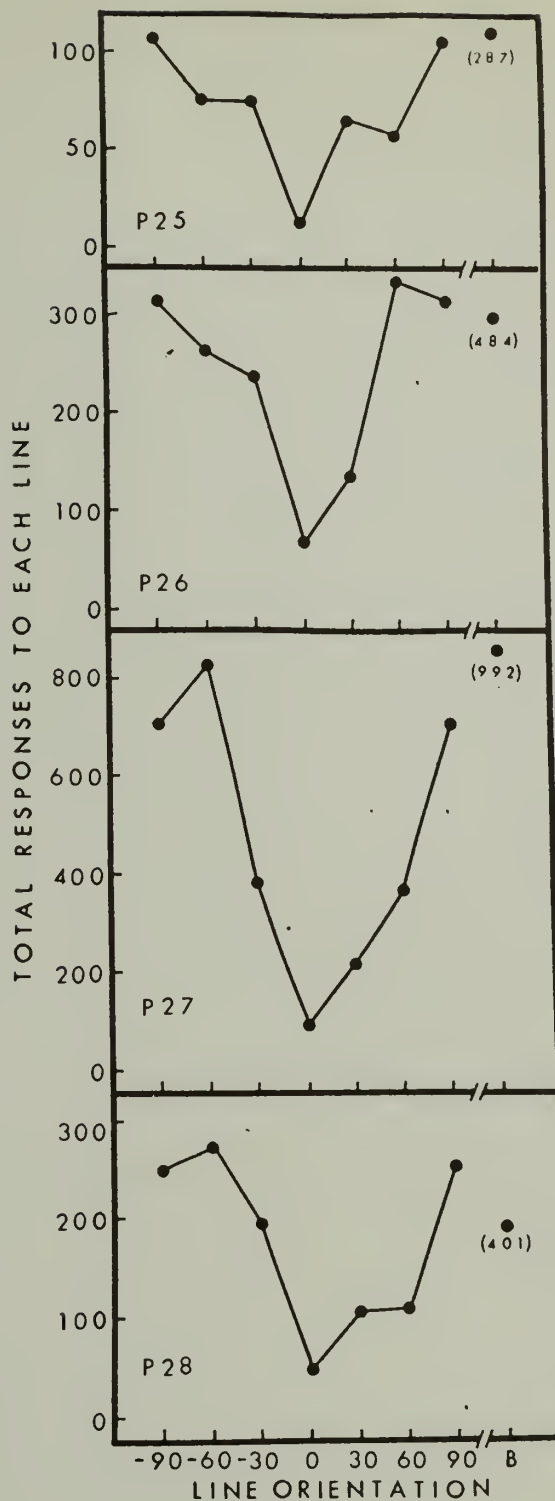


Fig. 16. Postdiscrimination Line Orientation Gradients for Each Subject of the VI-1 TO \rightarrow MULT VI-1 EXT Condition. The Total Number of Responses to the Blank Green Stimulus is Indicated by the Number in Parenthesis.

during presentations of the S2 stimulus. The generalization gradient exhibited by Bird 25 was U-shaped and is in no fundamental way different from the gradients exhibited by subjects who both increased their response rate during the S1 stimulus and decreased their response rate during the S2 stimulus, i.e. exhibited behavioral contrast. Therefore, the conclusion is reached that the occurrence of behavioral contrast is not a necessary antecedent for the development of inhibitory stimulus control as indexed by U-shaped generalization gradients.

In regard to the effect of the TO during baseline training, comparisons of the gradients in Figure 15 (non-TO subjects) and Figure 16 (TO subjects) indicate no qualitative differences. It appears, therefore, that the TO effect is specific to the training phase and does not interact with the test of dimensional control.

