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The post-discrimination gradient as a function of discrimination training on a line-tilt continuum.

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THE POST-DISCRIMINATION GRADIENT AS A FUNCTION OF DISCRIMINATION TRAINING ON A LINE-TILT CONTINUUM

by

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ABSTRACT

Following preliminary and S+ only training, three groups of pigeons were trained to discriminate between line-tilts of 0^{o} vertical (S+) and 30^{o}, 45^{o}, or 60^{o} to the right of vertical respectively. A control group, following a post-S+ only training generalization test, was trained to discriminate between S+ and a lighted key with no line. All Ss were then extinguished to 12 line orientations. While behavioral contrast was observed, no experimental S showed a peak shift in the post-discrimination generalization gradient. These results were interpreted as providing some evidence to render questionable the validity of generalizing from peak shift results obtained using the dimension of wavelength to the dimension of angularity since the results suggest that the peak shift is not always obtained using line tilt as the stimulus dimension.

PREFACE

The author wishes to express his gratitude and appreciation to Dr. Theodore Hirota under whose direction the present research was conducted. His willingness to give of his time and knowledge made the carrying out of the research much less burdensome than it might have been. Grateful appreciation is also extended to Drs. Arthur Smith and Theodore Horvath for their help and constructive criticism which they made available to the author throughout the course of the experiment.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

The purpose of the present study was to replicate Hanson's (1959) peak shift (PS) results using line-tilt as the stimulus dimension. The PS has been defined by Bloomfield (1967) as a:

> displacement of the maximum point of the generalization gradient from the reinforcement correlated stimulus (S^+) in a direction away from the negative, extinction correlated stimulus (S-) after discrimination training.

The significance of such a study is perhaps more suitably discussed in the light of some general background information concerning the phenomenon of the PS and some of the relevant variables.

Background of Related Research

In a study of the effects of discrimination training on the stimulus generalization gradient, Hanson (1959) demonstrated that under certain conditions the peak of the post-discrimination gradient (PDG) shifts away from the conditioned stimulus. He also demonstrated that the slope of the PDG correlated with S- would be steeper than that correlated with S^+, resulting in an area shift in the PDG away from S^+ in a direction away from S-.

Using pigeons, Hanson trained four groups of Ss to discriminate between 550 mμ (S^+) and 555, 560, 570, or 590 mμ (S-). He then tested for generalization to 13 stimuli, including the training S^+ and S- (except for the 555 mμ group). Using Spence's (1937) model, Hanson

made six specific predictions with regard to the PDG:

a) The post-discrimination gradient will be steeper than the generalization gradient in the region of S-.

b) If a complete discrimination is developed the value of the post-discrimination gradient will be zero at S-.

c) The mode of the post-discrimination gradient will be displaced away from S- in relation to the mode of the generalization gradient.

d) The magnitude of this displacement will increase as the S^+, S- difference is reduced.

e) The maximum heights of the post-discrimination gradients will be reduced as the S^+, S- difference is reduced.

The first three predictions were clearly supported by the results (although the second prediction appears to be a tautology since a complete discrimination implies, by definition, no responding). All but three of the 24 experimental Ss showed a PS in the PDG. Hanson claimed that the fourth prediction, that the magnitude of the modal displacement increases as the S^+, S- difference decreases, was also supported. However, an examination of the mean generalization gradients for the discrimination groups reveals that the mode of each gradient was at the 540 mμ stimulus. Thus, the amount of modal displacement in the PDGs with respect to the mode of the control gradient was the same for all groups. The last two predictions were not confirmed by the results.

Other experimenters have demonstrated this PS effect: Honig, Thomas & Guttman (1959); Honig (1962); Terrace (1964, 1966);

Friedman and Guttman (1965); Yarczower, Dickson & Gollub (1966); Stevenson (1966); and Thomas and Burr (1969). All the above studies used wavelength generalization in pigeons to demonstrate the PS effect. Citing the failure of Jenkins and Harrison (1960) to demonstrate the PS using an auditory continuum, Guttman (1965) suggested that the PS may be specific to wavelength. However, using tones as discriminative stimuli, Pierrel and Sherman (1960) obtained a PS in rats. Bloomfield (1967) and Thomas and Lyons (1968) have also obtained a PS on a line-tilt continuum with pigeons.

Several variables are known to be related to the occurrence of the PS. The first is the kind of discrimination training that is given. Orthogonal discrimination training (the discriminative stimuli are not on the same physical continuum) results in a symmetrical gradient with the peak at S^+ (Guttman and Kalish, 1956). Non-orthogonal discrimination training (the discriminative stimuli are both on the same physical continuum) results in a PS (cf: Hanson, 1959). The discrimination is established by differential reinforcement of the stimuli.

A second important variable is the amount of responding to S- during discrimination training. Terrace (1964) devised a procedure that minimizes the amount of responding to S- which he called "errorless learning". The low S- response rate was achieved by introducing S- for very short presentations (2 sec) after preliminary training on S^+. The duration of S- presentations was then gradually increased but Ss made few, if any, responses to S-. Learning with errors occurs when Ss respond to S- early in training with a subsequent

gradually decreasing response rate. Terrace found that when the discrimination was acquired without errors there was no PS in the PDG.

In a subsequent study, Terrace (1966) found that as the amount of discrimination training increased, the PS was eliminated. After 30 sessions of discrimination training (approximately 1500 min) all 4 Ss showed the PS. After 45 discrimination sessions only two of the 4 Ss showed the phenomenon. Only one of 4 Ss showed a PS after 60 training sessions.

Characteristics of the PDG are also related to the method of stimulus presentation during training. Honig (1962) has shown that if the discriminative stimuli are presented simultaneously there is no PS. Successive presentation of S^+ and S- seems to be critical.

Yarczower et al. (1966), by manipulating schedules of reinforcement to elicit comparable response rates to both discriminative stimuli while maintaining differential reinforcement, have shown that such comparable rates of responding eliminate the PS. Yarczower, Gollub & Dickson (1968) equated frequency of reinforcement in the two components of a MULT schedule which yielded different response rates. The PS was observed. These studies indicate that the frequency of reinforcement is not a factor in obtaining a PS provided there is a difference in response rates to S^+ and S-.

The present study was conceived as a result of failure to obtain a PS in three different studies. The first, by Hirota, Kitson & Gray (1969), involved two experiments, both using line-tilt and colour. In the first experiment, Shift - No-shift, pigeons were trained to discriminate between a red line tilted 15° left of vertical and

superimposed on a red tinted background (S^+) and a similar line tilted 15^o right of vertical (S-) for the shift condition. For the no-shift condition, the discrimination was orthogonal: a green line tilted 15^o left of vertical on a green tinted background (S^+) and an unlit key (S-). Subjects were tested for generalization to nine line orientations (including the training stimuli) with colour alternating evenly and the line orientations varying randomly. The second experiment involved a Shift Left - Shift Right situation. For the shift left condition, S^+ and S- were the same as in the shift condition of the first experiment. For the shift right condition, S^+ was a green line tilted 15^o right of vertical on a green tinted background, and S- was a similar line tilted 15^o left of vertical. In both experiments the appropriate discriminations were readily acquired but the PDGs showed no PS. The authors suggested that the failure to obtain the PS might have been due to the within subject design of the generalization test.

This suggestion led to a second attempt to obtain the PS. Gray (1970) essentially replicated the Shift - No-shift experiment of Hirota et al. (1969) except that Ss were tested for generalization under either the shift or the no-shift condition, but not both together. Again, the appropriate discriminations were easily and rapidly acquired but no PS materialized in the PDG of the shift condition.

A third study, Clarkson (1970), attempted to examine the effects of amount of discrimination training on the development of the PS. Using a line-tilt continuum, pigeons were trained to discriminate between a vertical black line on a white light background (S^+) and a similar line tilted 30^o right of vertical (S-). After 12 daily post-

criterion discrimination training sessions, control Ss were extinguished to 12 line orientations. For the experimental group, generalization tests were interspersed through discrimination training. Subjects were tested for generalization on the day following attainment of the criterion. A second generalization test was given after six post-criterion training sessions, and a third test after 12 post-criterion training sessions. Again, neither group showed a PS.

In the above three studies, a VI 30 sec schedule of reinforcement was used. In the studies cited as references by these experimenters, a VI 1 min schedule was generally used. However, the literature does not indicate that this difference was responsible for the absence of the PS. Hearst, Koresko & Poppen (1964) have shown that VI 30 sec and VI 1 min schedules lead to comparable gradients of stimulus generalization. In terms of the PS, Yarczower et al. (1966) obtained a PS using a VI 30 sec schedule. Their PDG is quite comparable to that obtained with a VI 1 min schedule (cf: Thomas and Burr, 1969). This suggests that the use of the VI 30 sec schedule as opposed to the VI 1 min does not account for the absence of the PS in the three studies under consideration.

A review of the literature cited in these three studies revealed that in all the PS studies, Ss had been given some single stimulus training to S+ (S+ only training) before acquiring the appropriate discrimination. S+ only training in all but Bloomfield's (1967) study entailed presentations of the stimulus that was to be used as S+ in subsequent discrimination training for a certain duration (generally 1 min) separated by time outs which generally lasted two to five seconds. Bloomfield (1967) did not have the time out periods. In all

cases reinforcement was administered on a VI schedule. In discussing his results, Clarkson (1970) adverted to this presence of S^+ only training and suggested that such training was a critical factor in obtaining the PS. He concluded that the ratio of exposure to S- to exposure to S^+ must be less than unity. For example, Bloomfield (1967) gave his Ss 14 daily one hour S^+ only training sessions followed by 14 daily one hour sessions of discrimination training on a MULT VI 1 min EXT schedule (with S^+ and S- each present for 30 min per session). The resulting S-:S^+ ratio (in terms of minutes) would be 420:1260. Clarkson gave his Ss no S^+ only training prior to discrimination training. Since there was equal exposure to S^+ and S- during discrimination training, the ratio in this case was unity.

The literature also indicates that most PS studies have used wavelength as the stimulus dimension. A few studies have demonstrated the PS using other dimensions (Bloomfield, 1967, and Thomas and Lyons, 1968, used line-tilt; Pierrel and Sherman, 1960, used an auditory dimension). The paucity of PS studies using dimensions other than wavelength suggests the following question: is the PS reliably obtained using another stimulus dimension? The literature does not generally report negative results. It is, therefore, difficult to determine how often experimenters have failed to obtain a PS. The point is an important one. To generalize validly from the results obtained using one stimulus dimension to situations involving another dimension requires that the results be reliably obtainable in the second situation. Thus, if Bloomfield's (1967) results, for example, represent only one successful outcome against a background of several failures to obtain a PS, it is difficult to see how it can be argued

that the PS is reliably obtained using a line-tilt dimension.

Because the PS was not obtained in the three studies cited above, it seemed appropriate to attempt to replicate Hanson's (1959) results using line-tilt as the stimulus dimension. Successful replication would indicate two things. Further evidence of the reliability of the phenomenon using the line-tilt dimension would be obtained. Secondly, since the PS was not obtained in the Clarkson (1970) study in the absence of S^+ only training prior to discrimination training, replication of Hanson's results would point to the importance of such S^+ only training in obtaining a PS, a fact not adverted to in the literature.

