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## The effects of reinforcement of the development of inhibitory stimulus control.

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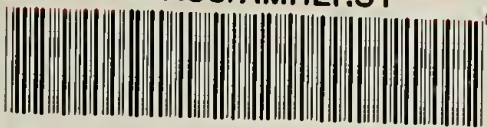
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THE EFFECTS OF REINFORCEMENT ON THE DEVELOPMENT  
OF INHIBITORY STIMULUS CONTROL

A Thesis Presented

By

Jeremiah P. Collins

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

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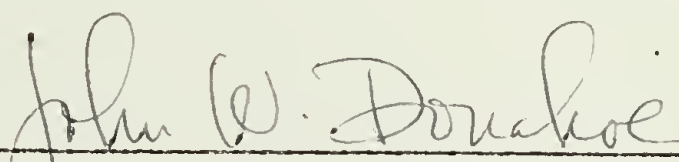
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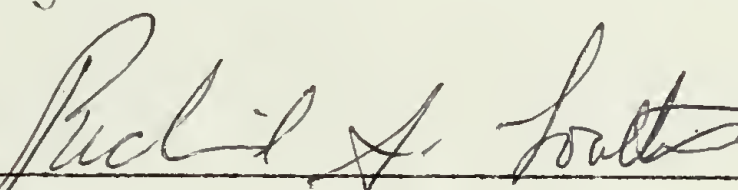
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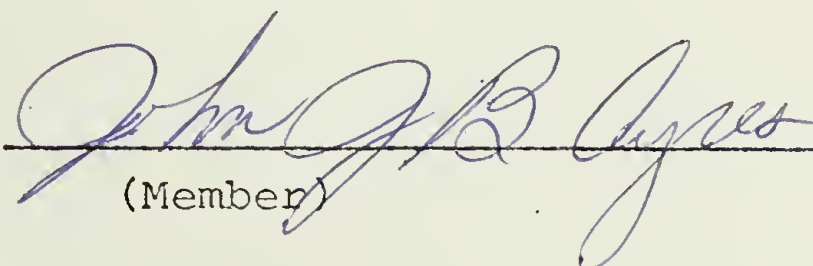
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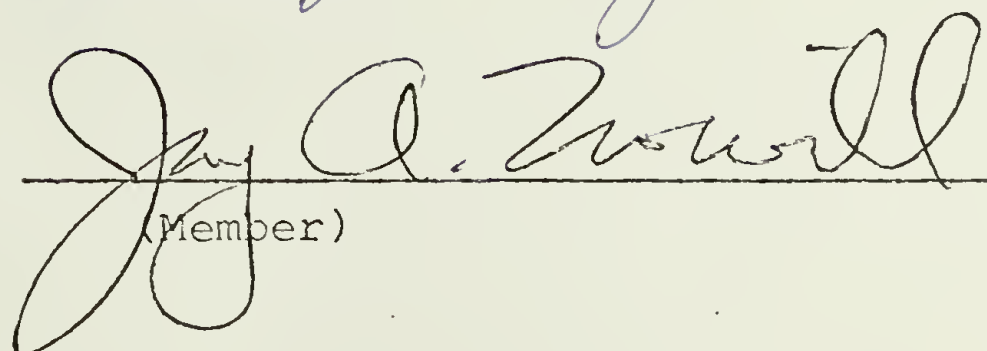
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## TABLE OF CONTENTS

	Page
ACKNOWLEDGMENTS .....	iii
LIST OF TABLES .....	v
LIST OF ILLUSTRATIONS .....	vi
ABSTRACT .....	vii
Section	
I. Introduction .....	1
Effects of Massed Extinction on the Generalization Gradient Inhibition as a Response Statement of the Problem	
II. Method and Procedure .....	11
III. Results and Discussion .....	14
IV. General Discussion .....	29
A Theoretical Model	
APPENDIX .....	45
REFERENCES .....	50

## LIST OF TABLES

Table		Page
1.	Mean S+ Rates Averaged Over Last Two Days ...	14
2.	Analysis of Transfer Effects .....	18
3.	Response Rates to S+ During Testing .....	20
4.	Comparisons of Relative Gradients - Test 5 ..	22

## LIST OF ILLUSTRATIONS

Figure		Page
1.	Mean Rate of Responding During Special Training Days (1-15) and Random Sequence Training Days (16-23) .....	16
2.	Relative Rate of Responding During Generalization Test 5 .....	21
3.	Mean Rate of Responding During Last Day of Sequence Training for the 18 One Minute Stimulus Periods .....	24
4.	Relative Rate of Responding During Generalization Test 6 .....	26



## ABSTRACT

The pecking response of pigeons was reinforced when directed at a key transilluminated by chromatic light. Subjects were assigned to one of three sequences of S+ and S- stimuli and to one of two multiple schedules of reinforcement. The AE Group (acquisition - extinction) received daily a block of nine S+ periods followed immediately by a block of nine S- periods. The EA Group received the reverse order of stimuli while a control group (R Group) received a random sequence of stimuli. Each of the above sequences of stimulus presentation was in effect in conjunction with either a Mult VI-1 min - Ext schedule or a Mult VI-1 min - VI-4 min schedule of reinforcement. A total of six groups were thus obtained.

Generalization tests were conducted at various stages of training in order to assess the development of stimulus control. In addition, following stabilization of performance, all groups were shifted to the random order of stimulus presentation as a further test of stimulus control. Results indicated that the AE (VI-1 - Ext) Group, only, failed to develop inhibitory stimulus control as evidenced by the absence of area shift in the generalization gradient and the disruption of performance when shifted to a random stimulus sequence. An unexpected result was the finding of a second peak in the generalization gradient of those groups where the

S- stimulus was associated with a VI-4 min schedule. These findings were interpreted as indicating that the nature of the behavior occurring during S- is an operant and that the generalization gradients are best explained by a decision theory model.

## INTRODUCTION

The use of schedules of reinforcement which delay the effects of extinction has provided a method for the detailed examination of gradients of generalization. Since the development of this technique by Guttman and Kalish (1956) a large amount of research has been conducted concerning stimulus control as the end product of various conditioning procedures. However, as Jenkins (1965) has pointed out our knowledge of the development of stimulus control has not progressed at a comparable rate.

An historically important model which sought to account for the development of stimulus control was proposed by Spence (1937). This analysis specifies that excitatory and inhibitory response tendencies are independently developed to the reinforced stimulus ( $S+$ ) and to the non-reinforced stimulus ( $S-$ ). The resulting gradients of excitation and inhibition summate algebraically and would normally have their respective maxima at  $S+$  and  $S-$ . In the case where the two stimuli are on the same stimulus dimension and sufficiently near one another to permit overlap of the gradients, then the model predicts a new maxima not at  $S+$  but at an adjacent value displaced away from  $S-$ .

Hanson (1959) obtained results consistent with Spence's model. Following training with one wavelength value with key-pecks reinforced on a VI-1 minute schedule and another wavelength with responding extinguished, the resulting post-

discrimination gradient showed a peak, not at the S+ value, but at an adjacent value displaced away from S-. Terrace (1966) suggested that the distribution of the area under the gradient may be a more sensitive measure of discrimination effects than the location of the peak itself since all of his subjects showed area shift following discrimination training but not all subjects showed peak shift.

#### Effects of Massed Extinction on the Generalization Gradient

Honig, Thomas, and Guttman (1959) examined one of the implications of Spence's model. They argued that if the simple summation of the effects of excitation and inhibition are responsible for the post-discrimination gradient, then extinction at some point on the generalization gradient should produce the same effect as discrimination training. In a study designed to test this prediction pigeons were first trained to respond to a stimulus of 550 nm on a VI-1 minute schedule of reinforcement for 10 days. On the day following the last VI session, continuous extinction for one session was given to a 570 nm stimulus. Generalization tests conducted the following day revealed that the effects of extinction training had been merely to lower the gradient at all points. The decrement was not centered at 570 nm. Subsequent successive discrimination, on the other hand, led to a suppression of responding specifically in the area of the S- with a shift both in the mean and the mode of the gradient



away from 570 nm. Thus, it appears that the simple effects of conditioning and extinction at different points on the stimulus dimension will not result in the post-discrimination gradient. Some interaction which occurs between the reinforced S+ trials and the non-reinforced S- trials would seem to be necessary.

Weisman and Palmer (1969) extended the generality of the Honig et al. finding to the interdimensional situation. Pigeons were first reinforced for responding to a green key and to a white vertical line with a green surround. Following this non-differential training, birds were given either six sessions of successive discrimination or six sessions of massed extinction to the white vertical line. Generalization tests conducted along the line tilt dimension showed shallow, U-shaped gradients of inhibition for the discrimination group but flat gradients for the massed extinction group. These results indicate, again, that the effect of massed extinction is a general lowering of the gradient rather than a specific suppression of responding at S-.

A method designed to avoid these general effects of massed extinction was proposed by Friedman and Guttman (1965, Experiment II). They argued that the formation of a prior discrimination might induce a susceptibility to the specific extinctive effects of the stimulus undergoing massed extinction. They first trained birds in a discrimination task with a green key (550 nm) as S+ and the green key

with a superimposed cross as S-. Following ten days of discrimination training, the experimental group was subjected to a 10 minute period of extinction to 570 nm. The control group was not given this extinction treatment. Generalization tests, the next day, revealed that the effect of extinction at 570 nm was not simply an over-all reduction in the gradient as Honig, et al. had found, but a relatively greater reduction in the region of S- accompanied by a shift in the peak of the gradient to 540 nm. However, compared with the control group the gradient was suppressed at all points.