Generalization gradients from subjects receiving the MULT VI-1 VI-5 discrimination are depicted in Figure 17 for the non-TO baseline trained subjects and in Figure 18 for the TO trained subjects. It is clear from these two Figures that the gradients obtained for all MULT VI-1 VI-5 subjects, with the exception of Bird 33, were U-shaped. The absence of a U-shaped gradient for Bird 33 was not unexpected since this subject did not respond differentially to the two discriminative stimuli. Therefore, given the baseline training conditions of Experiment II, a difference in response rate during discrimination training is necessary for U-shaped gradient

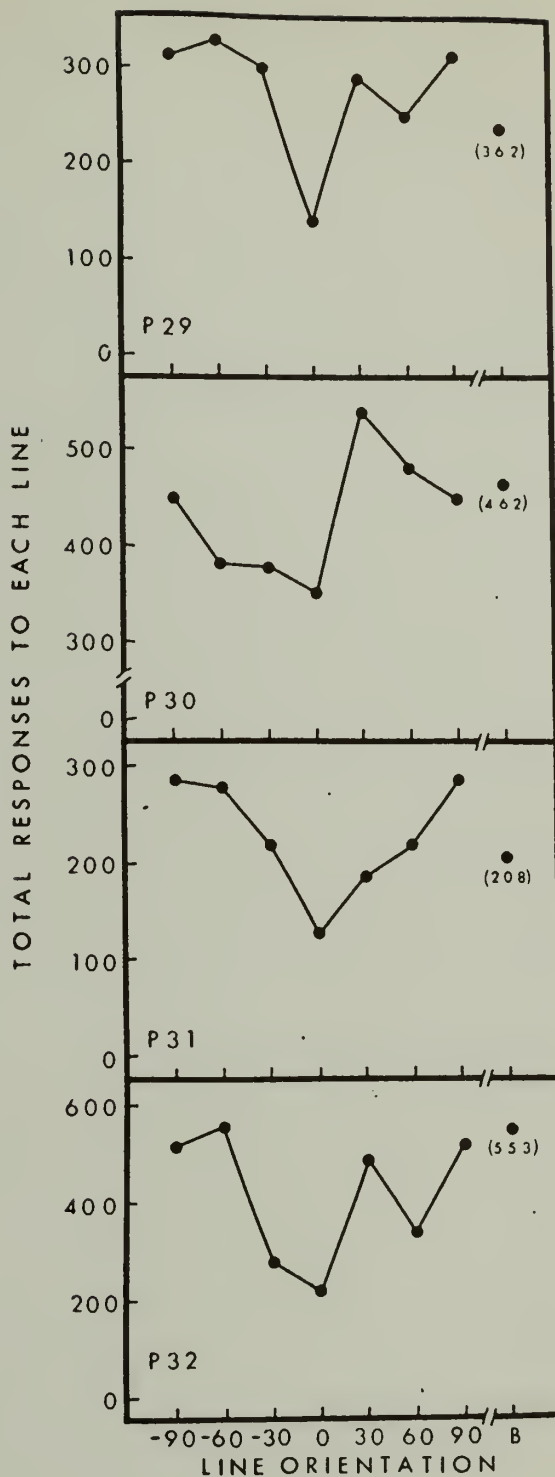


Fig. 17. Postdiscrimination Line Orientation Gradients for Each Subject of the VI-1 \rightarrow MULT VI-1 VI-5 Condition. The Total Number of Responses to the Blank Green Stimulus is Indicated by the Number in Parenthesis.