Purpose of Present Research

The present study, therefore, was designed to replicate Hanson's results using a line-tilt contimuum in order to determine whether there is empirical evidence justifying generalizing from results of PS studies using wavelength to the dimension of angularity. Three experimental groups and a control condition were used. After preliminary and S^+ only training, the three experimental groups were given discrimination training with 0° (vertical line) as S^+ and a line tilted 30°, 45°, or 60° right of vertical as S-. These discrimination groups are henceforth designated by the respective S- stimulus used. After discrimination training, these groups were tested for post-discrimination generalization to a variety of line orientations. A control group was tested for generalization after S^+ only training and again after orthogonal discrimination training.

On the basis on Hanson's (1959) study, the following hypotheses

were tested.

I. The PDGs of experimental groups will be steeper than the PDG of the control group in the region of S^+.

II. The mode of the experimental PDGs will be displaced away from S- in relation to the mode of the control gradient.

III. The magnitude of this displacement will increase as the S^+, S- difference is reduced.

The independent variables were the presence or absence of non-orthogonal discrimination training, and line orientation. The dependent variable was the mode of the PDG.

CHAPTER II

METHOD

Subjects

Twenty commercially obtained and experimentally naive male white Carneaux pigeons served as Ss. Subjects were 6 - 12 months old at the beginning of the experiment and were reduced by food deprivation to, and then maintained throughout the experiment at, approximately 80% of their free-feed body weight. There was ad lib access to water in Ss' home cages. Subjects were randomly assigned to four groups of five at the beginning of training: 30^{o}, 45^{o}, 60^{o}, and control groups.

Apparatus

Two standard Leheigh Valley 2-key pigeon chambers were used. The left key in each chamger was covered. Stimuli were projected onto the back of the right transparent response key by Grason-Stadler In-line Digital display units. Black lines, 2.5 cm long and 3 mm wide on a white light background, could be projected at 12 different orientations ranging from horizontal through 180^{o} in 15^{o} steps. Reinforcement consisted of a 4 sec access to a lighted food hopper containing a grain mixture. During reinforcement the stimulus key and house light were out. The light in the food hopper was on only when reinforcement was available. To mask extraneous sounds, white noise was provided in the experimental chambers through speakers. A separate speaker mounted on the wall in the room where the chambers were housed also provided

white noise. Experimental sessions were programmed from a separate room by relays, timers, and steppers. Responses and reinforcements were recorded on counters and on cumulative recorders.

Procedure

Preliminary Training. This training comprised four daily sessions. On Day 1, Ss were adapted to the experimental chambers. (Each S received all training and testing in the same chamber.) The house light was on but the response key was covered. Subjects received no reinforcement. Each S remained in the chamber for 30 min. On Day 2, with the response key still covered, Ss were magazine trained. This training was terminated after 60 reinforcements. On Day 3, a vertical black line (S^+) was projected on to the response key and the key peck response was shaped using the method of successive approximation. Shaping was terminated after 60 reinforcements. On Day 4, 60 CRFs to S^+ were given.

S^+ Only Training. This training commenced on the day following preliminary training. Each S received 14 daily sessions of S^+ only training on a VI 1 min schedule, each session lasting one hour, including feeding time. S^+ was continuously present except during reinforcement.

Discrimination Training. Each S in the three experimental groups received 14 daily sessions on a MULT VI 1 min EXT schedule with randomly alternating 2 min periods on each component (with the restriction that runs of either component never exceeded two). VI 1 min and EXT components were separated by a 4 sec black out. S^+ was present during the VI 1 min component. During EXT the stimulus was a

black line tilted 30°, 45°, or 60° to the right of vertical (S-) for the respective experimental groups. Each stimulus appeared an equal number of times during each session (cf: Appendix A). Daily sessions were terminated at the end of one hour (excluding feeding time). Each S was run at approximately the same time each day. Control Ss received orthogonal discrimination training in which S+ was the 0° line and S- was a lighted key with no line.

Generalization Test. This test occurred on the day following the 14th session of discrimination training for experimental Ss and, for control Ss, on the days following S+ only training and orthogonal discrimination training. Subjects were extinguished to 12 line orientations (including the training stimuli) which varied from 90° left of vertical through 90° right of vertical in 15° steps. Stimuli were presented for 30 sec periods, separated by a 4 sec black out. Each line orientation was presented a total of eight times. The line orientations were randomly presented with the restriction that no stimulus could succeed itself (cf: Appendix B).

CHAPTER III

RESULTS

S+ Only Training

Figures 1a, 1b, 1c and 1d show the mean response rates across all sessions for the four groups, control, 30^{o}, 45^{o}, and 60^{o} respectively. (The performance of individual Ss in each group is recorded in Appendix C.)

Discrimination Training

One S from the 60^{o} group failed to acquire the discrimination and was dropped from the experiment. Figures 2a, 2b, 2c, and 2d show the mean response rates to S+ and S- for the control, 30^{o}, 45^{o}, and 60^{o} groups respectively. The results indicate that each group had acquired the appropriate discrimination by Session 6 and that performance was relatively stable throughout the remaining training sessions. These figures also indicate that each group showed the phenomenon of behavioral contrast (cf: Reynolds, 1961). Responses per session for each S are recorded in Appendix D.

Generalization Test

The test for control Ss following S+ only training resulted in flat gradient across all Ss. During S+ only training, S+ was on continuously (except during reinforcement). Using this same procedure, Blough (1959) and Thomas, Klipec & Lyons (1966) have obtained gradients of generalization. However, Jenkins and Harrison (1960) and Newman

and Baron (1965) obtained gradients only when no stimulus or an orthogonal stimulus occurred between S^+ periods. They obtained flat gradients when S^+ had been on continuously. Thus, the evidence is somewhat conflicting in this regard.

In view of the flat gradients obtained in this particular case, control Ss were given 14 sessions of orthogonal discrimination training and then retested for generalization.

Mean relative PDGs were computed for each group by averaging the percentage of total responses of all Ss in a group to each test stimulus. These results are shown in Figures 3a, 3b, 3c, and 3d for the control, 30°, 45°, and 60° groups respectively. For all groups the mode of the PDG was at S^+. (Responses to each test stimulus are recorded for each S in Appendix E.) Thus, when compared to the control gradient, none of the experimental groups showed a PS.

Individual PDGs were treated as grouped frequency distributions (cf: Thomas and Burr, 1969) and the mean of each frequency distribution was computed. An analysis of variance was done to determine whether there were any significant differences among the group means. Table 1 shows the results of this analysis. The Newman-Keuls comparisons revealed that the 30° group differed significantly ($p < .05$) from all other groups as shown in Table 2.

Using the total number of responses by a S as an estimation of the area under the generalization gradient (cf: Hanson, 1959), an analysis of variance was done to test the hypothesis that the areas under the curves did not differ significantly among groups. To achieve

Table 1

Analysis of Variance of the Means of the Generalization Gradients by Treatment Groups

Source	df	SS	MS	F
Treatment	3	510.50	170.17	5.11*
Error	15	499.56	33.30	
Total	18	1010.06		

*$F_{.05}$ at 3 & 15 df = 3.29

Table 2

Newman-Keuls Comparisons of Means
of the Generalization Gradients

	C	60°	45°	30°
C	----	3.19	4.90	14.08*
60°		----	1.71	10.89*
45°			----	9.18*
30°				-----

*p <.05

homogeneity of variance, the raw scores were subjected to a square-root transformation. Table 3 presents the results of the analysis of the transformed data. Table 3 shows that areas under the curves were comparable.

Given equal areas under the respective mean generalization gradients, in order to test for differences in height among the gradients, the number of responses to the modal stimulus (0^{o}) for each S was subjected to a square-root transformation and an analysis of variance was done. Table 4 shows that there were no significant differences among groups in the height of the gradient at the modal stimulus.

Table 3

Analysis of Variance of the Means
of Total Responses During
Generalization by Treatment Groups

Source	df	SS	MS	F
Treatment	3	165.965	55.322	0.47
Error	15	1753.026	116.868	
Total	18	1918.991		

$F_{.05}$ at 3 & 15 df = 3.29

Table 4

Analysis of Variance of Means of Total Responses to the Modal Stimulus of the Generalization Gradient by Treatment Groups

Source	df	SS	MS	F
Treatment	3	81.911	27.304	1.57
Error	15	260.123	17.342	
Total	18	342.034		

$F_{.05}$ at 3 & 15 df = 3.29

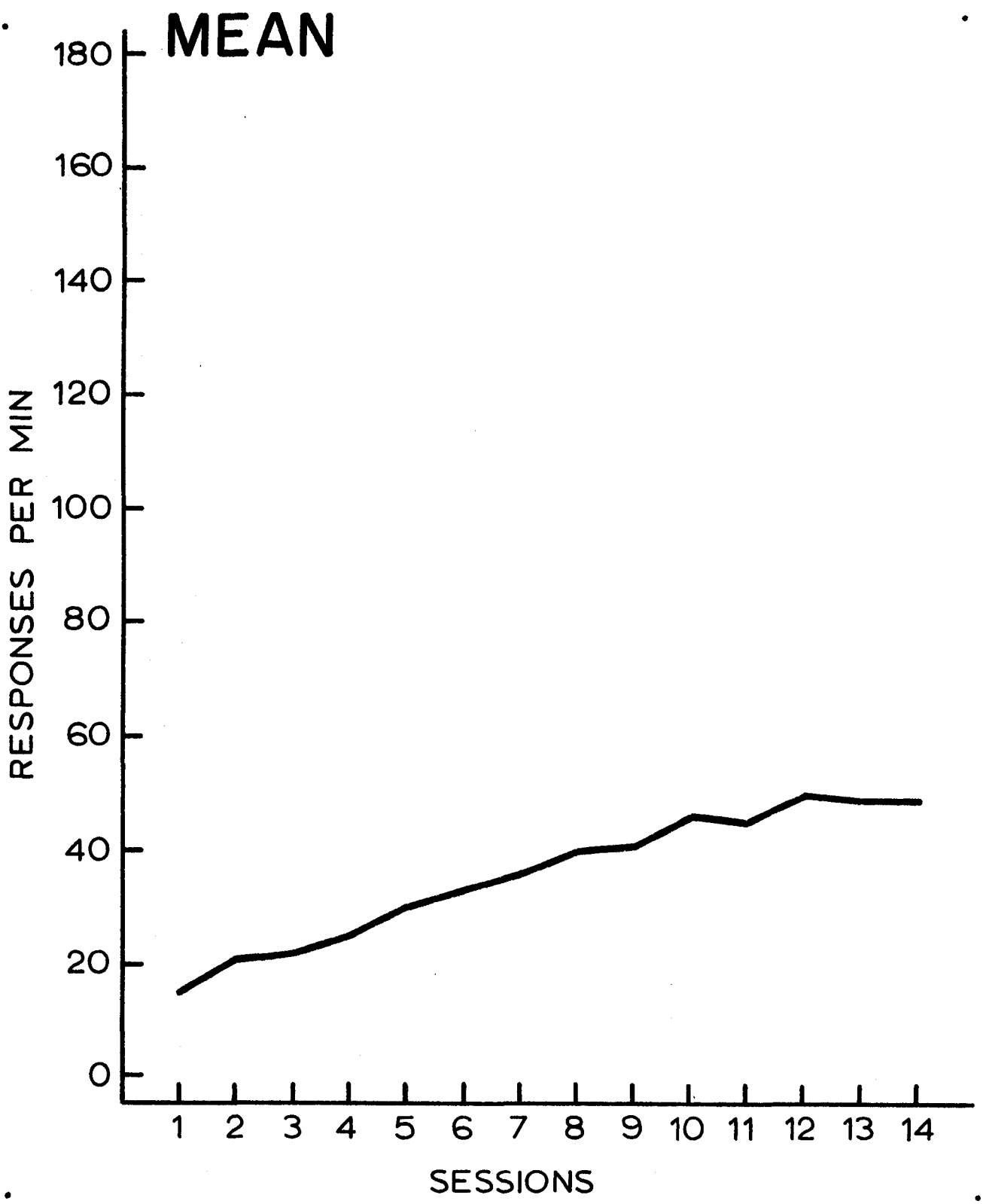

Fig. 1a Mean Response Rate as a Function of S^+ Only Training Sessions - Control Group.