A second experiment (Experiment III) reported in the same paper substituted a time-out procedure for the prior discrimination procedure. It was known from the work of Reynolds (1961) that time-out periods (completely dark operant chamber) used in place of S- periods prohibit responding and result in a rate increase to S+. This method was employed to determine whether the sufficient condition for peak shift following massed extinction was merely the temporal patterning of stimulus presentations and distribution of responding and reinforcements. This experiment was conducted in all respects indentically to the previous study with the substitution of one minute time-out periods in place of the former S-, a green key with cross. Following this training the experimental group was given separate extinction on 570 nm. The results replicated the Reynolds (1961) finding of a large contrast effect due to the time-out procedure. However, the effects

of the massed extinction did not result in a peak shift or a suppression of responding at 570 nm as reported for the previous experiment. It appears, then, that training on a prior discrimination task constitutes a sufficient condition for the development of the post-discrimination gradient following massed extinction, while the results from the time-out procedure demonstrate that neither the S+ rate increase nor the temporal patterning of responding and reinforcement is a sufficient condition. Apparently, some form of behavior adjustment has transferred, at least partially, from the prior discrimination training phase used in Experiment II to the massed extinction phase, and this behavior is responsible for the increased tendency for the development of inhibition as evidenced by the peak shift and depression at S-. The transfer was probably incomplete since the entire gradient following massed extinction was lowered compared to the control group. This depression did not occur if successive discrimination was used in place of massed extinction (Experiment I).

#### Inhibition as a Response

Speculation as to the nature of this transferred behavior involves assumptions concerning the nature of inhibitory stimulus control. Jenkins (1965) suggests an identification of inhibition with the development of a response to the S- stimulus which is incompatible with the reinforced response to S+. This incompatible response or movement pattern may develop as a result of being indirectly reinforced by certain



contingencies in discrimination training or as a result of an emotional state conditioned to S-. If the former applies it should be possible to identify a stereotyped movement pattern during the presentation of S-. Jenkins reports such an observation while using the discriminated trial procedure; "... what the pigeon does on presentation of S<sub>2</sub>- is different from what it does between trials. The pattern of movement initiated by an S<sub>2</sub>- presentation in a late stage of training often involves a momentary orientation toward the key, followed immediately by turning away to the side and remaining at some distance from the key until the S- trial is terminated by external control. At this point the animal resumes oscillatory pacing in front of the key and continues with these movements until the next trial." (p. 58).

Although it would be desirable to obtain some quantifiable measure of such behavior, still, such observations suggest that the successive discrimination procedure may actually result in concurrent responding; and the unspecified response which occurs in the presence of S- may be the locus of inhibitory stimulus control.

If the foregoing analysis is correct, then it becomes of immediate interest to determine the contingencies present and the reinforcements available during successive discrimination which give rise to a conditioned respondent or operant within the S- periods. A number of possibilities exist. If the response to S- is an operant then the situation appears



analogous to the concurrent schedules of reinforcement, where response  $R_1$  (key pecking) is required in the presence of  $S_+$  and response  $R_2$  (some behavior incompatible with key pecking) is required in the presence of  $S_-$ . Of course, no such scheduled requirements exist since behavior during  $S_-$  has no effect on the rate of reinforcement.

If the response is of the respondent type, it might be hypothesized that the  $S_-$  stimulus has acquired aversiveness as a consequence of non-reinforced responding. Withdrawal from the key would be the unconditioned response. If this were the case it would be difficult to explain why massed extinction should fail to impart aversiveness to the  $S_-$ . On the other hand, if the response is an operant, one would not expect massed extinction with  $S_-$  to result in conditioning since food reinforcement never follows the  $S_-$  period and never reinforces the response to  $S_-$ .

More direct evidence that an  $S_+$  period must follow the  $S_-$  period for inhibitory control to develop is supplied by Ellis (1969). In this study one group of birds received daily sessions consisting of nine one minute periods of  $S_+$  with VI-1 minute reinforcement schedule followed immediately by nine periods of  $S_-$  in extinction (AE Groups). A second group (EA) was presented with the reverse order of stimulus sequence and reinforcement. After 14 days, both groups appeared to be under stimulus control, i.e., were responding at a high rate to the  $S_+$  and at a low rate to the  $S_-$ .

However, subsequent generalization tests showed no peak shift for the AE Group while the EA Group did develop peak shift. Both groups were then shifted to a random sequence of stimulus presentation. The EA Group transferred readily, but the AE Group experienced a breakdown in the discrimination performance. The AE sequence did not result in inhibitory stimulus control, at least, not of the type necessary for efficient responding in a successive discrimination.

Ellis concluded that the S- S+ stimulus sequence (EA Group) was the necessary and sufficient condition for the development of stimulus control. His interpretation is consistent with the preceeding analysis which stresses that a period of reinforcement must follow the S- period for inhibition to develop. This implies that the response to S- is of the operant type.

#### Statement of the Problem

Ellis' study raises another interesting point. Although, the AE Group showed no evidence of inhibitory stimulus control during subsequent testing, they were responding differentially to the stimuli during training with the S+ S- sequence. It might well be enlightening to ask what stimulus is controlling responding if not the light intensities used as the S+ and S-. There appear to be at least two other events which are confounded with the presentation of S+ and S-:

- (a) The subject could be responding under the control of temporal factors since the same number of S+ and

S- periods were used daily. But since temporal cues would be the same for all groups, there is no accounting for the difference between the EA and AE Groups.

(b) A second stimulus confounded with the presentation of the S+ stimulus is the reinforcing stimulus itself. For the AE Group, an adequate rule would be; continue responding until a period of non-reinforcement exceeding a certain duration occurs, then stop responding. At most, use of this rule would require that the birds respond into the first few minutes of S- in order to experience that reinforcement was no longer available. While this rule would suffice for the AE Group, it would not be efficient for the EA Group since it requires this group to respond throughout the S- periods. Obviously, the reinforcing stimulus can exist as a cue only if the subjects are responding at a considerable rate. Thus, the EA Group would achieve more efficient behavior by utilizing the stimulus on the key.

The evidence of the "overshadowing effect" (Kamin, 1969) indicates that under conditions where a reliable stimulus is available additional stimuli which are present do not develop stimulus control. This is potentially the case for the AE Group since the stimulus provided by the reinforcing event is adequate, and the stimulus provided on the key is redundant. In addition, one might expect the reinforcement to be the more salient of the two stimuli.



The intent of the present experiment was to avoid confounding of the reinforcing stimulus with the stimulus on the key while, otherwise, systematically replicating Ellis' design. A direct method for accomplishing this end would be to make reinforcement an unreliable cue by occasionally introducing reinforcement within the S- periods. This was effected by using a multiple VI-1 - VI-4 schedule of reinforcement. In addition, as a further extension of Ellis' design the hue dimension was used in place of light intensity.

The use of multiple schedules which differ in respect to density of reinforcement has been shown to produce differential stimulus control. Guttman (1959) and Terrace (1966) obtained peak shift after training on a Mult VI-1 - VI-5 schedule. Weisman (1969) using interdimensional stimuli (green key and line tilt) obtained inhibitory gradients around the stimulus associated with the VI-5 component. Thus, if the reinforcement is controlling differential responding for the AE Group, and thereby obstructing the development of control by the stimulus on the key, then the utilization of a Mult VI-1 - VI-4 schedule should result in control by the stimulus on the key.



## Method

Subjects. The subjects were 24 naive White Carneaux pigeons, 6-12 months old, obtained from the Palmetto Pigeon Plant. The subjects were maintained at approximately 80% of their initial non-deprived weights.

Apparatus. The apparatus consisted of four Lehigh Valley operant chambers for pigeons. Programming and recording equipment were located in an adjacent room. Masking noise was delivered at an intensity of 80 db by a speaker mounted on the front wall. Industrial Electronic in-line display cells projected the stimuli onto the left response key. The stimuli were provided by Kodak Wratten filters Nos. 65, 74, 99, 73 and 72 B which enabled illumination of the key with hues of 501, 538, 555, 576, and 606 nm, respectively. The S+ was the 538 nm light and the S- was 576 nm. A house light was provided whenever the stimuli were presented. Reinforcement was delivered by operation of the food hopper for five seconds.

## Procedure

Pretraining. The subjects were habituated to the operant chamber for approximately five minutes on each of the first two days. The following day, feeder training was accomplished by presenting 30 non-contingent reinforcements. On Day 4, the subjects were shaped by the successive approximations method with S+ stimulus on the key. Subjects were then given two days of continuous reinforcement with 35 reinforcements obtained each day. VI training was scheduled for the next

12 days and consisted of one minute stimulus periods separated by five second time-out periods. VI training consisted of one day of VI-15 sec with 10 periods, one day of VI-30 sec with 20 periods, and ten days of VI-60 sec with 30 stimulus periods.