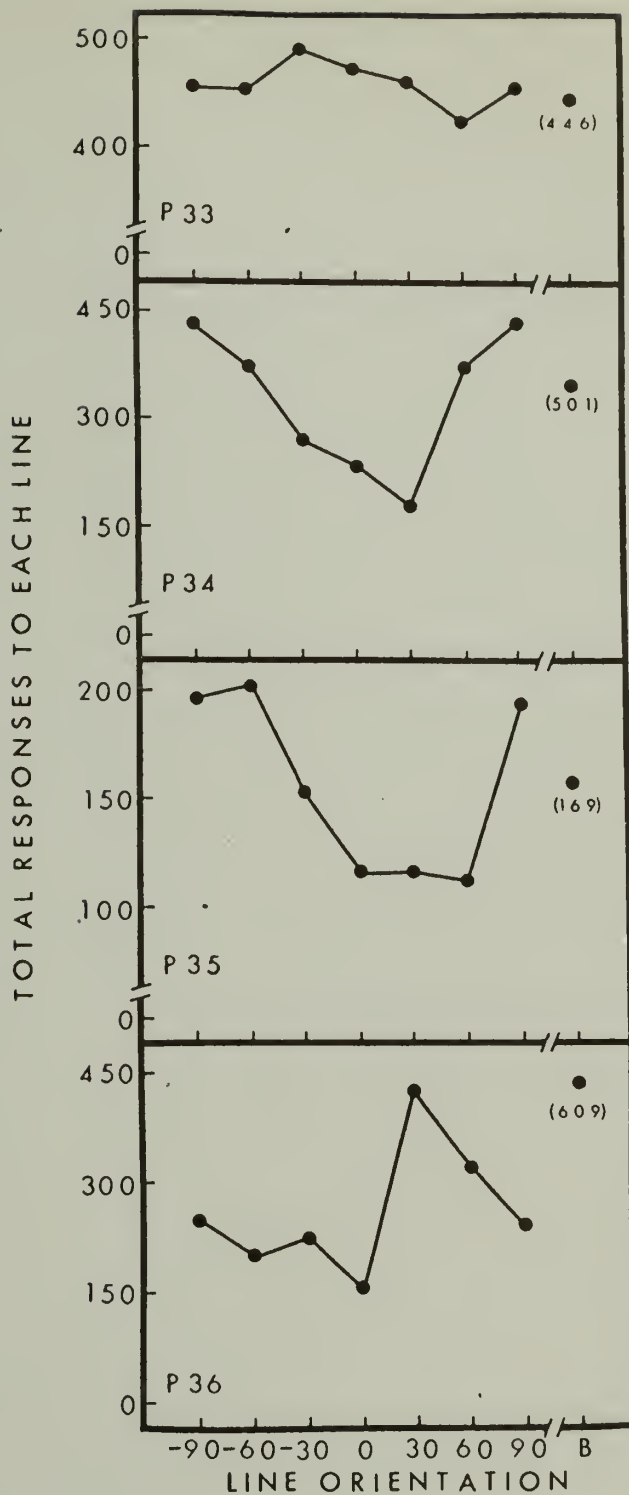


Fig. 18. Postdiscrimination Line Orientation Gradients For Each Subject of the VI-1 TO \rightarrow MULT VI-1 VI-5 Condition. The Total Number of Responses to the Blank Green Stimulus is Indicated by the Number in Parenthesis.

It should be noted that while the gradients from the MULT VI-1 VI-5 subjects are not as steep as the gradients obtained from the MULT VI-1 EXT subjects, the gradients from the former condition are comparable to those presented by Weisman (1969).

As was the case for the MULT VI-1 EXT subjects, the occurrence or non-occurrence of behavioral contrast during the MULT VI-1 VI-5 discrimination phase was not a reliable predictor of U-shaped generalization gradients. That is, while some subjects exhibited a slight degree of behavioral contrast, seven of the eight MULT VI-1 VI-5 subjects exhibited reliable U-shaped gradients. This result is taken as conclusive evidence against the hypothesis relating behavioral contrast and inhibitory stimulus control.

In order to compare the gradients obtained from the last two baseline sessions with the gradients derived from the generalization test, the mean response rates emitted during each line tilt stimulus for each subject was submitted to an analysis of variance. Considering the gradients from the MULT VI-1 EXT and MULT VI-1 VI-5 conditions, the analysis indicated that the gradients obtained during the generalization test differed significantly from the baseline gradients, $F(5,60) = 13.87, p < .001$. Furthermore, this difference was modulated by whether the reinforcement schedule during S2 was extinction or VI-5. That is, the postdiscrimination generalization gradients showed a greater degree of depression

around the S2 stimulus (the gradient was steeper) for subjects receiving extinction during S2 presentations than for subjects receiving VI-5 during S2 presentations, $F(5,75) = 3.30$, $p < .025$. The TO effect did not interact significantly with the above S2 schedule difference, ($F < 1$).

Of particular interest in regard to the antecedent of U-shaped generalization gradients is the change in the gradient shape for subjects receiving single stimulus VI-5 training as compared to subjects receiving MULT VI-1 VI-5 discrimination training. Considering the single stimulus VI-5 condition, it was found that the gradient following single stimulus training did not differ significantly from the gradient obtained from the final two VI-1 baseline sessions, $F(5,75) = 2.80$. In contrast, the postdiscrimination generalization gradient for the subjects receiving the MULT VI-1 VI-5 discrimination did differ significantly from the baseline gradient, $F(5,75) = 2.71$, $p < .05$. Since the gradients for the VI-1 \rightarrow VI-5 subjects did not change significantly due to the VI-5 training, the effect of a reduction in reinforcement density from VI-1 to VI-5 during the S2 stimulus is not the sole antecedent for the gradient change observed in the MULT VI-1 VI-5 conditions. It would appear, therefore, that the occurrence of U-shaped generalization gradients around the S2 stimulus following MULT VI-1 VI-5 discrimination training was due primarily to the presence of the orthogonal S1 stimulus during which reinforcement was