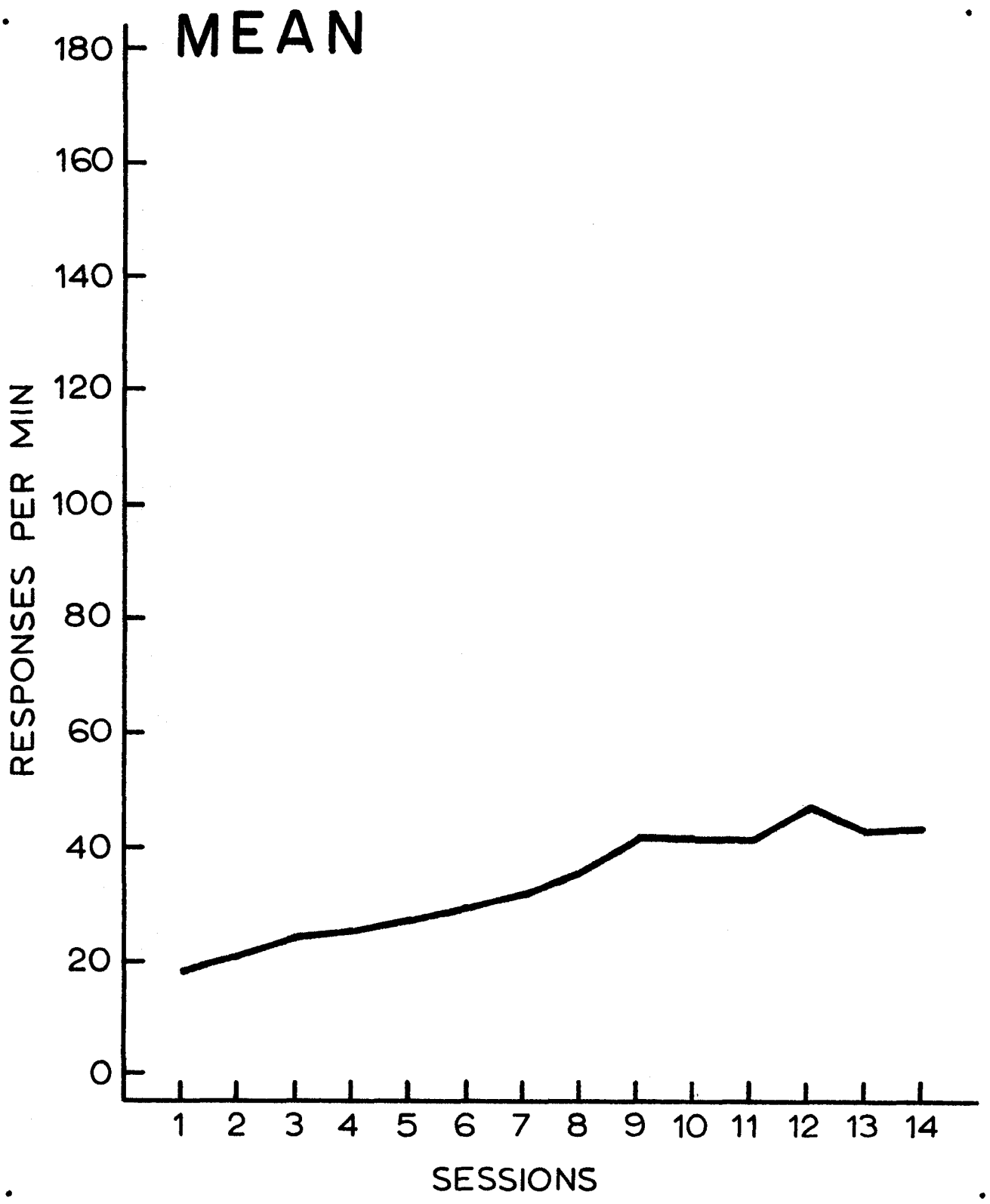

Fig. 1b Mean Response Rate as a Function of S+ Only Training Sessions - 30° Group.

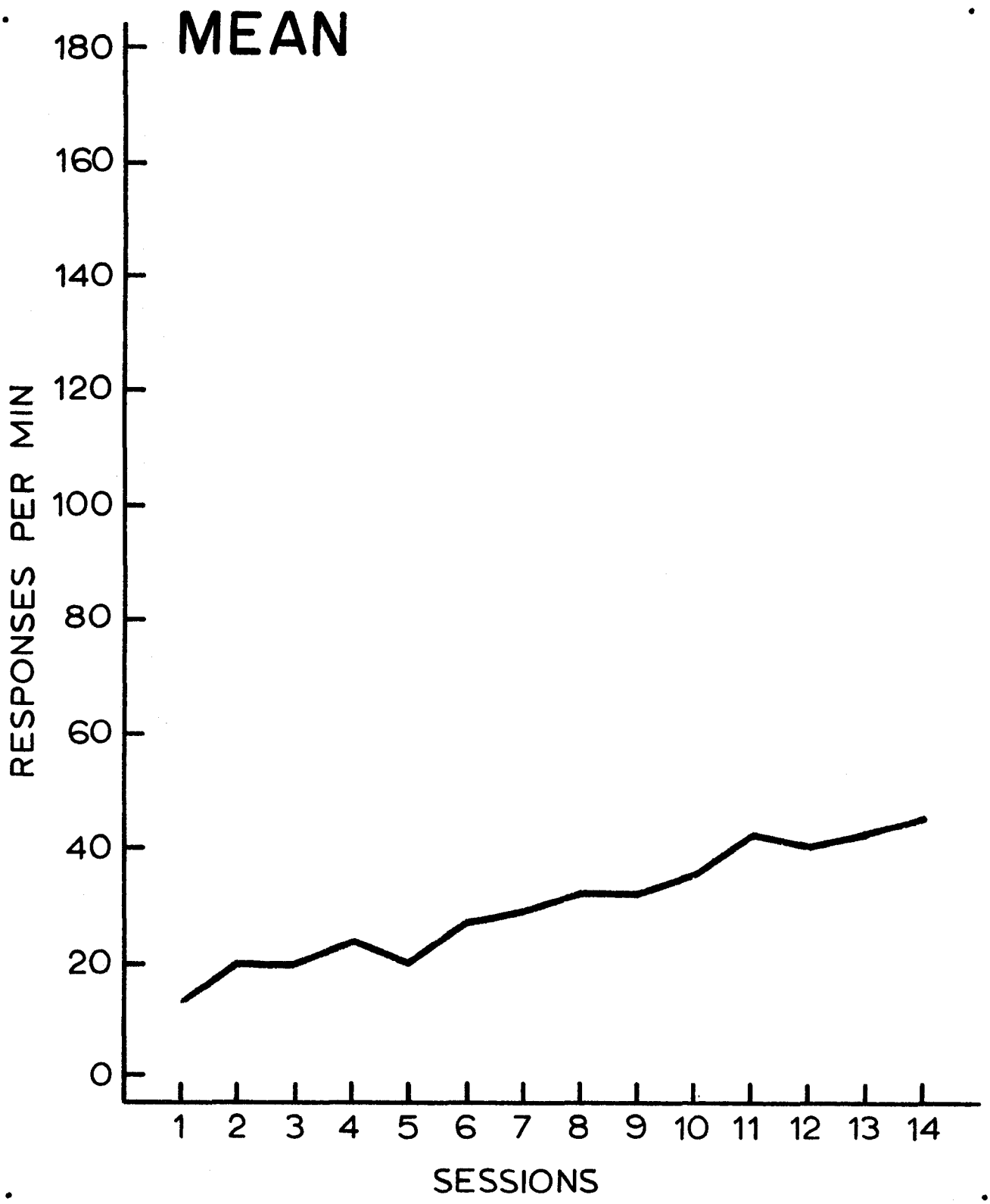

Fig. 1c Mean Response Rate as a Function of S+ Only Training Sessions - 45° Group.