Sequence Training. Based on their performance prior to the last three days of pretraining, the 24 subjects were divided into six groups equated for mean response rate. The six groups formed a 2 x 3 factorial design with three stimulus sequences as one factor and two multiple schedules as the second factor. The stimulus sequences consisted of the following:

(1) AE Sequence - The daily session consisted of nine one minute S+ periods followed by nine one minute S- periods.

(2) EA Sequence - The sessions consisted on nine one minute S- periods followed by nine one minute S+ periods.

(3) Random Sequence - This sequence consisted of 31 one minute periods of quasi-random presentations of S+ and S- periods. This schedule was used by Ellis (1960) and was designed such that there were eight S+ S+ and eight S- S- transitions presented. Thus, all groups receive the same number of like transitions. The order for odd-numbered days was: +---+++---++-+---+++---++-+---+. The order for even-numbered days was constructed by interchanging + and -.

The two levels of schedule consisted of multiple VI-1 minute - Ext and multiple VI-1 minute - VI-4 minute schedules. Thus, three groups received reinforcement on a VI-1 minute

schedule during S+ and extinction during S-. The remaining three groups received VI-1 minute in S+ and a VI-4 minute schedule in S-.

All groups received training on their respective schedules for 15 days. Generalization tests consisted of the presentation of five stimulus values. The order of presentation was designed such that every stimulus was preceded by every other stimulus once. Tests were conducted after Sequence Training Days 1, 3, 7, 11, and 15. No reinforcements were delivered on test days. Tests were given early in training in order to determine if the gradients shifted differentially between the groups over training.

Transfer. Groups AE and EA were transferred to the random order of stimulus presentations following the Sequence Training phase while the Random Group remained on the random order. These schedules were maintained for the next eight days. Generalization tests were conducted after transfer Days 4 and 8.



## Results and Discussion

Pretraining. By the end of the pretraining which consisted of 10 days of VI-1 minute training with S+, all groups appeared to be relatively stable but were still showing small daily increases in rate. Following the introduction of discrimination training, all groups showed an increase in rate to S+ which was most apparent for the two random sequence groups and, to a lesser degree, for the other groups. Table 1 shows a comparison for the mean rates for the last two days of pretraining and the last two days of discrimination training.

Table 1  
Mean S+ Rates Averaged Over Last Two Days

Groups		Pretraining	Discrimination
VI-1 - Ext	AE	44	73
	EA	42	68
	R	51	136
VI-1 - VI-4	AE	50	68
	EA	46	57
	R	48	92

While it is clear that the two random groups showed evidence of behavioral contrast, the results from the other groups are somewhat unclear. The lack of a control group which continued under the pretraining schedule makes it impossible to separate the increase due to discrimination



training and the increase due to the general effects of training.

Sequence Training. The acquisition of the discrimination task under the sequence training conditions is shown in Figure 1 (first 15 days). The results from the transfer to the random sequence (8 days) are shown following the vertical line. With the introduction of the S- stimulus on the first day of discrimination training, all groups showed generalization decrement to the new stimulus which resulted in an initial suppression, rather than a gradual decline. Evidence that this early suppression is due to generalization decrement rather than the schedule of reinforcement is shown by the VI-1 - VI-4 groups. These groups show a recovery of the rate to S- by the third day. It must be recalled that the S+ S- difference is relatively large (38 nm) compared to other studies utilizing a hue discrimination (typically about 20 nm).

By the end of sequence training, all groups appeared to have stable response rates, although the Random Groups continued to show increases in S+ rate until the end of the study. The Random Groups showed a higher rate to S+ than other groups but the S- rate appeared the same. The AE and EA Groups were both very similar in their response rates to S+ and S-. Analysis of variance indicated that the interaction of Groups x Stimuli was significant,  $F(2.18) = 4.88$ ,  $p < .025$ . However, interpretation of this difference is

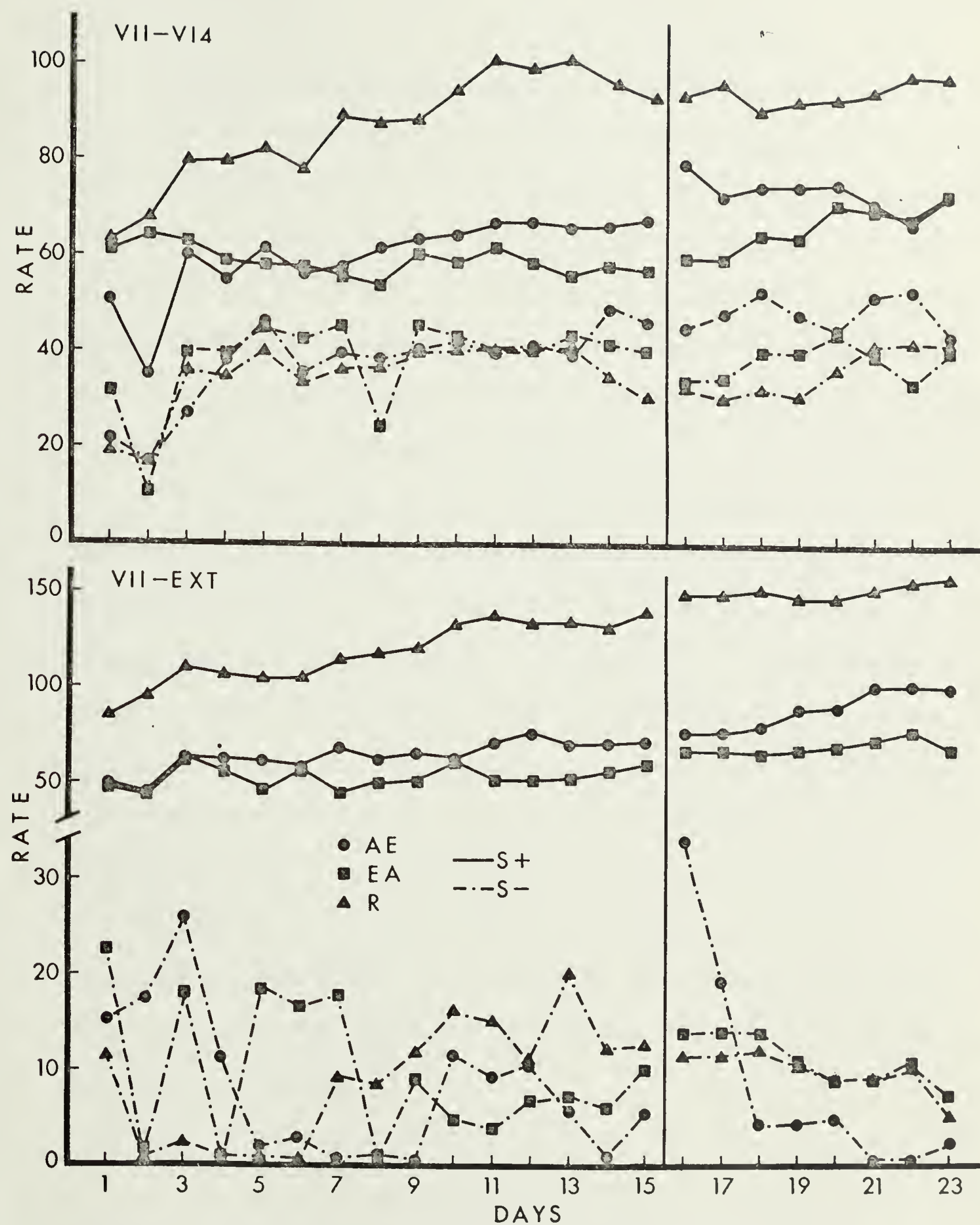


Figure 1. Mean Rate of Responding During Special Training Days (1-15) and Random Sequence Training Days (16-23).

is complicated by the fact that the Random Groups received 31 stimulus periods daily while all other groups had 18.

Transfer to Random Sequence. Following the last day of Sequence training, the AE and EA Groups were placed on the Random Sequence while the schedule of reinforcement remained the same. Figure 1 shows that all groups except for the AE Group in the VI-1 - Ext condition transferred to the random sequence with no disruption of discrimination performance. The AE (VI-1-Ext) Groups showed a large increase in S- rate as a result of the transfer. Inspection of the pattern of responding to S- within the first session of transfer showed that responding to the initial S- periods was low, and as the session progressed the S- rate increased to rates approaching the S+ mean rate, and then, begins to decrease for some subjects or remained high for others. The range of S- rates for the four subjects in the AE (VI-1-Ext) Group was; 2 to 83 responses per minute for Subject 4, 4 to 36 for Subject 3, 1 to 61 for Subject 2, and 1 to 80 for Subject 1.

Analysis of variance was performed for the last day of Sequence Training and the first day of Transfer Training. Table 2 shows the comparisons between the groups and the obtained significance levels.



Table 2  
Analysis of Transfer Effects

Group Comparison		<u>df</u>	<u>F</u>	<u>p</u>
VI-1 - Ext	AE vs EA + R	1,18	11.81	.005
	EA vs R	1,18	< 1	NS
VI-1 - VI-4	AE vs EA + R	1,18	< 1	NS
	EA vs R	1,18	< 1	NS

The finding that only the AE (VI-1 - Ext) Group was affected by the transfer to random supports the Ellis results. The finding that the AE (VI-1 - VI-4) does not show this effect indicates that the introduction of some reinforcement during the S- periods provides the sufficient condition for discrimination to develop. This result is consistent with the hypothesis that the AE Group under a VI-1 - Ext schedule may be under the control of reinforcement and that the introduction of reinforcements in S-, by making reinforcement unreliable, allows for the development of stimulus control by the stimulus present on the key.