delivered more densely relative to the S2 schedule. The presence of the stimulus associated with the VI-1 reinforcement schedule also contributed to the greater response rate reduction during the S2 stimulus for the MULT VI-1 VI-5 subjects as compared to the single stimulus VI-5 subjects. The greater reduction in the rate during S2 observed for the MULT VI-1 VI-5 condition was due to the decreased rate of responding during S2 stimulus periods which were preceded by S1 stimulus periods. This effect has been termed negative induction (Pavlov, 1927).

Relative generalization gradients. The changes in gradient shape that are due to the conditions imposed following baseline training are more easily observed when relative generalization gradients are considered. In order to depict the relative generalization gradients, a percentage measure was formed by dividing the total number of responses to each stimulus for each subject by the total number of responses emitted to all stimuli. A mean of these percentage scores for each group on both the last two baseline sessions (triangles) and the generalization test session (circles) is shown in Figure 19.

Considering the VI-1 \longrightarrow VI-5 condition, it can be seen from the top panel of Figure 19 that the reduction in reinforcement density did not substantially alter the baseline generalization gradient. In effect, the gradient following VI-5 single stimulus training is identical to the gradient

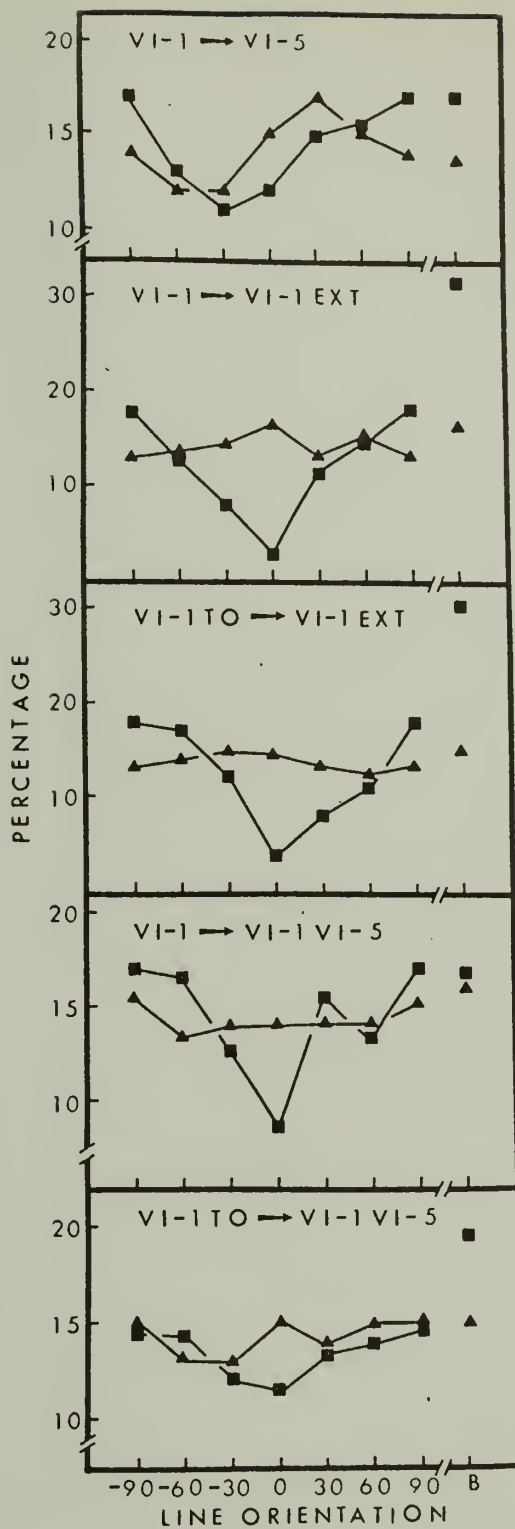


Fig. 19. Relative Generalization Gradients for all Five Conditions on Last two Baseline Sessions (triangles) and on the Generalization Test Session (circles).

obtained from the last two baseline sessions. However, the gradient following single stimulus training does indicate a slight increase in the percentage of responses emitted to the $\pm 90^\circ$ line stimulus and to the blank green stimulus. The increase in the responses to the blank green stimulus is interesting since the green stimulus had not been presented since the termination of baseline training.