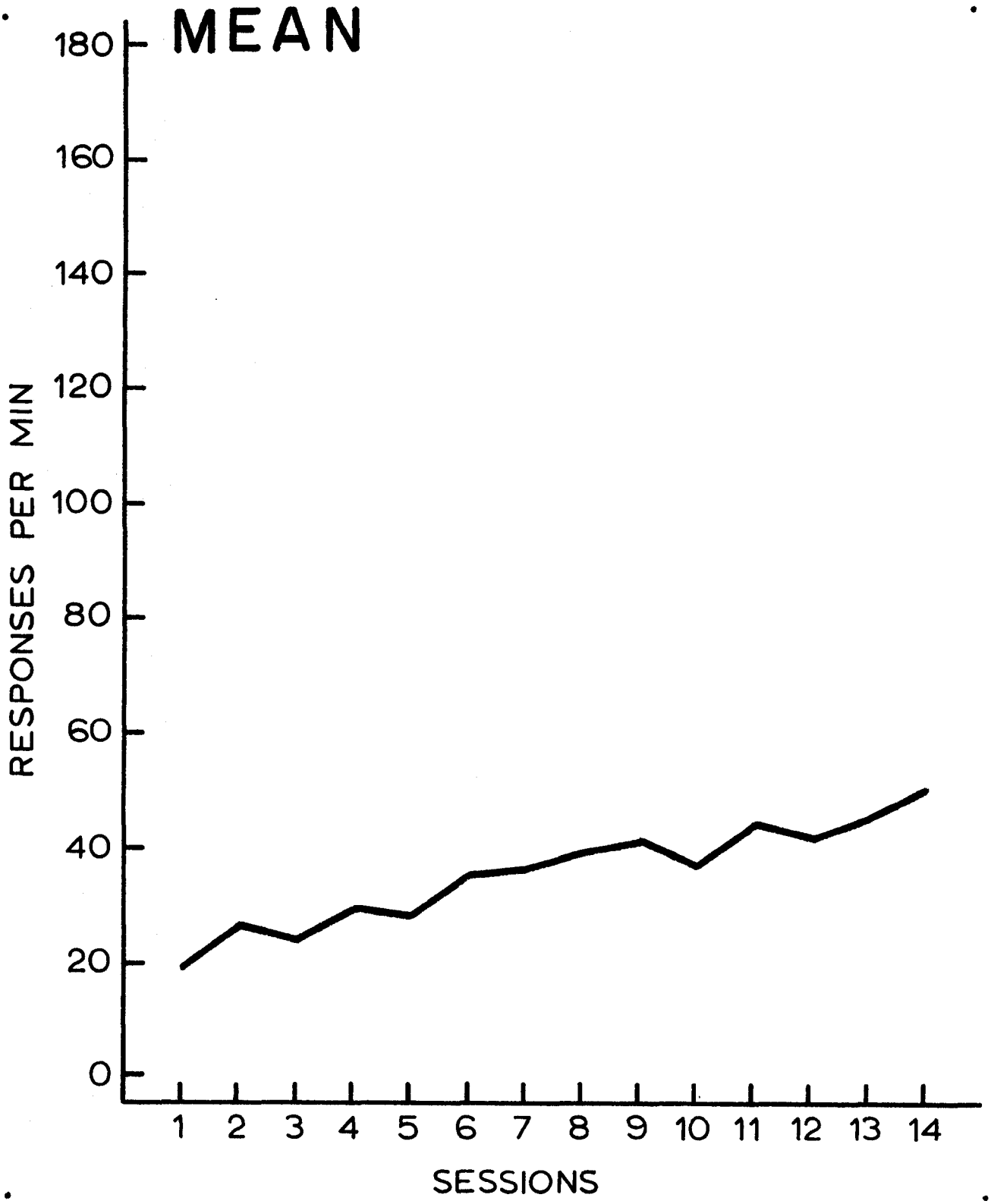

Fig. 1d Mean Response Rate as a Function of S+ Only Training Sessions - 60° Group.

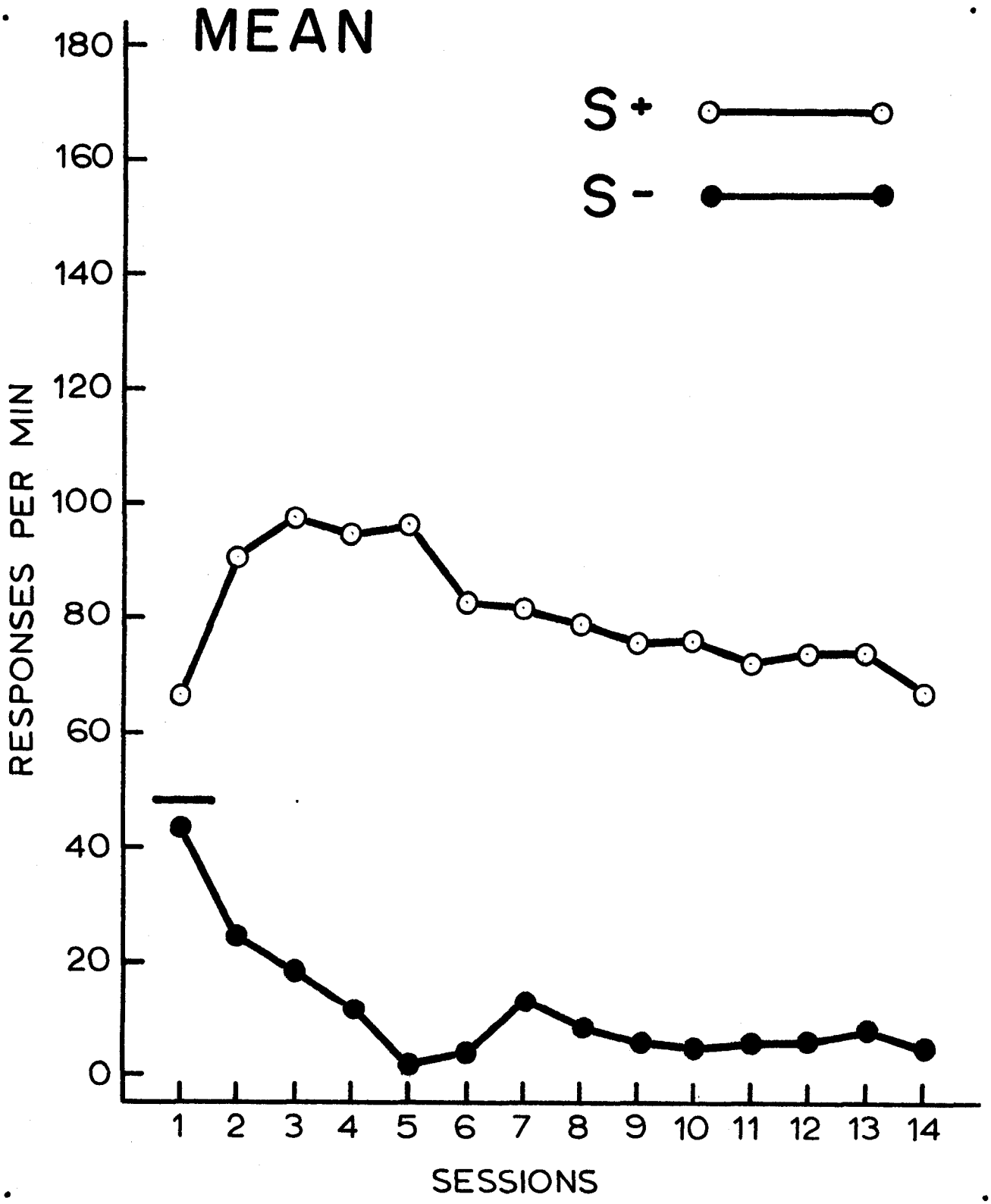

Fig. 2a Mean Response Rate as a Function of Discrimination Training Sessions - Control Group: S- = no line. Horizontal Line Represents the Mean Response Rate for the Last Four Days of S+ Only Training.

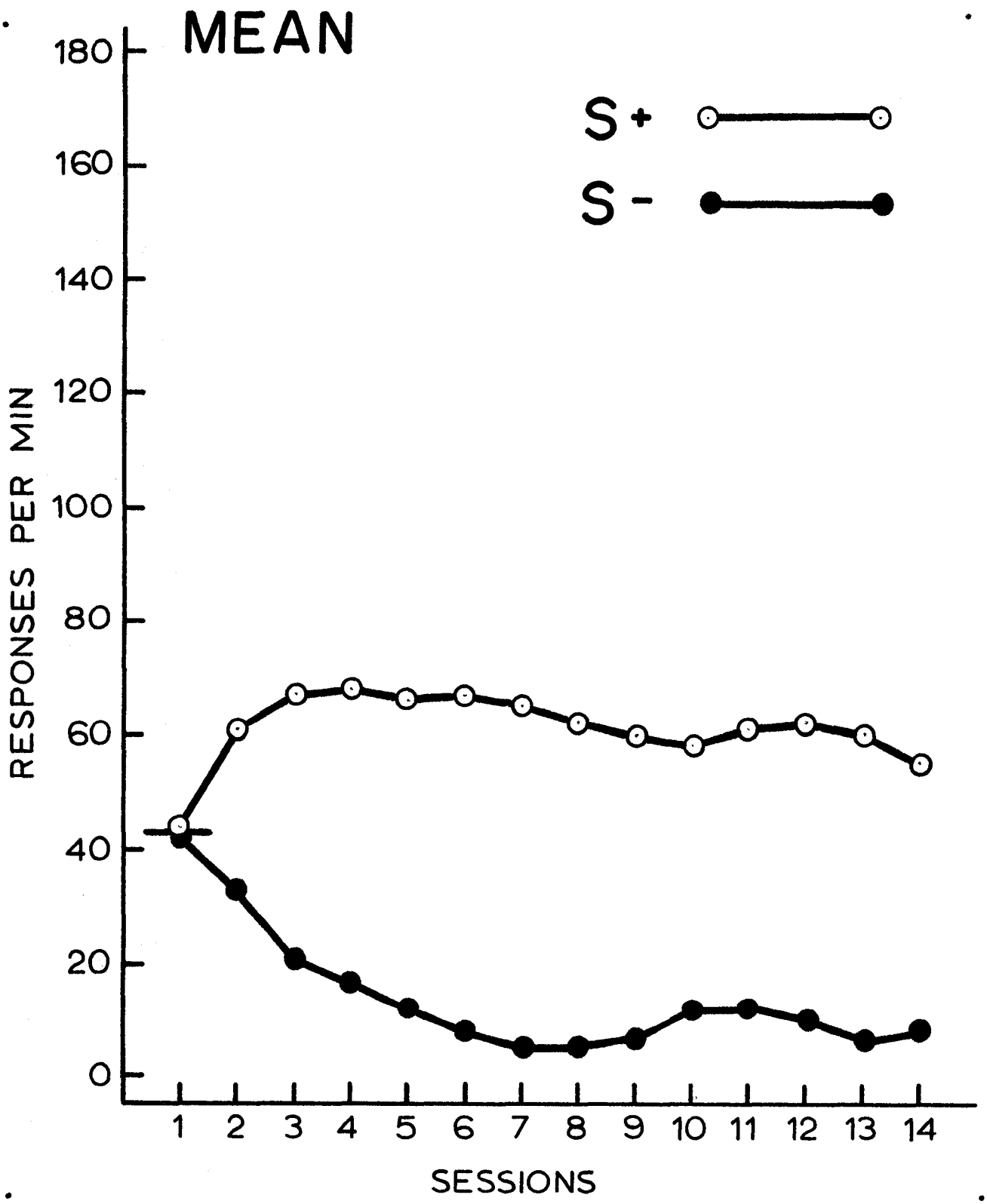

Fig. 2b Mean Response Rate as a Function of Discrimination Training Sessions - S- = 30°. Horizontal Line Represents the Mean Response Rate for the Last Four Days of S+ Only Training.