One difference between these results and those of Ellis should be pointed out. The AE Group in Ellis' study had shown not only an increase in the S- rate but a decrease in the S+ rate when shifted to the random schedule. In the present study, the decrease in the S+ rate did not occur. According to the interpretation that the AE Group only devel-

ops inhibitory stimulus control after the transfer to the random schedule, it appears that in Ellis' study a substantial generalization of inhibition occurred to the S+ but not in the present experiment. This is consistent with other data which indicate that the S+ S- difference in terms of discriminability is much greater in the present study than in Ellis'. All groups showed large differences in S+ and S- rates on the first day of discrimination training while Ellis' groups showed a more gradual separation. In addition, subsequent generalization gradients were steeper in the present experiment.

Generalization Tests 1-5. Results of the generalization tests conducted during Sequence Training revealed a gradual steepening of the gradients. For most of the groups this steepening was due to the reduction in the rate to stimuli adjacent to the S+ value. The rate to the S+ stimulus itself, appeared not to change across the five test with the exception of the R (VI-1 - Ext) Group. Table 3 shows the rate to the S+ stimulus for the five tests.

Table 3  
Response Rates to S+ During Testing

Group	Test 1	Test 2	Test 3	Test 4	Test 5
VI-1 - Ext					
AE	69	78	54	68	69
EA	38	71	53	61	73
R	108	127	114	134	141
VI-1 - VI-4					
AE	81	80	51	64	81
EA	76	68	78	76	77
R	96	77	85	89	85

Since the R (VI-1 - Ext) eventually developed a rate to S+ during testing approximately twice that of the other groups, the rates were transformed to relative measures for purposes of comparison. Figure 2 shows the relative generalization gradient obtained after the last day of Sequence Training. Response strengths at each stimulus value are represented as a proportion of the total responding during the test. Inspection of Figure 2 reveals that no group showed a peak shift, but this result was not unexpected because of the large differences between the test points. However, the AE (VI-1 - Ext) Group did show less responding to the 501 nm stimulus and consequently showed a symmetrical gradient around S+. All other groups had a greater response rate to the 501 nm than to the 555 nm stimulus, indicating a



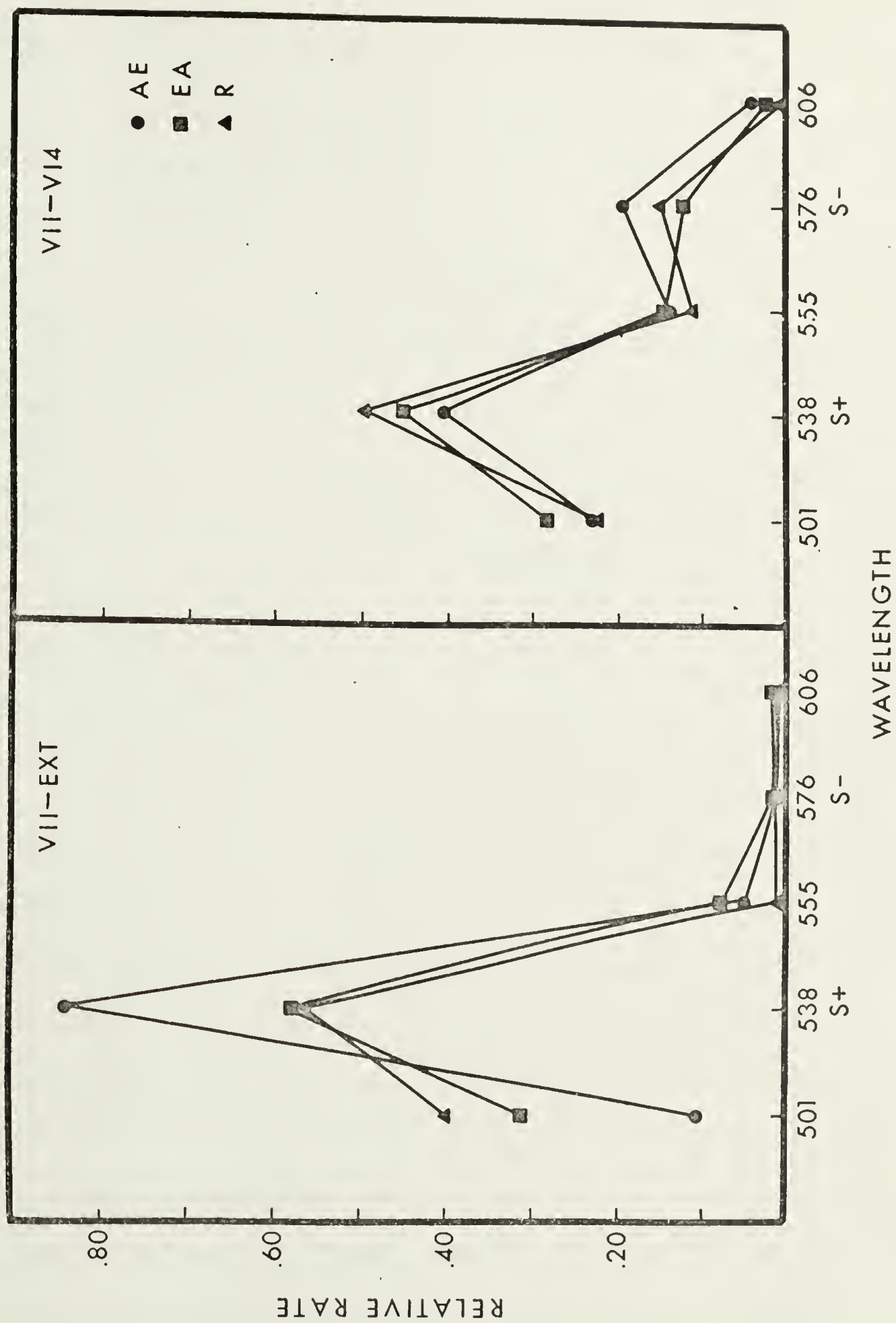


Figure 2. Relative Rate of Responding During Generalization Test 5.

substantial area shift. The analysis of variance showed that this difference between the AE (VI-1 - Ext) and the other VI-1 - Ext Groups was highly significant while there were no differences within the VI-1 - VI-4 Groups. Table 4 shows the group comparisons.

Table 4  
Comparisons of Relative Gradients - Test 5

Group		<u>df</u>	<u>F</u>	<u>p</u>
VI-1 - Ext	AE vs EA + R	(4, 72)	9.39	.001
	EA vs R	(4, 72)	< 1	NS
VI-1 - VI-4	AE vs EA + R	(4, 72)	< 1	NS
	EA vs R	(4, 72)	< 1	NS

These results showing that within the VI-1 - Ext condition only the AE Sequence Groups failed to show an area shift supports the Ellis' finding that only the AE Group failed to show a peak shift. Within the VI-1 - VI-4 condition, however, the AE Group develops area shift to the same extent as the EA and the Random Groups. Again, the effect of the VI-4 schedule during S- rather than extinction provides a sufficient condition for the development of inhibition to S-. These results are consistent with the hypothesis that the AE (VI-1 - Ext) Group is under the control of reinforcement.

An unexpected result was the development of a second

peak in the gradient to the stimulus associated with the VI-4 schedule. This finding will be discussed in a later section.

Responding Within the Session. Inspection of the pattern of responding during the S- periods for the AE and EA (VI-1 - Ext) Groups revealed that the suppression of responding to S- resulted from both a lowering of the rate and an increase in the latency of responding across the nine S- periods. Even early in training, subjects showed little tendency to respond to the first few S- periods, but then responding would begin and reach a peak rate during the last few stimulus periods. This tendency to withhold responding increased as training progressed until some animals did not respond at all. However, it was still the case that, given responding, the rate of responding was highest during the last few S- periods. This pattern was evident for both the AE and EA Groups.