The gradients for the two groups receiving extinction during the S2 stimulus (VI-1 \rightarrow MULT VI-1 EXT and VI-1 TO \rightarrow MULT VI-1 EXT conditions) indicate a reduction in the percentage score for stimuli around the S2 stimulus and an increase in the percentage score for the $\pm 90^\circ$ stimulus value and the blank green stimulus. This increase in the number of responses to the blank green stimulus and to the stimuli on the wings of the generalization gradient reflects the occurrence of behavioral contrast during discrimination training.

The gradients for the VI-1 \rightarrow MULT VI-1 VI-5 condition are shown in the fourth panel of Figure 19. The same general gradient shape was obtained in this condition as was obtained in the conditions in which extinction was scheduled during S2 presentations. However, there was only a slight increase in the percentage of responses emitted to the blank stimulus for the MULT VI-1 VI-5 condition during the generalization test as compared to the percentage of responses emitted to the blank green stimulus at the ter-

mination of baseline training.

The gradient from the generalization test for the VI-1 TO \rightarrow MULT VI-1 VI-5 condition, shown in the bottom panel of Figure 19, is almost identical to the gradient obtained from the last two baseline sessions with two exceptions: a decrease was observed in the number of responses emitted to the S2 stimulus and an increase was obtained in the number of responses emitted to the S1 stimulus during the generalization test. The decrease in response rate for the S2 stimulus is due to negative induction effects occasioned by the S1 stimulus during discrimination training while the mean increase in S1 response rate is due primarily to Bird 36 who emitted an unusually large percentage (28%) of the generalization test responses to the S1 stimulus.

It is evident, therefore, that when the relative generalization gradients before discrimination training are compared with the gradients after discrimination training, the effect of behavioral contrast during discrimination training is reflected in the postdiscrimination generalization test gradients as an increase in the proportion of responses emitted to those stimuli on the line tilt dimension most removed from the S2 stimulus and by an increase in the proportion of responses emitted to the blank green stimulus. Likewise, the effect of a reduction in reinforcement density during S2 stimulus presentations along with the possibility for induction effects due to the S1 stimulus was reflected as a depression

of the baseline generalization gradients around the S2 stimulus. These two factors taken together lead to the observation of U-shaped absolute and relative postdiscrimination generalization gradients along the line tilt dimension.

CHAPTER IV

Discussion and Conclusions

The major finding of the present set of experiments can be summarized as follows: Behavioral contrast as defined by Reynolds (1961) is neither a necessary nor a sufficient condition for the development of inhibitory stimulus control. That contrast is not a necessary condition is seen from the results of Experiment II where steep incremental U-shaped generalization gradients were obtained from subjects showing little if any behavioral contrast. Likewise, the results of Experiment I indicate that behavioral contrast can not be taken as a sufficient condition for inhibitory stimulus control since the MULT VI-1 VI-1 \rightarrow MULT VI-1 VI-5 condition, while showing a degree of contrast during discrimination training comparable to that reported by Weisman (1969), showed no inhibitory control when a generalization test was given. Instead, the resulting generalization gradients of Experiment I were peaked at or near the S2 stimulus value and exhibited all of the characteristics attributed to excitatory generalization gradients. The findings of the present investigation would necessarily call into question those hypotheses relating behavioral contrast and the development of inhibitory stimulus control.

A further conclusion of the present experiments concerns the usefulness of the TO as an aid in investigating

behavioral contrast and related discrimination effects. Since the TO effect did not significantly interact with the measure of stimulus control (generalization gradients), the TO effect appears to be specific to the training phase. Through the use of the TO in a variety of experimental arrangements, the antecedents of behavioral contrast might be more meaningfully determined.

The procedure employed in Experiment II whereby all of the generalization test stimuli coupled with the VI-1 reinforcement schedule were presented during the baseline training phase has been criticized by Honig (1961) for the following reason. Honig considers that a generalization test administered following training to all of the test stimuli is not a "true" test of the generalized response strength since the generalization test stimuli are not novel to the subject. Honig also assumed that a U-shaped generalization gradient on a stimulus continuum where all of the test stimuli had previously been paired with reinforcement and then responses in the presence of one stimulus value extinguished, is not comparable to an excitatory gradient obtained following exposure to only one training value. While this distinction is undeniably valid, the importance of this distinction between the two generalization gradients has yet to be submitted to a direct experimental test. In fact, it is not presently clear whether the inhibitory gradient can theoretically be considered to be the converse of the excitatory gradient since it has been observed that

the excitatory and inhibitory gradients obtained using the orthogonal training procedure, which equates for pre-exposure experience, are not the converse of one another.