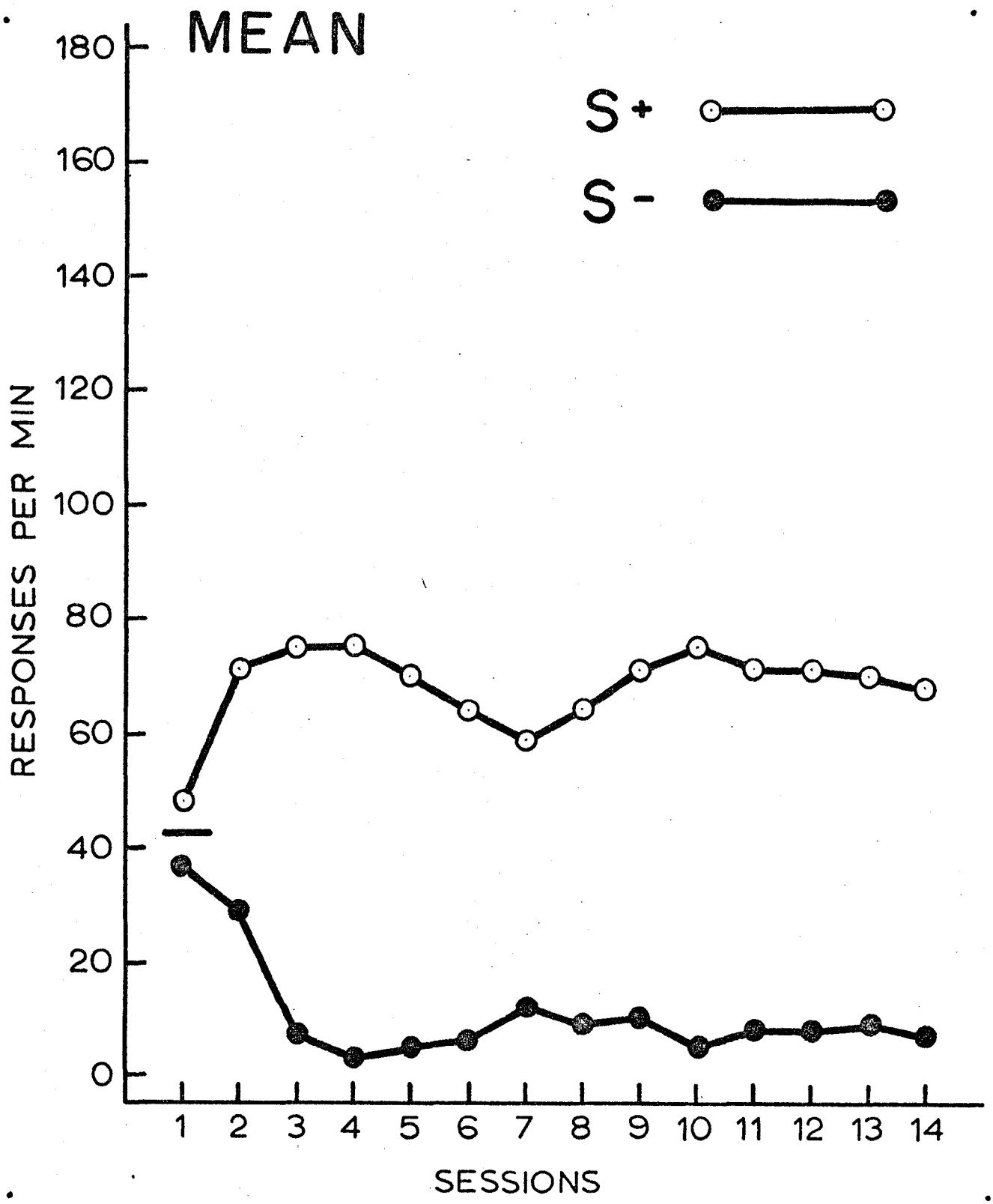

Fig. 2c Mean Response Rate as a Function of Discrimination Training Sessions - S- = 45°. Horizontal Line Represents the Mean Response Rate for the Last Four Days of S+ Only Training.

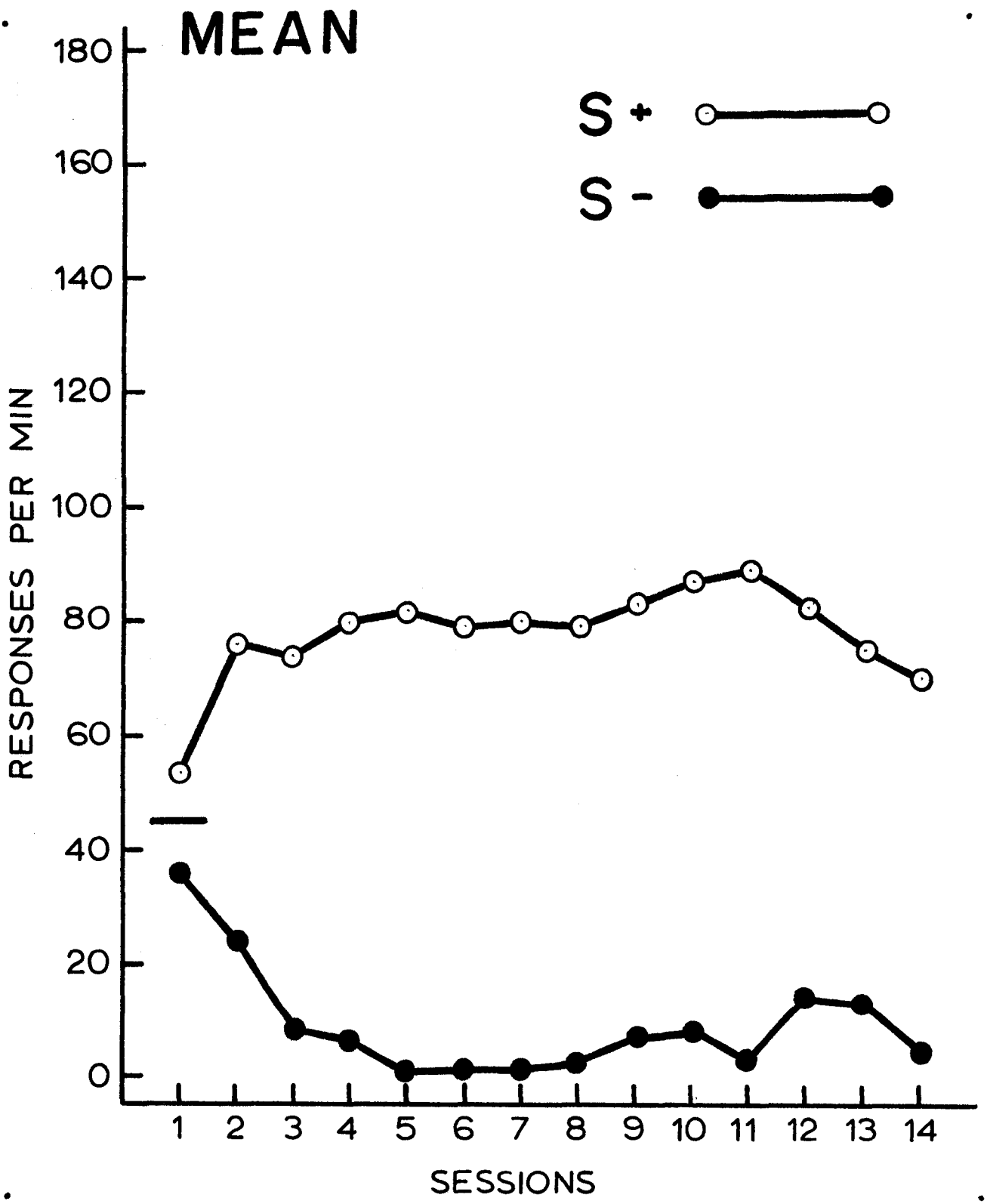

Fig. 2d Mean Response Rate as a Function of Discrimination Training Sessions - S- = 60°. Horizontal Line Represents the Mean Response Rate for the Last Four Days of S+ Only Training.

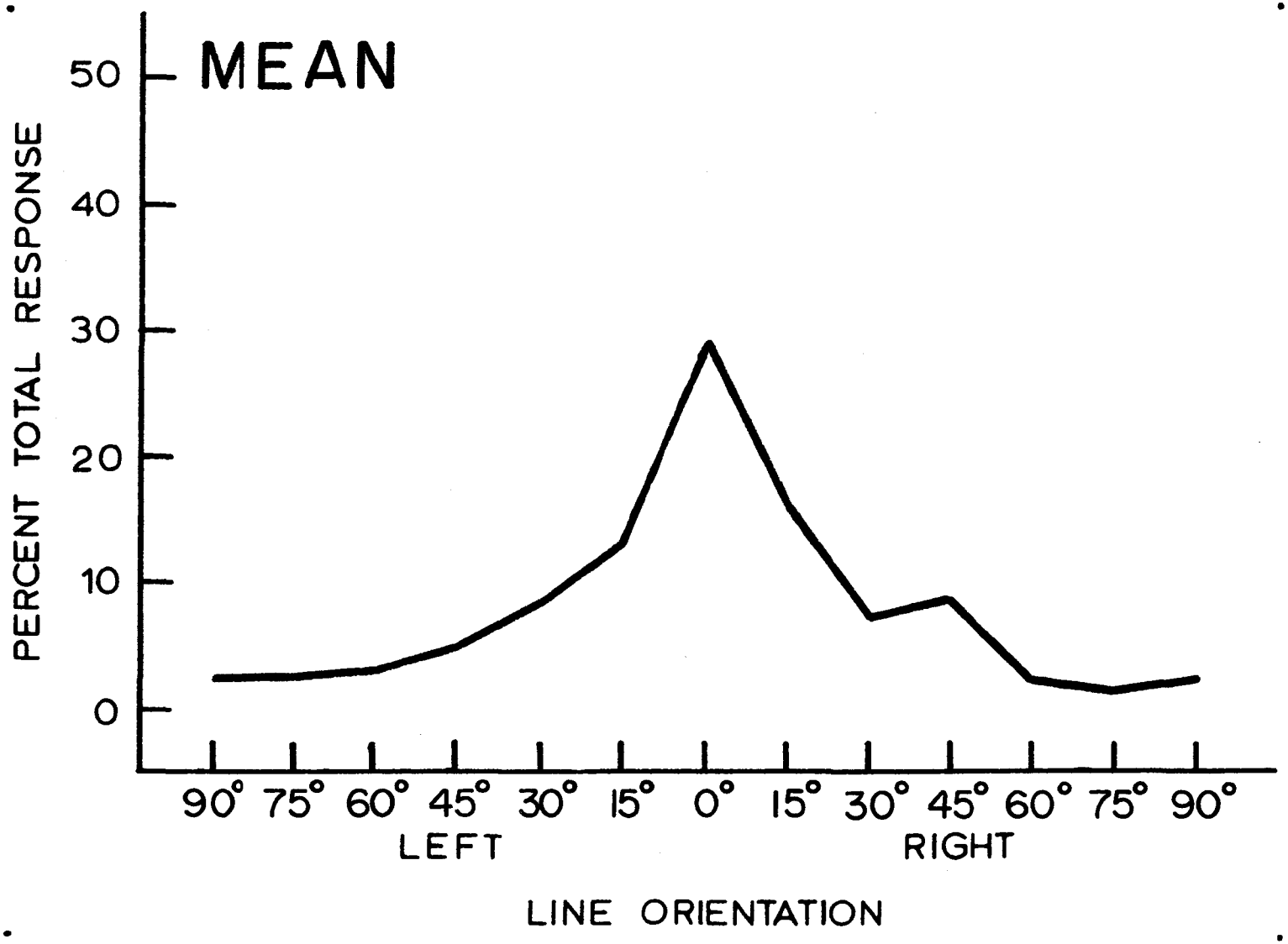

Fig. 3a Generalization Gradient: Mean Per Cent Total Response as a Function of Line Orientation - Control Group.