Figure 3 shows the mean response rates over the 18 1-minute stimulus periods on the last day of Sequence Training. For the AE Group, the stimulus changed from S+ to S- between the ninth and tenth period, and the opposite change occurred for the EA Group. Both the AE and EA (VI-1 - Ext) Groups demonstrated an immediate change in response rate coincident with the change in stimulus. This pattern of responding was typical of the later days of Sequence Training and had developed gradually from the



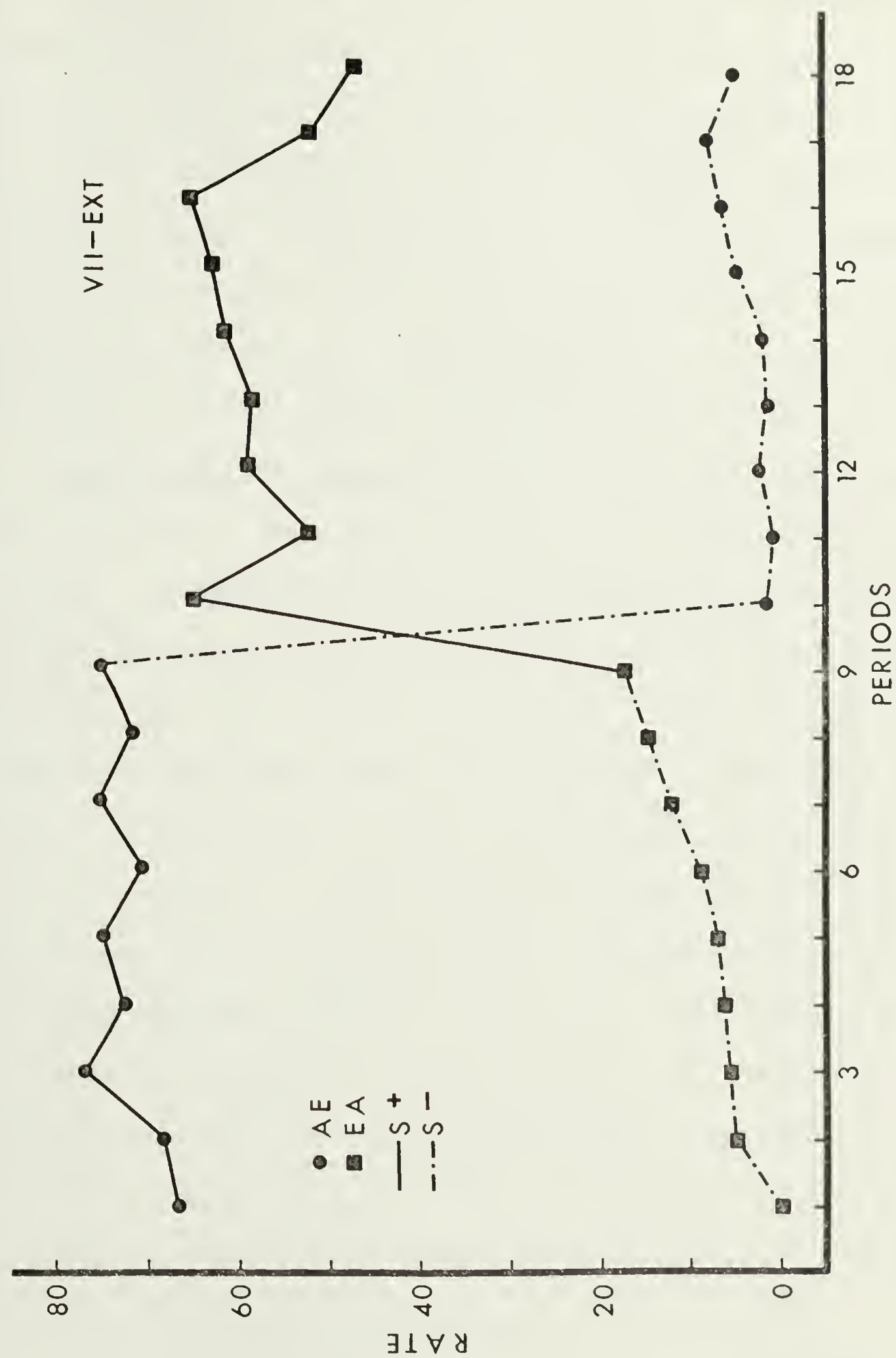


Figure 3. Mean Rate of Responding During Last Day of Sequence Training for the 18 One Minute Stimulus Periods.

beginning of training. Obviously, this result is inexplicable in terms of the hypothesis that the AE (VI-1 - Ext) Group is under the control of reinforcement. This hypothesis requires that the AE Group respond, at least, into the first few S-periods in order to experience non-reinforced responding. Clearly they do not. This result also rules out a simple temporal discrimination. The AE Group is very much under the control of the stimulus appearing on the key.

Generalization Tests 6 - 7. These tests were conducted after the fourth and eighth sessions following the Transfer Training. Figure 4 shows the relative generalization gradients obtained after four days of training on the random schedule. Comparison of this gradient with that of Figure 2 (prior to Transfer) shows that there was very little change in the gradients resulting from the random sequence training. This result is contrary to that obtained by Ellis. In that study the AE Group developed peak shift after the random training. This difference in results may be due to the highly discriminable stimuli employed in the present study. While Ellis' subjects were still showing substantial responding to stimuli other than the S+, the AE (VI-1 - Ext) Group in the present study was emitting over 85% of its responding to the S+ stimulus. There was little "area" left to shift.

The gradient displayed by the VI-1 - VI-4 Groups shows that all groups had by now developed a second peak at the stimulus value associated with the VI-4 minute schedule. This

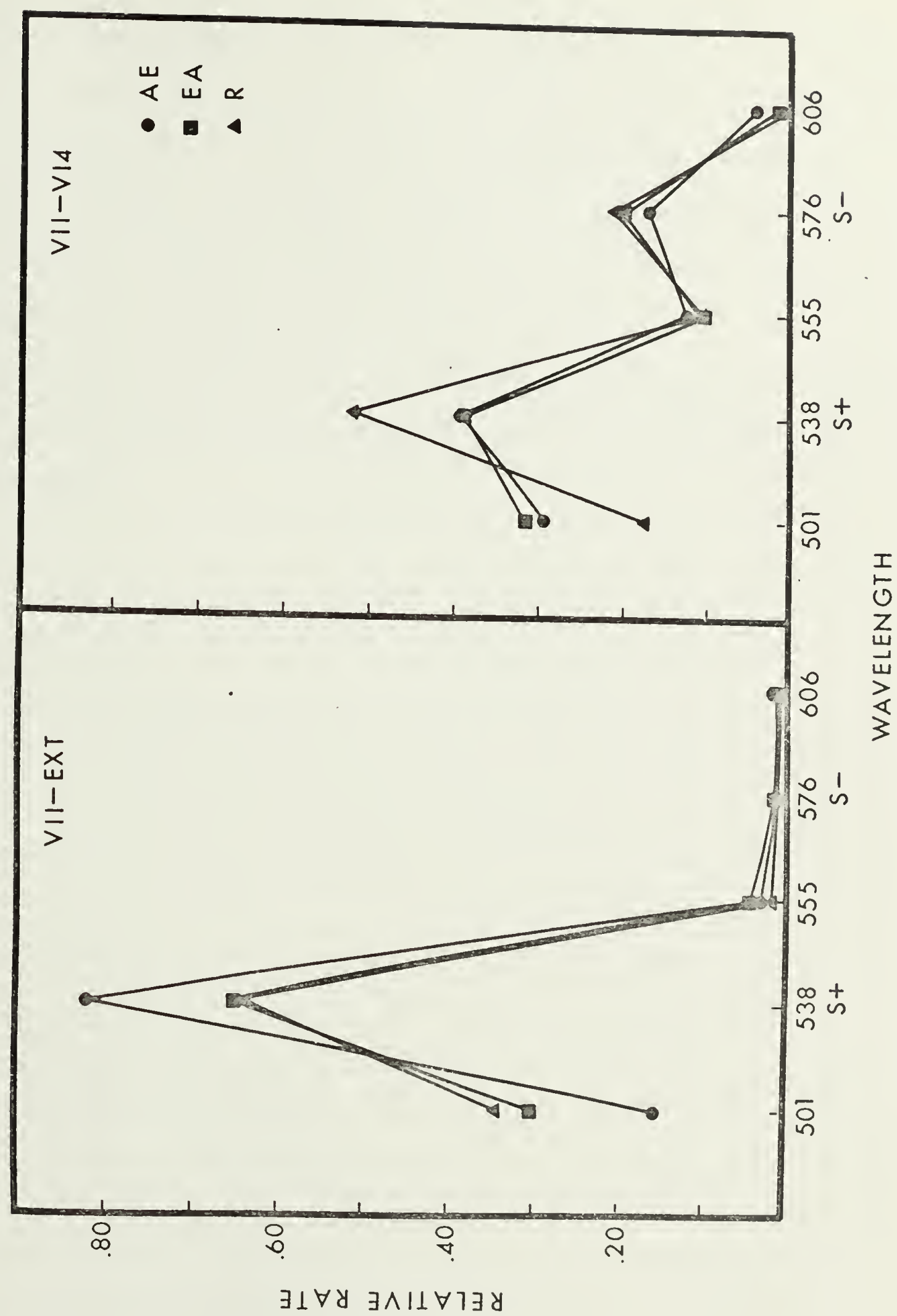


Figure 4. Relative Rate of Responding During Generalization Test 6.



result was unexpected and is contrary to the results obtained by Guttman (1959) and Terrace (1966). After training with a multiple VI-1 - VI-5 minute schedule their gradients did not show a double peak but, on the contrary, appeared similar to gradients obtained after VI-1 - Ext schedules. One major difference between the procedures used is that both Guttman and Terrace used S+ and S- stimuli separated by a difference of 20 nm while in the present study the difference in hue was 36 nm.

### General Discussion

In summary, the results obtained in the present study from the VI-1 - Ext Groups are consistent with finding of Ellis. The AE Sequence in this study resulted in significantly-less area shift than did the other sequences used. This supports Ellis' finding that his AE Groups did not develop peak shift as did the EA and Random Groups. The discrimination performance of subjects trained with the AE Sequence was disrupted when transferred to the Random Sequence which is, again, consistent with Ellis' results.

One result which was at variance with Ellis' study was the failure to obtain area shift for the AE Sequence following the transfer to the Random Sequence. This difference was analyzed as being due to the more highly discriminable stimuli used in the present study. This interpretation is supported by the fact that over 85% of responding was to the S+ stimulus during the last two generalization tests.