When the initial operant level of a response system is considered, an experimenter investigating behavioral inhibition is immediately confronted with a crucial and serious problem. This problem centers around the fact that the operant level of most response systems currently used is, for all practical purposes, zero. The experimenter may employ one of three strategies to alleviate this problem: (1) he may rely upon the generalized response tendency due to reinforced responding in the presence of some distant stimulus value on the same stimulus continuum as the inhibitory stimulus or the generalized response tendency from some orthogonal stimulus, (2) he may elevate the response rate across the entire stimulus continuum by reinforcing responses made in the presence of many exemplars of the stimulus dimension, or (3) the experimenter may switch response systems and concentrate his efforts on a response system with a non-zero operant level, e.g. the running response in rats. While all of the above solutions to the problem of a zero operant level are experimentally sound, there is no guarantee that the concept of inhibition, as a process separate from excitation, will be found to be transituational across the three aforementioned paradigms.

While most of the investigations reporting U-shaped

generalization gradients for the pigeon key pecking response have used the first procedure given above, the resulting data does not necessarily require an interpretation using inhibition as a separate and unique process. Much of the accumulated data might be more parsimoniously viewed as the result of a reduction in excitation or response rate at the training value; a suggestion originally stated by Skinner (1938, p. 17).

Consider Experiment II of the present investigation. During baseline training the subjects were reinforced for responding in the presence of all stimuli values later to be given in the generalization test. At the termination of baseline training a flat elevated generalization gradient was observed across the line tilt dimension. When discrimination training was begun the responses of certain subjects were non-reinforced in the presence of the 0° line while other subjects encountered a reduced reinforcement density (VI-5) during presentations of the 0° line stimulus. For the subjects receiving extinction during S2 (MULT VI-1 EXT conditions), the response rate decreased and approached the zero operant level. The final S2 rate for some subjects was elevated above the operant level due to generalization from the S1 stimulus or because S2 responses are superstitiously reinforced by the onset of the S1 stimulus. Similarly, the response rate for the VI-5 subjects (MULT VI-1 VI-5 condition) decreased due to the reduction in reinforcement density and the induction effects from the S1 stimulus. That is, when the VI-5 schedule

was introduced some extinction occurred before the initial reinforcements were delivered. The extinction lowered the response rate and when reinforcement was finally delivered this lower rate could become conditioned.

The argument may also be stated in terms of the interresponse time (IRT) which has been shown to have certain characteristics of an operant (Wilkie and Pear, 1972; but see Reynolds and McLeod, 1971). That is, with the introduction of the VI-5 schedule and the extinction effects due to the decreased reinforcement density, the probability of a long IRT immediately preceding reinforcement delivery is increased. The increase in emission of long IRTs has the effect then of lowering the response rate. When a generalization test is given, an observed U-shaped gradient might be the result of the generalized tendency to respond at the response rate conditioned during S2 stimulus presentations and not because inhibition is present at the S2 stimulus. Or, in IRT terms, as the stimulus distance from the S2 increases, the frequency of the IRT associated with the S2 decreases and the response rate increases. Since the IRT characteristic of the S2 stimulus is longer than the IRT characteristic of the adjacent stimulus values the resulting generalization gradient is U-shaped.

This account of an incremental U-shaped gradient makes no assumptions concerning a separate inhibitory process. Instead, the account is based solely in terms of the response rate or IRT that is conditioned during presentations of the

S2 stimulus and the relationship between the S2 response rate and the response rate associated with the other stimuli values. While the data of the present experiment are suggestive and could be interpreted according to this model, the data do not necessarily rule out an inhibition account. Further investigations are needed which analyse in depth the IRT distributions generated when the different generalization test stimuli are presented. These IRT distributions could then be compared to IRT distributions obtained following the initial training phase. The results of such comparisons could possibly lead to the ultimate rejection of the concept of inhibition as an explanatory term for the occurrence of U-shaped generalization gradients.