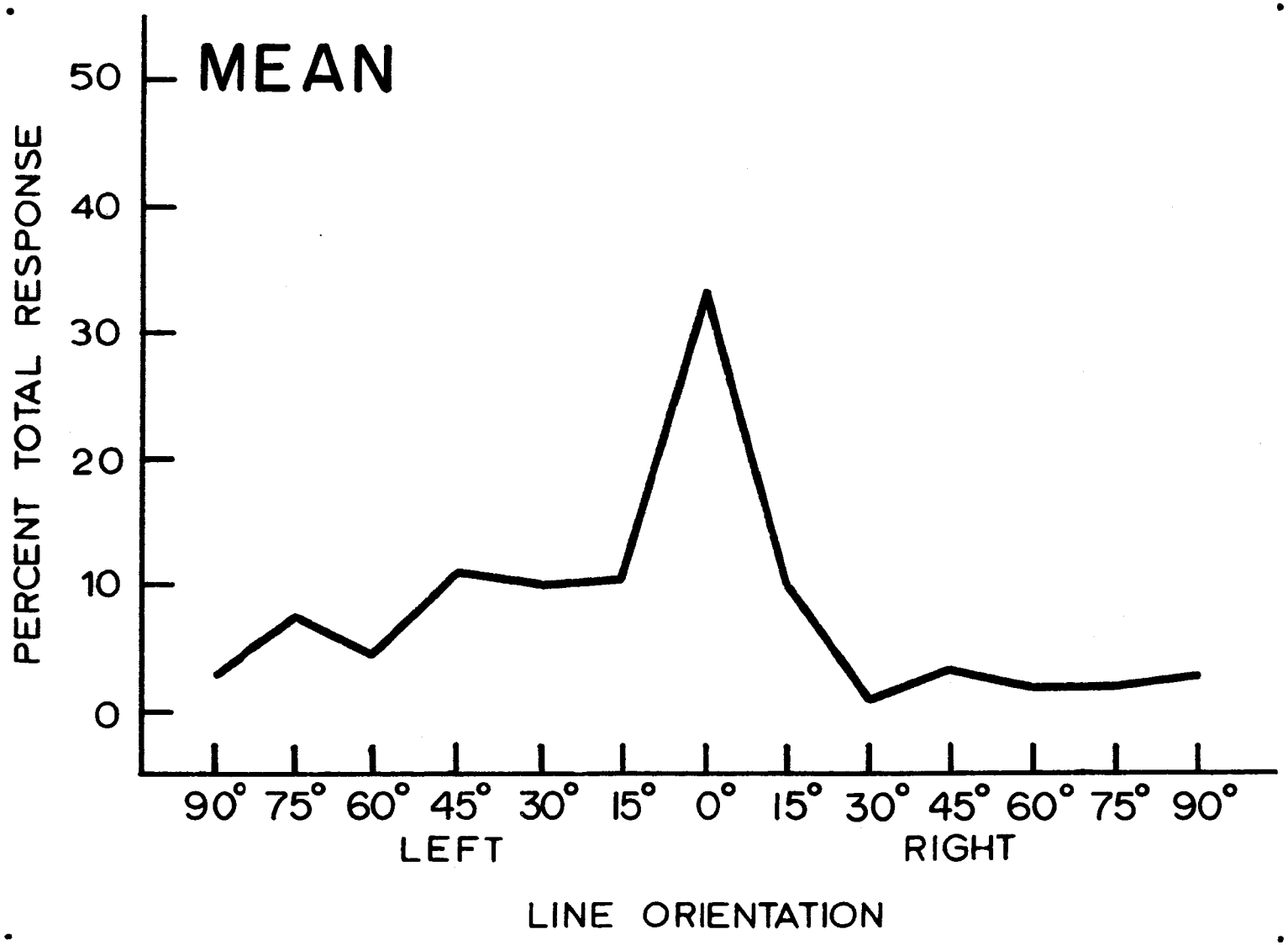

Fig. 3b Generalization Gradient: Mean Per Cent Total Response as a Function of Line Orientation - 30° Group.

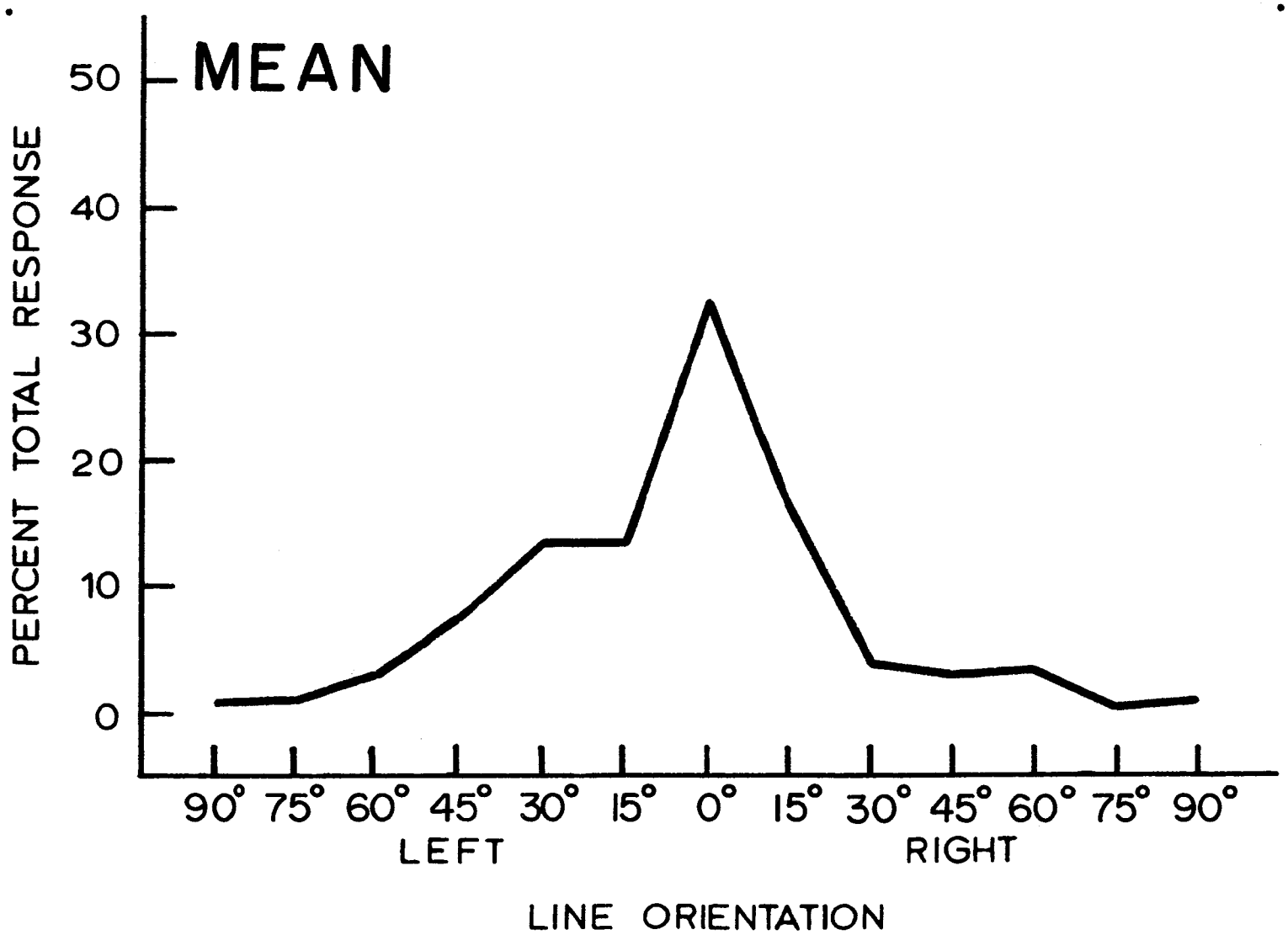

Fig. 3c Generalization Gradient: Mean Per Cent Total Response as a Function of Line Orientation - 45° Group.

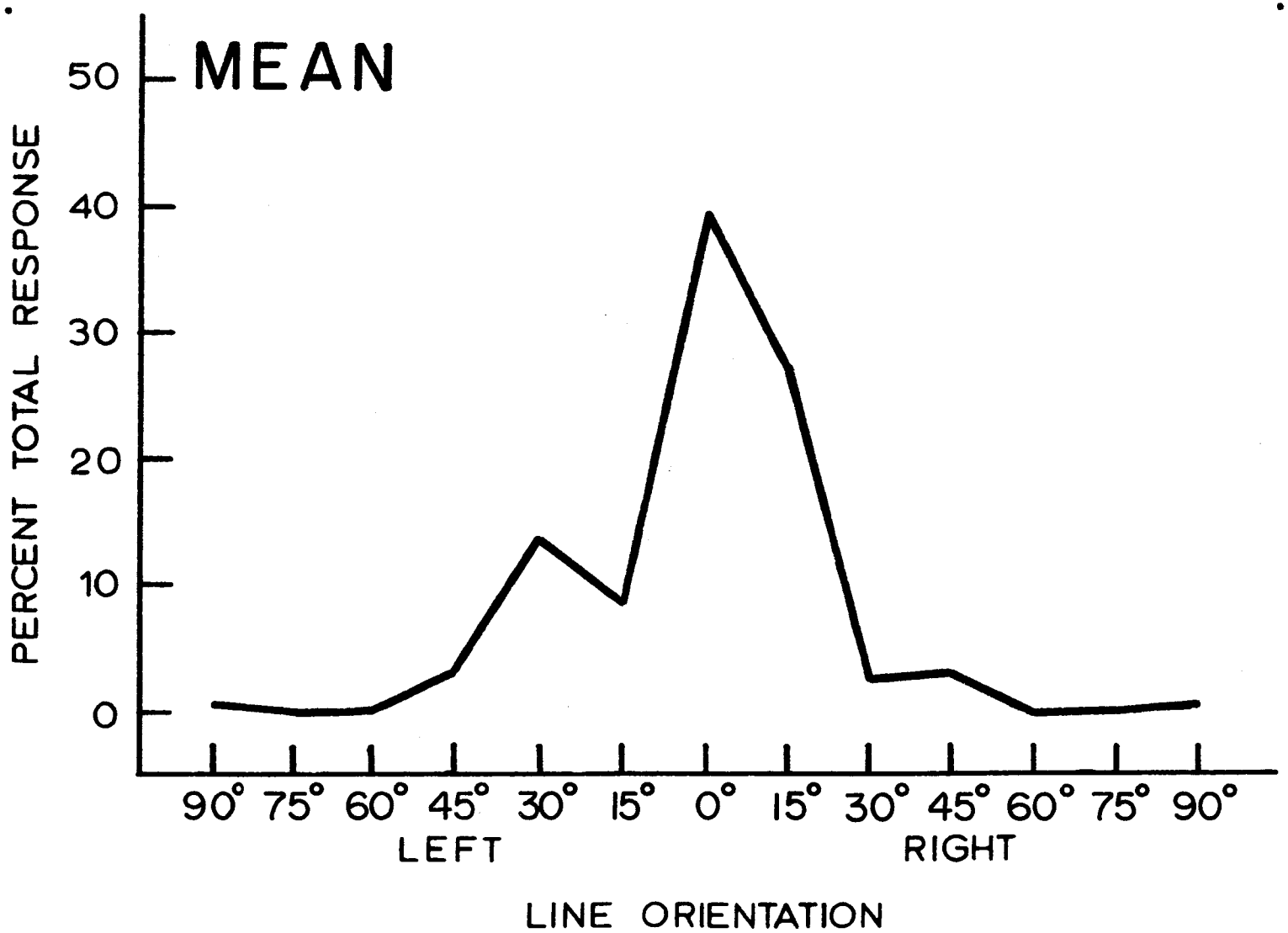

Fig. 3d Generalization Gradient: Mean Per Cent Total Response as a Function of Line Orientation - 60° Group.