In extension of Ellis' findings, the results of this study indicated that neither the reinforcement stimulus nor the stimuli arising from temporal factors were controlling the responding of the AE Group. The precipitous drop in response rate coincidental with the stimulus change from S+ to S- leaves no doubt that the stimulus present on the key was controlling responding (Figure 3).

Consideration of the generalization test procedures raises several important points concerning the behavior of the

AE (VI-1 - Ext) Group. The tests were conducted throughout the Sequence Training phase of the study and at all times reliably reflected the S+ and S- rates obtained during training. This indicates that the subjects attended the key consistently and, more importantly, that the tests themselves did not disrupt discrimination performance, even though they involved presenting the S+ and S- stimuli in a random order. However, when the AE Group was transferred to the Random Sequence, the discrimination performance was immediately disrupted. The response rate to S- during the first session of random training rose to rates overlapping the S+ rates.

The major difference between the testing random schedule and the training random schedule is, of course, the delivery of reinforcement. It is possible that the occurrence of reinforcement during an S+ period acts to directly reinforce key pecking during S- periods. But this effect only occurs when the reinforced S+ period follows the S- period such as in the EA Sequence and the Random Sequence. Furthermore, it is only when this increased rate of responding to S- is subsequently extinguished as training continues on the random schedule, that inhibitory stimulus control results. Evidence for this last point is supplied by both the present study and Ellis (1969) which demonstrated that even though the AE Group had experienced substantial non-reinforced responding to S- early in training, inhibitory stimulus control did not develop.



The initiation of this responding to S- was, presumably, induction from the S+ stimulus, as training continued, the responding to S- extinguished. With the transfer to the random sequence, the S- response rate rose back to its former level and then, again diminished. It is only at this point that inhibitory stimulus control developed as indicated by the development of peak shift in the Ellis study.

The present analysis stresses the role of a covert form of behavior within S- which has some of the characteristics of an operant. This behavior effectively competes with the key peck response and results in a higher ratio of reinforcement per key peck over the session. In many respects, this behavior is similar to the collateral or mediating behavior that has been observed in a variety of situations. Laties, Weiss, Clark and Reynolds (1965) identified the mediating behavior in a rat study using a schedule requiring temporally spaced responding (DRL). They showed that this behavior (the rat would hold its tail in its mouth) was functionally related to the efficiency of responding. Similarly, Laties, Weiss, and Weiss (1969) observed wood gnawing as the mediating behavior. When the wood block was removed the response pattern was again disrupted. Segal and Holloway (1963) have suggested that water drinking may serve a similar purpose with rats on a food reinforcement schedule. However, Falk (1966) has rejected this account and has called this type of behavior "adjunctive behavior" and has not specified the contingencies responsible

for its appearance, other than that an intermittent schedule of reinforcement is necessary.

The comparison with results obtained from studies using DRL schedules may prove useful in understanding the behavior of the VI-1 - VI-4 Groups. These groups were intended to test the hypothesis that the behavior of Ellis' (1969) AE Group was due to the confounding of stimulus control by the reinforcing event. Consistent with this hypothesis the AE (VI-1 - VI-4) Groups showed the same amount of area shift and transferred as well as the EA and Random Groups. However, examination of responding within the session convincingly demonstrated that this effect was not due to the use of reinforcement as a stimulus. Therefore, we are again led to the conclusion that the occurrence of reinforcement, this time within the VI-4 component, is responsible for the development of inhibitory stimulus control.

The VI-1 - VI-4 schedule results in a situation wherein relatively longer inter-response times (IRTs) are reinforced in the VI-4 component. It is consistent with the analysis of the VI-1 - Ext condition to propose that these relatively longer IRTs and resulting lower rates are due to the interspersal of some form of mediating behavior between the key peck responses. This behavior results in a stable and decreased rate of responding to the S- stimulus (VI-4 component). As training progresses, the occurrence of the two responses of key pecking and mediating behavior should become

stereotyped. As a consequence the rate of key pecking, itself, comes to function as an operant.

However, this account does not explain the discrepancy between the present results where a second peak in the generalization gradient was obtained around the S- stimulus (VI-4) and the results obtained by both Guttman (1959) and by Terrace (1968) where a depression in the gradient was obtained around the stimulus associated with a VI-5 minute schedule of reinforcement. If inhibitory stimulus control results from training with a stimulus associated with a relatively less-dense schedule of reinforcement, then the generalization gradient around such a stimulus should appear U-shaped or, perhaps, flat if the rate is very low. But under no conditions should the gradient appear peaked at the inhibitory stimulus value as occurred in the present study. The following model is offered as an alternative account of generalization which can incorporate the results obtained here and is consistent with a variety of results obtained in other studies.

#### A Theoretical Model

The proposed model entails two basic assumptions; (1) Following the acquisition of stabilized performance on a VI schedule the rate of key pecking, itself, has the characteristics of an operant. The animal responds in the presence of a stimulus ( $S_1$ ) at the rate ( $R_1$ ) determined by its history of reinforcement in the presence of that stimulus. Morse (1966) has discussed the rationale for assigning to the interresponse



times the characteristics of an operant. (2) The operant rate will be emitted with decreasing probability as the stimulus conditions are varied from those present during training. This view is to be contrasted with the decremental spread of association concept which predicts a lower rate of responding under these conditions.

In addition, when the prevailing stimulus conditions are very different from the training conditions, and the animal is not responding, we may say that the animal is emitting some behavior other than that which was reinforced by the experimenter or, more generally, that the animal is not in the conditioned state. This response is designated as  $\bar{R}$  and is identified by the occurrence of long IRTs.

Following training with a VI schedule of reinforcement in the presence of some stimulus ( $S_1$ ), a model IRT category ( $R_1$ ) will emerge as the most probable response. If a generalization test is then conducted, the model IRT ( $R_1$ ) will appear with the greatest probability in the presence of the  $S_1$  training stimulus and with decreasing probability for the other test stimuli ( $S_n$ ) as a function of the stimulus distance from  $S_1$ . The IRT distribution for the  $S_n$  stimuli should show an increase in very long IRT categories which represent the unconditioned state ( $\bar{R}$ ). However, this approach predicts that no intermediate IRT categories will show an increase in frequency. The intermediate rates of responding which occur in the presence of the intermediate test stimuli will be

composed of a mixture of the  $R_1$  IRT category and the  $\bar{R}$  IRT.

Blough (1969) has reported data consistent with this view and has proposed a similar account based on decision theory. Subjects were reinforced for key pecking in the presence of one hue and then tested for generalization to adjacent stimuli on the hue dimension. Although the plotting of mean rates showed the typical peaked generalization gradient, an IRT analysis presented quite a different picture. The IRT's per opportunity (the conditional probability that a response will occur in an IRT category given that the category has been reached (Anger, 1956) ) were plotted as a function of test stimuli. These gradients were much flatter than the rate measures. As Blough points out "The effect is largely a result of the fact that at stimuli relatively distant from  $S_+$ , a rather high proportion of trials yield very few or no responses". It is by averaging over trials that the peaked gradients are obtained.

For the discrimination situation the same mechanism will apply except in this case there will be two operant rates present. Following training on a multiple schedule consisting of VI-1 min - Ext, a characteristic rate will develop to the  $S_1$  stimulus (VI-1 min) and a low or zero rate will develop to the  $S_2$  stimulus (Ext). In addition, the animal may be in the unconditioned state and the  $\bar{R}$  rate may appear. It may appear gratuitous in this case to distinguish between the rate appearing in the presence of  $S_2$  (the  $R_2$  rate) and the  $\bar{R}$  rate



since both are identified as consisting of long IRT's. However, a distinction can be made from a procedural stand point. The  $R_2$  rate has developed as a consequence of non-reinforced responding in the presence of the  $S_2$  stimulus while the  $\bar{R}$  rate was unconditioned.

Other differences between the  $R_2$  rate and the  $\bar{R}$  rate may be reflected in the errorless training procedure (Terrace, 1962). This procedure may be viewed as a technique which reduces the tendency of the animal to generalize from  $S_1$  to  $S_2$  by either gradually introducing  $S_2$  or by introducing  $S_2$  early in training. The initial low or zero rate ( $\bar{R}$ ) consequently, persists in the presence of  $S_2$ . Following training with errors, however, the low rate ( $R_2$ ) develops as a consequence of non-reinforcement. Terrace noted several differences between the behavior of animals depending upon whether the low rate in the presence of  $S_2$  resulted from errorless training or training with errors. The animals trained with errors displayed what Terrace termed emotional behavior in the presence of  $S_2$ , showed a rate increase in the presence of  $S_1$  (contrast), and in subsequent generalization testing revealed a shift in the peak of the gradient away from  $S_2$ . The errorless procedure resulted in none of these characteristics.

The failure to find peak shift following errorless training implies that the low rate emitted in the presence of  $S_2$  is not under stimulus control in the errorless situation. More direct evidence for this point is supplied by Lyons (1968).



Pigeons were trained with interdimensional stimuli as the  $S_+$  (hue) and  $S_-$  (line tilt). Following training with errors, the generalization gradient around  $S_-$  was U-shaped but after errorless training the gradient was flat, again, indicating that the low rate in the presence of  $S_2$  which results from errorless training is not under the control of  $S_2$ . The differences noted here between the low rates which are developed as a consequence of errorless training or of training with errors indicate that it is justifiable to distinguish between the low rates which result from conditioning ( $R_2$ ), and the unconditioned low rates ( $\bar{R}$ ).