Several interesting predictions could be generated by the proposed model. That is, if it is assumed that the necessary condition for a U-shaped gradient is that the conditioned response rate be lower, or the conditioned IRT be longer, during the S2 stimulus than for stimuli more distant on the stimulus continuum, then the model would predict that any procedure, be it inter-reinforcement interval conditions or schedule restrictions of the response rate, that would decrease the response rate during the S2 would produce a U-shaped generalization gradient. This assumption makes no demands on the occurrence or non-occurrence of the reinforcing stimulus but is based solely on the response rate evident during S2 stimuli presentations. Therefore, it would be

predicted that if initial training were to be given using a high density reinforcement schedule, say VI-30 sec, followed by training with a reduced density schedule (VI-150 sec), a U-shaped gradient would be obtained around the specific training stimulus. This experiment has not, as yet, been reported but if the obtained results were as predicted, it would be extremely interesting since Hearst, Koresko, and Ponnin (1964) have previously reported excitatory gradients following single stimulus training with VI-2 and VI-3 schedules.

Similarly, the model predicts that if a reinforcement schedule is paired with the S2 stimulus that reduces the S2 rate while leaving the density of reinforcement in the S2 component equivalent to the density of reinforcement in the S1 component (VI-1), a U-shaped generalization gradient would be obtained. Weisman (1969, 1970) has conducted two such experiments. Following MULT VI-1 VI-1 training, either a differential reinforcement of low rate (DRL) (Weisman, 1969) or a differential reinforcement of other behavior (DRO) (Weisman, 1970) was correlated with a O^0 on a green background while a VI-1 schedule was correlated with a green background alone. Reinforcement densities were equated for both components by manipulating the minimum IRT value necessary for reinforcement during the S2 stimulus. Following MULT VI-1 DRL or MULT VI-1 DRO training, a line tilt generalization test was given. The resulting generalization gradients were clearly U-shaped

and were centered around the 0° line value. The DRL result is particularly interesting since Hearst, et al (1969) had previously reported shallow excitatory gradients around a stimulus paired with a DRL 6 sec schedule. The two important differences between the Hearst, et al study and the Weisman study are that in the latter investigation previous VI-1 training was given to the 0° line and secondly, an orthogonal stimulus (green key stimulus), during which VI-1 was scheduled, was alternated randomly with the DRL component. These two variables would have the effect of increasing the operant level across the line tilt dimension both through initial contingent reinforcement for responses to the 0° line and through generalization from the S1 stimulus. Furthermore, the addition of the S1 stimulus would have the effect of aiding in lowering the S2 response rate due to the negative induction effects from the S1 stimulus. Therefore when a generalization test was administered in the Weisman investigation the response rate was lower for the S2 stimulus because of the DRL or DRO contingencies than for the surrounding stimulus values and a U-shaped generalization gradient was obtained.

While the present argument discounts explanations of existing data which employ the inhibition construct as a separate and independent process, it is possible that behavioral results in the future could owe their origin to such an inhibitory process. What is being illustrated in

the present argument, however, is that the experimental evidence to date does not necessarily demand an inhibition interpretation. A response system of the future might demand an inhibitory construct so as to account adequately for the observed behavior. Such a response system might possibly be analogous to certain neurophysiological systems where the concept of inhibition as a separate process has been fruitfully investigated. Until a response system is determined, however, which necessitates an inhibitory construct for explanatory completeness, it would be more parsimonious to account for the existing data in terms of a unitary process, i.e. excitation.

It is apparent, therefore, that the concept of inhibition as a process, separate from excitation, is not necessary to give an adequate account of a growing amount of data. However, before a construct such as inhibition, which admittedly has enjoyed a long and experimentally fruitful tenure in the psychological literature, can be dismissed conclusive evidence must be obtained. It would appear at this time that the evidence would come in terms of extensive IRT analyses from diverse experimental situations. Whatever form the analysis finally takes, it would seem safe to conclude that the concept of behavioral inhibition is quickly becoming obsolete as an explanatory construct in the experimental analysis of behavior.