CHAPTER IV

DISCUSSION

With one exception, the results failed to support the hypotheses. The exception occurred with respect to the first hypothesis: that the experimental gradients would be steeper in the region of S- than the control gradient. This prediction was supported by the results obtained for the group with the smallest S+, S- difference, the 30^{o} group.

The complete absence of the PS phenomenon across all experimental Ss is somewhat puzzling. This is especially true of the 45^{o} group which was a replication of Bloomfield's (1967) experimental group in which all Ss showed a PS.

Terrace (1968) has gathered evidence showing that the PS and the phenomenon of behavioral contrast (BC) covary with manipulation of the same variables. BC is defined as a change in the rate of responding on one component of a multiple schedule of reinforcement in a direction opposite to the rate of responding on the other component. In a successive discrimination situation, this implies that the rate of responding to S+ increases over what it would have been had there been no extinction component (cf: horizontal lines in Figures 2a, 2b, 2c, and 2d). In the present study, all experimental Ss showed BC even though no PS was obtained. Thus, Terrace's (1968) contention that "a peak shift results whenever contrast occurs during discrimination training" was not supported by the results of the present study. It would seem, therefore, that conditions sufficient to produce BC are

not sufficient to produce a PS. This would suggest that the two phenomenon may not be as closely related as Terrace has argued. It may, perhaps, be more accurate to say that BC is a necessary, but not a sufficient condition for the occurrence of a PS.

A common finding in PS studies has been the fact that when compared to control gradients, PDGs showing the PS are noticeably elevated (cf: Hanson, 1959; Bloomfield, 1967). The results of the present study revealed no differences in height among the gradients. This result is in line with the absence of the PS in the experimental gradients.

The fact that Thomas et al. (1966) have demonstrated mirror-image transfer in pigeons does not appear to offer a valid explanation for the absence of the PS in the present study. These experimenters trained two groups of pigeons to respond on a VI 30 sec schedule to a white line tilted 30° and 60° right of vertical respectively on a black surround. A third group was given VI 1 min EXT training on an orthogonal discrimination task (S^+ = white line tilted 30° left of vertical on a black surround; S- = a blank key). Generalization gradients were bimodal for all groups, each group showing a peak at the training S^+ and a peak at the mirror-image of S^+. In terms of the present study, it might be argued that inhibition built up to the various S- line orientations transferred to the appropriate mirror-images, and then generalized to surrounding stimuli, thus preventing the occurrence of a PS. If such an assumption were valid, control Ss should show significantly more responding to the mirror-images of the S- stimuli than experimental Ss for the respective mirror-images, since

inhibition to the mirror images would be virtually non-existent for control Ss. However, the appropriate t-tests for differences of means failed to reveal any significant differences. Moreover, such an explanation would also have to apply to the Bloomfield (1967) results which showed the PS. Thus, if some sort of transfer due to mirror-image effects did occur, it was not sufficient to eliminate the PS in Bloomfield's Ss.

One possible explanation for the absence of the PS in the present study is that the PS cannot be reliably obtained in pigeons when the dimension is line-tilt. The present author found two studies which showed a PS using line-tilt (Bloomfield, 1967; and Thomas and Lyons, 1968). On the other hand, apart from the present study, the author is aware of four experiments which failed to show the phenomenon on the line-tilt dimension (the two experiments in Hirota et al., 1969; Clarkson, 1970; and Gray, 1970). With the exception noted above, the present study, using the dimension of angularity, failed to replicate Hanson's wavelength results. Such a failure to replicate would seem to lend some support to Guttman's (1965) caution as to the kind of dimensions on which a PS can be obtained, and to his suggestion that the PS may be stimulus specific. The present results may render questionable the validity of generalizing from the results of wavelength studies to the dimension of angularity.

In discussing the absence of the PS in his study, Clarkson (1970) suggested that the pre-test ratio of $S^-:S^+$ exposure had to be less than unity for the occurrence of a PS. The present study provided Ss with 14 sessions of pre-discrimination training exposure to S^+,

thus weighting the exposure to the discriminative stimuli in favour of S^+. However, the results of the first generalization test of control Ss indicate that under the conditions of the present study Ss' behavior was not under the control of the line-tilt dimension. This suggests that Ss were not "paying attention" to S^+ at this stage of training. If it can be assumed that experimental Ss would also have shown flat gradients had they been tested - as noted above, the evidence here is conflicting - then it could be argued that the $S^-:S^+$ ratio was effectively unity. This argument, however, would also apply to Bloomfield's results since his procedure and that of the present study for experimental Ss were identical. In this case, it would have to be argued that the PS occurred with a pre-test $S^-:S^+$ ratio of unity. If, on the other hand, it is argued that such S^+ exposure, even though not attended to, is sufficient to reduce the $S^-:S^+$ ratio from unity, then results of the present study, taken together with those of Bloomfield, would suggest that while such additional exposure to S^+ may be a necessary condition, it is not sufficient for the occurrence of the PS.

In conclusion, the present results suggest that further studies might be done to determine whether the PS might be more a function of the stimulus dimension used than of discrimination training itself. Further study of the relationship between behavioral contrast and the PS also appears warranted.

CHAPTER V

SUMMARY

The peak shift, identified as a displacement of the mode of the post-discrimination gradient from S+ in a direction away from S-, has been found to occur regularly following non-orthogonal wavelength discrimination training. Guttman (1965) has suggested that this phenomenon may be specific to the dimension of wavelength. In the light of some failures to obtain a PS on the line-tilt dimension, the possibility arose that the PS may not occur as reliably with the line-tilt dimension as with wavelength. The purpose of the present study was to replicate Hanson's (1959) original PS results using the dimension of angularity.

Three experimental groups and a control group were given S+ only training. Experimental groups were then given non-orthogonal discrimination training in which S- was a different line orientation for each group. Following a post-S+ only training generalization test, control Ss were given orthogonal discrimination training. Following discrimination training, all Ss were tested for generalization to 12 line orientations.

While behavioral contrast occurred in all Ss for all experimental Ss the modal stimulus of the generalization gradient was S+. These results were interpreted as giving some support to the possibility that PS results obtained on the wavelength dimension may not be generalizable to the dimension of angularity, and as providing some support for

Guttman's (1965) suggestion that the PS may be a function of the stimulus dimension used.

The results of this study further suggested that more research might be done to examine the relationship between behavioral contrast and the PS in order to determine whether they are as closely related as Terrace (1968) has suggested.

APPENDIX A

Order of Presentation of S^+ and S-

During Discrimination Training

1. S^+
2. S-
3. S-
4. S^+
5. S-
6. S^+
7. S-
8. S-
9. S^+
10. S^+
11. S-
12. S^+
13. S^+
14. S-
15. S^+
16. S^+
17. S-
18. S-
19. S^+
20. S-
21. S^+
22. S-
23. S-
24. S^+
25. S^+
26. S-
27. S-
28. S^+
29. S-
30. S^+

APPENDIX B

Order of Presentation of Stimuli

During Generalization Test

1.	60°	Right
2.	15°	Left
3.	75°	Left
4.	15°	Right
5.	0°	-
6.	30°	Left
7.	75°	Right
8.	45°	Left
9.	90°	-
10.	30°	Right
11.	60°	Left
12.	45°	Right
13.	60°	Right
14.	90°	-
15.	30°	Left
16.	45°	Right
17.	45°	Left
18.	15°	Right
19.	30°	Right
20.	60°	Left
21.	75°	Right
22.	15°	Left
23.	0°	-
24.	75°	Left

Presented four times.

APPENDIX C

Responses During S+ Only Training

Group:	S #	Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14
60°:	#3411		1538	1362	1481	1259	1168	1635	1623	1990	2466	2341	2743	2105	2557	3229
60°:	#7406		1067	1471	1580	2163	2231	2124	2233	2226	2579	2995	2987	2109	1909	2060
60°:	#6904		691	957	978	1404	1463	1711	1744	1932	1807	1608	1753	1933	2090	2369
60°:	#8647		1658	2026	1327	1706	1765	2275	2342	2762	3019	2712	2693	3216	3511	3492
45°:	#7949		332	801	854	942	793	1027	820	1032	803	899	1128	1265	1748	1705
45°:	#3548		810	1273	1235	1457	1156	1318	1727	1903	1926	1885	2342	2368	2103	2110
45°:	#1537		925	1491	1300	1671	1896	2186	2286	2431	2623	2826	3504	3377	3754	3432
45°:	#8645		896	1367	1800	2180	1232	2570	2766	2948	3135	3692	4169	3602	3809	4949
45°:	#7685		786	931	711	767	652	638	660	821	762	604	749	670	564	568
30°:	#7496		700	914	1401	1460	1694	1952	2020	2435	2903	2750	2531	2975	2309	2131
30°:	#6883		1153	1449	1314	1114	1115	967	1102	1147	1564	1436	1471	1439	1343	1481
30°:	#1932		939	1441	1431	1611	1583	1732	1503	2067	1786	1713	1623	1714	2095	2734
30°:	#1010		1142	909	1403	1623	1810	1764	2286	2264	2718	2948	2962	2928	3057	2929
30°:	#8507		1233	1352	1345	1348	1485	1839	1893	2100	2753	2863	3048	3951	3110	2611
C :	#7433		1068	1087	1239	1158	1553	1537	1436	1342	1157	1478	1522	1475	1440	1540
C :	#8588		708	1210	1671	1689	2334	2363	2408	3124	3317	3179	3102	2820	2883	2418
C :	#8943		393	1289	986	1386	1516	2235	2767	2646	3134	3643	4309	4940	4049	4770
C :	#8447		584	1337	1348	1262	1453	1284	1173	1211	1135	1337	1313	1305	1427	1265
C :	#8860		1669	1235	1058	1593	1709	1908	2512	3009	2856	3347	2574	3672	4171	4031