In addition, Jenkins (1965) has argued that by making the distinction between inhibitory stimulus control ( $R_2$ ) and all other factors which result in non-responding ( $\bar{R}$ ), the characteristic shallowness of the inhibitory gradient can be explained. When the  $S_1$  stimulus is varied a decrease in  $R_1$  is observed which may be due to an increase in  $R_2$  or an increase in  $\bar{R}$  and when  $S_2$  is varied, losses in  $R_2$  may be reflected in an increase in  $R_1$  or an increase in  $\bar{R}$ . Consequently, when  $S_1$  is varied the losses which occur are in the direction of a lowered response rate. However, the losses occurring when  $S_2$  is varied are in opposite directions. As a result, a relatively shallow gradient is always expected for the inhibitory gradient.

The generalization gradient developed following multiple stimulus training reflects a composite of the rates established

during training. If responding in the presence of  $S_1$  has been reinforced on a VI-1 minute schedule, then test stimuli near  $S_1$  on the stimulus dimension will evoke the  $R_1$  rate a large proportion of the time. Testing with stimuli near  $S_2$  where  $S_2$  has been associated with extinction will result in the appearance of the  $R_2$  rate. If test stimuli intermediate to  $S_1$  and  $S_2$  are presented, a sharpening of the gradient will appear due to the increased probability of obtaining the  $R_2$  rate.

In the case where  $S_1$  and  $S_2$  are relatively close on the stimulus dimension, there will be an increased probability that the  $R_2$  rate will appear when  $S_1$  is presented. Thus, the rate of responding at  $S_1$  may be lower than the rate to other stimuli adjacent to  $S_1$  but further removed from  $S_2$ . In general, for the multiple schedules containing an extinction component, the generalization gradient interactions will be similar to those predicted by the model proposed by Spence (1937).

Results consistent with the preceding account of the multiple VI-1 minute - Ext situation are reported by Crites, Harris, Rosenquist, and Thomas (1967). These investigations examined the IRT distributions developed during generalization testing following discrimination training with two click frequencies. The rats had been reinforced for responding on a VI-1 minute schedule in the presence of a low click frequency and non-reinforced in the presence of a high click frequency. The results of the generalization tests indicated

that if mean interresponse times were plotted, a typical generalization gradient was obtained showing intermediate responding to intermediate stimuli. However, examination of the frequency distribution of IRT's revealed that the differences in the IRT's in the presence of the  $S^D$  and in the presence of the test stimuli consisted of a greater proportion of very long IRT's (greater than 10 seconds) which occurred in the presence of the test stimuli. The rats did not show a progressive increase in model IRT category with stimuli increasingly removed from the  $S^D$ .

The predictions made for the multiple stimulus situation involving two different schedules of reinforcement are similar to the predictions for the multiple situation where one component of the schedule is extinction. The  $S_1$  and  $S_2$  stimuli have been associated with the  $R_1$  and  $R_2$  response rates, and these rates will appear with some probability which varies as a function of the stimulus distance between the test stimuli and the training stimuli.

Migler and Millenson (1969) have reported behavior of this type in an experiment in which two incompatible responses were brought under the control of two different stimuli. Rats were trained to press the left bar ( $R_l$ ) in the presence of a low click frequency ( $S_l$ ) and to press the right bar ( $R_r$ ) in the presence of a high click frequency ( $S_r$ ). Reinforcement for the right bar was delivered on a VI-226 sec. schedule while a VI-30 sec. schedule was in effect for the left bar



responses. Subsequent generalization tests along the click frequency dimension revealed that the stimulus exerted control over which bar was pressed, but once the response had been selected, the rate of responding itself remained under the control of the prior schedule history. The subjects responded at their training rates for the left bar (high rate) and the right bar (low rate) with no tendency to respond at intermediate rates in the presence of intermediate stimulus values.

It is important to note that this account never predicts summation between two points of a stimulus dimension, each of which has a history of reinforcement associated with it, as does Hull's (1943) account. Rather, this account predicts that the rate observed in training will be present during testing and that intermediate points will be responded to at either of the two reinforced rates. If the rates to the intermediate points are inappropriately averaged across periods (perhaps within periods for the free operant case), then intermediate rates may result. This is due to the subjects' responding as if to  $S_1$  during one trial and as if to  $S_2$  during a second trial. However, even when rates are averaged across trials, summation can never occur but only some rate intermediate between  $S_1$  and  $S_2$ . This rate will approach  $S_1$  or  $S_2$  as a function of the stimulus difference between them and the test point.

The application of this conception of stimulus generalization provides a new interpretation of results obtained following

training on multiple schedules of reinforcement. In a training situation where  $S_1$  is reinforced on a VI-1 schedule and  $S_2$  is reinforced on a VI-5, the shape of the resulting gradient will depend on the stimulus distance between  $S_1$  and  $S_2$ . In the case where  $S_1$  and  $S_2$  are relatively close, this response strength due to generalization from  $S_1$  is greater than the response strength due to the VI-5 schedules around  $S_2$ . Since the resultant strength of responding around  $S_2$  is an average rather than a summation of the effects, the obtained generalization gradient shows a depression around  $S_2$  and, subsequently, an area shift or peak shift to the other side of  $S_1$ . This describes the results obtained by Guttman (1959) and Terrace (1966) where both used a multiple VI-1 - VI-5 schedule and training stimuli separated by a 20 nm wave-length difference.

In the case where  $S_1$  and  $S_2$  are further apart, as in the present experiment, the response strength around  $S_2$  due to generalization from  $S_1$  may be less than the strength due to the VI-5 schedule. The resulting generalization gradient now shows a double peak, but there may still be a lowering of the  $S_1$  gradient on the  $S_2$  side due to overlap between the gradients. This result was obtained in the present study (Figure 4) using a 38 nm stimulus difference and a VI-1 - VI-4 schedule. In the case of more extreme differences between  $S_1$  and  $S_2$  where the gradients around  $S_1$  and  $S_2$  do not overlap, both gradients should be peaked and symmetrical.

This same analysis would apply in the situation where

orthogonal stimuli are used. Weisman (1969) trained pigeons to respond to a stimuli consisting of a green key (VI-1) and a green key with a white vertical line superimposed (VI-5). The obtained generalization gradient along the line tilt dimension showed a shallow U-shaped gradient around  $S_2$ . Testing with the green background undoubtedly resulted in substantial generalized responding from the  $S_1$  stimulus, the blank green key. Thus, when the line tilt is varied from vertical during testing, the probability that the animal will respond at the  $S_2$  training rate is decreased and the probability of responding at the  $S_1$  rate is consequently, increased. The green background is still present and maintains the generalized response strength from  $S_1$  at a constant value.

This account is readily tested by using a training procedure similar to Weisman's. Instead of testing with the line tilt on the green background, however, the generalization test would consist of varying the line tilt on a neutral gray or black background. With the neutral background, the generalized strength from  $S_1$  (green key) would be reduced and a gradient peaked at the  $S_2$  (vertical line) should appear. As in the present experiment, the response strength at  $S_2$  would then be greater than the generalized response strength from  $S_1$ .

The present account in terms of the interaction of gradients around stimuli associated with different schedules of reinforcement offers a relatively simple explanation



that does not necessitate assuming that a stimulus can become "functionally negative" (Guttman, 1959) as a result of being paired with some other stimulus. Guttman's conclusion was based partly on the observation that there was very little responding to the  $S_2$  (VI-5) stimulus during the generalization test compared to the rate during training. Yet, it should be noted, that the rate to the  $S_1$  stimulus (VI-1) was even more depressed in terms of the absolute response rate. Apparently, Guttman's testing procedure resulted in unusually large extinction effects. Training had consisted of four alternating five minute stimulus periods while testing consisted of 120, random 30 second stimulus periods.

Terrace (1968) conducted a similar study but both the training and testing stimulus periods were one minute each. The response rate to  $S_1$  and  $S_2$  during testing was approximately the same as that during training. The negative effects around  $S_2$  which Guttman had observed did not occur. The only remaining evidence for functionally negative effects around  $S_2$  is the shape of the generalization gradient. However, the relative depression around  $S_2$  and the resulting peak shift away from  $S_2$  appear to be negative only if summation at  $S_2$  had been the expected outcome. The account offered here does not predict summation but averaging of response strengths at  $S_2$ . This account predicts either the occurrence of a depression or a second peak at  $S_2$  as a function of the relative res-

ponse strengths due to generalization from  $S_1$  and to the history of reinforcement at  $S_2$ .

One further prediction, concerning the occurrence of behavioral contrast, can be made. Following non-differential training in the presence of two different stimuli (Mult VI-1 - VI-1), responding in the presence of one of the stimuli ( $S_2$ ) is subsequently non-reinforced (Mult VI-1 - Ext). The response rate in the presence of  $S_2$  will decrease as training progresses. In addition, the response rate in the presence of  $S_1$  will show an increase eventhough the schedule of reinforcement associated with  $S_1$  has remained constant. This increase in rate has been termed behavioral contrast (Reynolds, 1961).