References

- Catania, A. C. and Reynolds, G. S. A quantitative analysis of the responding maintained by interval schedules of reinforcement. Journal of the Experimental Analysis of Behavior, 1968, 11, 327 - 383.
- Deutsch, J. Discrimination learning and inhibition. Science, 1967, 156, 988.
- Farthing, G. W. and Hearst, E. Generalization gradients of inhibition after different amounts of training. Journal of the Experimental Analysis of Behavior, 1968, 11, 743 - 752.
- Fleshler, M. and Hoffman, H. S. A progression for generating variable interval schedules. Journal of the Experimental Analysis of Behavior, 1962, 5, 529 - 530.
- Guttman, N. Generalization gradients around stimuli associated with different reinforcement schedules. Journal of Experimental Psychology, 1959, 58, 335 - 340.
- Hearst, E. Discrimination learning as the summation of excitation and inhibition. Science, 1968, 162, 1303 - 1306.
- Hearst, E. Excitation, inhibition, and discrimination learning. In N. J. Mackintosh and W. K. Honig (Eds.), Fundamental issues in associative learning. Halifax, Canada: Dalhousie University Press, 1969. Pp. 1 - 41.
- Hearst, E., Koresko, M. B., and Poppen, R. Stimulus generalization and the response-reinforcement contingency.

- Journal of the Experimental Analysis of Behavior, 1964, 7, 369 - 379.
- Hearst, E., Besley, S., and Farthing, G. W. Inhibition and the stimulus control of behavior. Journal of the Experimental Analysis of Behavior, 1970, 14, 373 - 409.
- Honig, W. K. Generalization of extinction on the spectral dimension. Psychological Record, 1961, 11, 269 - 278.
- Honig, W. K., Boneau, C. A., Burstein, K. R., and Pennypacker, H. S. Positive and negative generalization gradients obtained after equivalent training conditions. Journal of Comparative and Physiological Psychology, 1963, 56, 111 - 116.
- Jenkins, H. M. and Harrison, R. H. Generalization gradients of inhibition following auditory discrimination learning. Journal of the Experimental Analysis of Behavior, 1962, 5, 435 - 441.
- Pavlov, I. P. Conditioned Reflexes. London: Oxford University Press, 1927.
- Reynolds, G. S. Behavioral contrast. Journal of the Experimental Analysis of Behavior, 1961, 4, 57 - 71.
- Reynolds, G. S. and McLeod, A. On the theory of interresponse-time reinforcement. In G. Bower and J. T. Spence (Eds.), The psychology of learning and motivation, vol. 3. New York: Academic Press, 1971. Pp. 85 - 107.

- Sadowsky, S. Behavioral contrast with Multiple VI - time-out training. Paper presented at Eastern Psychological Association, Atlantic City, 1970.
- Segal E. F. A rapid procedure for generating random reinforcement intervals on VI and VR tapes. Journal of the Experimental Analysis of Behavior, 1964, 7, 20.
- Skinner, B. F. The behavior of organisms. New York: Appleton-Century-Crofts, 1938.
- Spence, K. W. The nature of discrimination learning in animals. Psychological Review, 1936, 43, 427 - 449.
- Taus, S. E. and Hearst, E. Effects of intertrial (blackout) duration on response rate to a positive stimulus. Psychonomic Science, 1970, 19, 265 - 266.
- Terrace, H. S. Stimulus control. In W. K. Honig (Ed.), Operant behavior: areas of research and application. New York: Appleton - Century-Crofts, 1966. Pp. 271 - 344. (a)
- Terrace, H. S. Discrimination learning and inhibition. Science, 1966, 154, 1677 - 1680. (b)
- Terrace, H. S. Discrimination learning, the peak shift and behavioral contrast. Journal of the Experimental Analysis of Behavior, 1968, 11, 727 - 741.
- Weisman, R. G. Some determinants of inhibitory stimulus control. Journal of the Experimental Analysis of Behavior, 1969, 12, 443 - 450.
- Weisman, R. G. Factors influencing inhibitory stimulus

- control: differential reinforcement of other behavior during discrimination training. Journal of the Experimental Analysis of Behavior, 1970, 14, 87 - 91.
- Weisman, R. G. and Palmer, J. A. Factors influencing inhibitory stimulus control: discrimination training and prior non-differential reinforcement. Journal of the Experimental Analysis of Behavior, 1969, 12, 229 - 237.
- Wilkie, D. M. and Pear, J. J. Intermittent reinforcement of an interresponse time. Journal of the Experimental Analysis of Behavior, 1972, 17, 67 - 74.
- Yarczower, M. Behavioral contrast and inhibitive stimulus control. Psychonomic Science, 1970, 18, 1 - 3.