The occurrence of contrast would appear to be inconsistent with the model presented here since a new, higher rate is now present. However, as stated previously the response rate which is observed in the presence of the training stimulus is a mixture of the  $R_1$  rate and the  $\bar{R}$  rate (the unconditioned state). Thus, the probability of the  $R_1$  rate approaches unity as a limit. In order to account for contrast, the model must specify that those variables which result in the contrast effect must operate by decreasing the probability of the occurrence of the  $\bar{R}$  rate. This prediction is testable by examination of the change in the IRT distribution which occurs when contrast occurs. The model predicts that the model IRT category ( $R_1$ ) will not be shifted. The increase in rate will be due to a decrease in the frequency of long IRT's ( $\bar{R}$ ).

## APPENDIX

TABLE A

ANALYSIS OF VARIANCE FOR SEQUENCE TRAINING  
RESPONSE RATE OVER 15 DAYS

Source	df	MS	F
Between Subjects	23		
Sequence (A)	2	34,174.0	3.15
Schedule (R)	1	14,490.2	1.33
R X A	2	7,651.2	<1
Subjects within AR	18	10,841.3	
Within Subjects			
Days (D)	14	1,487.5	7.70***
A X D	28	444.4	2.30***
R X D	14	259.0	1.34
A X R X D	28	165.1	<1
D X Subj. within AR	252	193.0	
Stimuli (S)	1	450,400.0	54.1***
A X S	2	40,678.4	4.88*
R X S	1	68,250.2	8.19*
A X R X S	2	5,217.1	<1
S X Subj. within AR	18	8,325.0	
D X S	14	365.1	3.47***
A X D X S	28	223.2	2.12**
R X D X S	14	369.0	3.51***
A X R X D X S	28	77.6	<1
D X S X Subj. within AR	252	105.1	

\*\*\*

 $p < .001$ 

\*\*

 $p < .005$ 

\*

 $p < .025$



TABLE B  
ANALYSIS OF VARIANCE FOR LAST DAY OF SPECIAL  
SEQUENCE TRAINING VS THE FIRST  
DAY OF TRANSFER

Source	<u>df</u>	<u>MS</u>	<u>F</u>
Between Subjects	23		
Sequence (A)	2	5,449.7	2.94
Schedule (R)	1	31.5	<1
R X A	2	2,494.4	1.35
Subjects within AR	18	1,847.8	
Within Subjects	72		
Days (D)	1	1,033.6	10.84**
A X D	2	186.8	1.96
R X D	1	128.3	1.34
A X R X D	2	150.6	1.58
D X Subj. within AR	18	95.3	
Stimuli (S)	1	79,292.5	51.88***
A X S	2	8,192.7	5.36*
R X S	1	11,859.3	7.76*
A X R X S	2	1,528.5	1.0
S X Subj. within AR	18	1,528.2	
D X S	1	106.3	2.12
A X D X S	2	149.9	3.00
R X D X S	1	304.6	6.09*
A X R X D X S	2	161.3	3.22
D X S X Subj. within AR	18	49.9	

\*\*\*  
p < .001

\*\*  
p < .005

\*  
p < .025

TABLE C  
ANALYSIS OF VARIANCE FOR  
GENERALIZATION TEST 5

Source	<u>df</u>	<u>MS</u>	<u>F</u>
Between Subjects	23		
Sequence (A)	2	0.0	
Schedule (R)	1	.033	<1
R X A	2	.033	<1
Subjects within AR	18	.039	
Within Subjects	96		
Stimuli (S)	4	11,629.46	139.84***
A X S	8	180.86	2.17*
R X S	4	1,161.49	13.96***
A X R X S	8	286.90	3.44**
S X Subj. within AR	72	83.16	

\*\*\*

 $p < .001$ 

\*\*

 $p < .005$ 

\*

 $p < .05$

TABLE D

## GENERALIZATION TESTS - MEAN RATES

## VI1 - EXT SCHEDULE

Group	stimuli	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7
AE	501	42	32	12	18	10	20	13
	538(S+)	69	78	54	68	69	104	118
	555	33	15	10	12	4	3	1
	576(S-)	18	5	4	2	1	0	0
	606	11	2	1	1	0	0	0
EA	501	36	52	31	43	42	48	24
	538(S+)	38	71	53	61	73	81	68
	555	19	35	9	10	12	9	2
	576(S-)	5	10	2	3	2	2	1
	606	5	4	2	0	2	0	0
R	501	78	104	78	77	113	85	56
	538(S+)	108	127	114	134	141	162	133
	555	10	3	4	2	4	3	1
	576(S-)	1	1	7	10	6	3	1
	606	2	0	2	3	3	1	0



TABLE E  
GENERALIZATION TEST - MEAN RATES  
VI1 - VI4 SCHEDULE

Group	Stimuli	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7
AE	501	63	66	39	52	48	52	64
	538(S+)	81	80	51	64	81	66	81
	555	37	37	17	14	30	19	25
	576(S-)	20	33	18	20	43	33	39
	606	11	8	6	8	7	6	11
EA	501	53	68	48	55	51	60	52
	538(S+)	76	68	78	76	77	73	81
	555	25	33	29	25	28	19	14
	576(S-)	17	28	23	26	25	41	32
	606	4	4	4	1	4	1	1
R	501	54	36	41	57	35	27	22
	538(S+)	96	77	85	89	85	59	85
	555	31	31	21	28	22	12	15
	576(S-)	18	31	23	39	25	28	30
	606	6	3	1	1	0	1	0

## REFERENCES

- Anger, D. The dependence of interresponse times upon the relative reinforcement of different interresponse times. Journal of the Experimental Analysis of Behavior, 1956, 52, 145-161.
- Blough, Donald, S. Generalization gradient shape and summation in steady-state tests. Journal of the Experimental Analysis of Behavior, 1969, 12, 91-104.
- Crites, Richard J., Harris, R. T., Rosenquist, H. and Thomas, David R. Response patterning during stimulus generalization in the rat. Journal of the Experimental Analysis of Behavior, 1967, 10, 165-168.
- Ellis, W. R. Role of stimulus sequences in stimulus discrimination and stimulus generalization. Journal of Experimental Psychology, 1970, 83, 155-163.
- Falk, J. L. Schedule induced polydipsia as a function of fixed interval length. Journal of the Experimental Analysis of Behavior, 1966, 9, 37-39.
- Friedman, H. and Guttman, G. Further analysis of the various effects of discrimination training on stimulus generalization gradients. In D. I. Mostofsky (Ed.) Stimulus Generalization, Stanford: Stanford University Press, 1965, Pp. 255-267.
- Guttman, N. Generalization gradients around stimuli associated with different reinforcement schedules. Journal of Experimental Psychology, 1959, 58, 335-340.

- Hanson, H. M. Effects of discrimination training on stimulus generalization. Journal of Experimental Psychology, 1959, 58, 321-334.
- Honig, W. K., Thomas, D. R., and Guttman, N. Differential effects of continuous extinction and discrimination training on the generalization gradient. Journal of Experimental Psychology, 1959, 58, 145-152.
- Hull, C. L. Principles of Behavior. New York: Appleton-Century, 1943.
- Jenkins, H. M. Generalization gradients and the concept of inhibition. In D. I. Mostofsky (Ed.), Stimulus Generalization, Stanford: Stanford University Press, 1965, Pp. 55-61.
- Kamin, L. J. Selective association and conditioning, In N. J. Mackintosh (Ed.), Fundamental Issues In Associative Learning, Halifax: Dalhousie University Press, Pp. 42-63.
- Laties, V. G., Weiss, B., Clardk R. L., and Reynolds, M. D. Overt "mediating" behavior and the discrimination of time. Journal of the Experimental Analysis of Behavior, 1965, 8, 107-116.
- Laties, V. G. Weiss, B., and Weiss, A. B. Further observations on overt mediating behavior and the discrimination of time. Journal of the Experimental Analysis of Behavior, 1969, 12, 43-57.
- Lyons, J. Stimulus generalization as a function of discrimina-



tion learning with and without errors. Science, 1959, 163, 490-491.

Migler, B. and Millenson, J. R. Analysis of response rate during generalization. Journal of the Experimental Analysis of Behavior, 1969, 12, 81-87.

Morse, W. H. Intermittent reinforcement. In W. K. Honig (Ed.), Operant Behavior: Areas of Research and Application. New York: Appleton-Century-Crofts, 1966, Pp. 52-108.

Pavlov, I. P. Conditioned Reflexes. Trans. and ed. by G. V. Anrep. London: Oxford University Press, 1927.

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

Spence, K. W. The differential response in animals to stimuli varying within a single dimension. Psychology Review, 1937, 44, 430-444.

Segal, E. F. and Holloway, S. M. Timing behavior in rats with water drinking as a mediator. Science, 1963, 140, 888-889.

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.

Terrace, H. S. Discrimination learning, the peak shift, and behavioral contrast. Journal of the Experimental Analysis of Behavior, 1969, 11, 727-741.

Weisman, R. G. Some determinants of inhibitory control.

Journal of the Experimental Analysis of Behavior, 1969, 12, 443-450.

Weisman, R. G. and Palmer, J. A. Factors influencing stimulus control: discrimination training and prior non-differential reinforcement. Journal of the Experimental Analysis of Behavior, 1969, 12, 229-238.