APPENDIX D

Responses During Discrimination Training

Group	S #	Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14
60°:	#3411	S+:	2003	2303	2316	3021	2480	2173	2332	2240	2635	2464	3062	3134	2362	3234
		S-:	1006	861	298	347	7	20	19	259	893	710	262	1589	1382	290
60°:	#7406	S+:	1340	2648	2294	2413	2549	2309	2297	2181	2048	2060	1986	1812	2025	1924
		S-:	1195	1261	386	281	29	72	40	24	25	273	21	19	10	10
60°:	#6904	S+:	1131	1543	1755	1655	1622	1654	1598	1736	1755	1818	1853	1740	1930	1978
		S-:	1070	674	288	188	31	33	96	6	23	41	82	94	167	118
60°:	#8647	S+:	1945	2688	2626	2531	3191	3358	3432	3415	3535	4176	3817	3188	2704	2554
		S-:	992	151	41	9	12	8	3	11	11	2	24	58	70	93
45°:	#7949	S+:	1075	1466	1591	1519	1471	1424	1509	1790	1915	2216	2301	1905	2039	1902
		S-:	616	637	44	2	18	26	40	13	41	128	149	22	33	65
45°:	#3548	S+:	1047	1541	1591	1549	1472	1454	1299	1482	1549	1872	1610	1757	1776	1918
		S-:	576	612	225	50	42	32	6	8	1	4	8	16	15	91
45°:	#1537	S+:	1520	2342	2387	2440	2431	1917	1735	1950	2136	2256	2052	1949	1952	1930
		S-:	1681	1274	393	201	98	50	195	107	46	29	46	46	29	67
45°:	#8645	S+:	3089	4577	5074	5157	4395	3878	3457	3562	3850	3719	3656	4006	3788	3520
		S-:	2555	1709	355	170	709	741	1530	1184	1400	664	1070	1233	1361	972
45°:	#7685	S+:	537	665	633	731	751	953	921	934	1334	1211	1073	1104	1004	940
		S-:	2201	218	94	107	18	75	58	38	46	19	0	8	2	0

Group	S #	Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14
30°:	#7496	S+:	1189	1878	2262	2641	2889	3116	2969	2939	2662	2843	3184	3146	3158	2904
		S-:	1317	1205	689	638	80	36	30	33	335	762	718	476	344	504
30°:	#6883	S+:	879	1085	1011	791	961	1082	1048	874	1034	903	985	976	858	919
		S-:	859	968	689	477	596	483	267	214	162	156	184	261	131	119
30°:	#1932	S+:	1276	1401	1454	1509	1439	1343	1326	1269	1354	1295	1396	1598	1228	1122
		S-:	1415	984	458	337	315	271	255	150	177	384	385	471	272	392
30°:	#1010	S+:	1389	1719	1652	2373	2648	2959	2715	2474	2360	2117	2051	2063	2166	1593
		S-:	1513	1181	1002	859	485	381	181	354	473	551	413	235	206	293
30°:	#8507	S+:	1977	3106	3699	2965	2053	1588	1816	1833	1614	1573	1381	1660	1596	1857
		S-:	1233	710	437	248	338	98	60	52	21	14	229	96	67	18
C :	#7433	S+:	999	1293	1418	1490	1636	1405	1694	1585	1830	1406	1664	1543	1665	1303
		S-:	717	396	36	0	0	1	0	1	2	3	0	0	1	0
C :	#8588	S+:	2140	3067	2788	2662	2793	2835	2542	2776	2504	2730	2818	2688	2880	2143
		S-:	1011	437	45	15	64	51	325	15	46	65	60	168	664	195
C :	#8943	S+:	2835	3653	3963	3800	4085	3169	2541	2084	2262	2437	2436	2716	2867	2524
		S-:	2427	2868	1544	738	49	236	1156	1134	741	427	832	615	481	492
C :	#8447	S+:	1601	1683	2296	2393	2640	2613	2619	2749	2650	2872	2467	2745	2515	2477
		S-:	1076	113	193	19	35	29	1	3	0	0	0	0	0	1
C :	#8860	S+:	2393	3859	4150	3872	3099	2358	2819	2516	2015	1886	1360	1264	1106	1595
		S-:	1323	872	992	967	129	139	385	68	5	8	1	1	0	0

APPENDIX E

Responses During Generalization Test

		60°: #8647								60°: #3411							
Presentation		1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
Stimulus	90°	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
	75°L	4	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
	60°L	4	0	0	0	0	0	0	1	3	4	2	0	4	6	0	0
	45°L	2	7	0	0	1	1	0	5	21	14	1	0	2	2	1	2
	30°L	43	11	0	0	3	4	17	0	44	41	31	1	15	6	41	5
	15°L	38	0	0	26	10	0	0	0	29	0	1	0	0	0	1	0
	0°	57	1	0	69	78	49	53	62	60	70	36	59	61	64	58	62
	15°R	0	0	1	48	13	73	0	72	47	7	62	3	51	37	69	30
	30°R	7	0	0	1	1	2	0	0	5	1	4	2	1	0	1	1
	45°R	0	0	0	0	0	0	0	0	56	7	0	0	2	2	0	1
	60°R	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
	75°R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

		60°: #7406								60°: #6904							
Presentation		1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
Stimulus	90°	0	0	0	0	0	0	0	0	14	0	0	0	0	0	0	0
	75°L	0	0	0	0	0	0	0	1	0	0	2	0	1	0	0	0
	60°L	0	1	0	1	0	0	0	0	11	0	0	9	0	0	0	0
	45°L	2	26	1	3	0	0	1	1	13	0	4	1	0	6	0	0
	30°L	18	32	12	20	25	24	18	8	5	18	0	19	9	29	2	0
	15°L	0	4	22	28	17	25	26	17	46	1	0	13	1	0	11	0
	0°	41	35	35	42	33	29	32	31	36	46	34	49	53	54	44	0
	15°R	49	41	32	28	35	22	24	26	41	27	38	50	54	0	0	0
	30°R	18	5	3	2	1	1	0	0	30	6	1	2	1	0	0	0
	45°R	0	0	0	1	0	0	0	4	1	0	0	6	0	27	0	0
	60°R	1	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
	75°R	0	0	0	0	0	0	0	0	2	4	0	3	0	0	0	0

		45°: #7685								45°: #8645							
Presentation		1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
Stimulus	90°	0	0	0	0	0	0	0	0	23	0	0	10	0	7	0	0
	75°L	0	0	0	1	1	1	0	0	13	7	17	2	0	0	0	0
	60°L	0	0	0	0	0	5	0	0	24	5	9	0	78	1	4	0
	45°L	0	0	0	0	0	0	3	0	0	69	83	47	1	88	11	60
	30°L	0	16	9	6	5	0	2	7	55	70	0	98	65	92	62	84
	15°L	31	18	21	12	3	12	4	2	18	78	51	109	79	75	10	47
	0°	27	31	29	7	19	41	31	0	89	82	85	104	86	89	115	94
	15°R	13	25	20	15	1	11	0	0	42	59	74	78	69	75	49	21
	30°R	0	0	0	0	0	3	0	0	49	0	0	5	19	33	10	1
	45°R	0	0	0	0	0	0	0	0	37	0	46	0	0	25	29	0
	60°R	0	0	0	0	1	0	1	0	3	27	32	28	39	15	17	0
	75°R	0	0	0	0	0	2	0	0	0	30	0	0	3	0	0	0

		45°: #7949								45°: #1537							
Presentation		1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
Stimulus	90°	0	0	0	0	0	0	0	0	0	0	0	4	0	0	2	0
	75°L	2	0	0	1	0	1	0	1	0	8	0	0	0	3	0	4
	60°L	0	0	0	5	0	0	0	4	4	2	8	1	3	1	0	0
	45°L	1	0	0	7	0	0	0	3	0	6	4	5	2	6	3	1
	30°L	3	0	0	19	3	0	2	6	6	37	3	3	9	5	2	26
	15°L	10	0	0	28	10	0	4	11	5	13	8	25	19	0	9	0
	0°	10	0	0	47	45	0	47	41	47	38	42	38	37	46	43	47
	15°R	6	0	0	34	8	0	29	0	46	14	1	2	1	20	29	1
	30°R	0	0	0	0	0	0	0	0	13	7	3	2	0	19	0	0
	45°R	0	0	0	0	0	0	0	0	4	1	0	0	0	0	0	1
	60°R	0	0	0	0	0	0	0	2	4	1	0	1	0	0	0	0
	75°R	0	0	0	0	0	0	1	0	0	0	3	0	0	0	0	0

		45°: #3548								30°: #7496							
Presentation		1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
Stimulus	90°	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0
	75°L	0	0	0	0	0	0	0	0	11	1	2	0	0	0	0	0
	60°L	1	0	0	0	2	4	2	1	0	0	0	0	0	0	0	0
	45°L	0	0	0	0	1	5	0	9	5	0	1	0	0	0	0	0
	30°L	2	0	1	0	5	17	5	14	8	0	0	0	0	0	0	0
	15°L	9	0	7	0	10	17	3	3	6	0	0	0	0	0	0	0
	0°	39	48	31	47	28	47	42	42	48	29	36	0	0	0	0	0
	15°R	13	25	9	5	31	12	40	24	17	0	4	0	0	0	0	0
	30°R	3	15	16	0	24	2	10	0	2	0	0	0	0	0	0	0
	45°R	0	0	1	0	0	7	1	7	0	0	0	0	0	0	0	0
	60°R	2	5	0	0	7	3	5	3	6	1	3	0	0	0	0	0
	75°R	0	0	0	0	0	3	0	0	2	0	0	0	0	0	0	0

		30°: #6883								30°: #1932							
Presentation		1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
Stimulus	90°	14	0	4	6	3	10	8	5	0	0	12	15	0	0	0	1
	75°L	13	14	9	18	3	14	11	9	0	21	14	1	0	11	6	8
	60°L	4	12	4	1	5	0	1	2	0	10	13	15	0	10	13	4
	45°L	18	9	13	17	18	16	12	15	0	25	22	15	0	0	16	21
	30°L	12	0	4	14	17	5	16	16	0	9	21	21	0	0	23	17
	15°L	8	6	1	9	19	9	7	0	0	7	25	17	0	21	19	13
	0°	17	19	17	19	17	13	19	12	0	28	23	20	0	27	28	28
	15°R	17	2	4	16	9	2	4	7	0	2	17	0	0	4	14	13
	30°R	0	1	3	5	0	2	2	0	0	0	3	2	0	0	4	1
	45°R	0	3	9	9	8	10	6	1	0	12	14	7	0	0	3	9
	60°R	5	0	0	1	10	3	0	2	2	0	3	11	0	0	3	4
	75°R	0	15	1	2	7	4	0	5	0	0	3	4	0	7	5	0

		30°: #1010								30°: #8507							
Presentation		1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
Stimulus	90°	0	1	0	0	1	2	0	0	1	0	0	0	0	0	4	3
	75°L	3	8	5	1	3	1	0	0	2	1	0	0	1	11	23	1
	60°L	5	2	8	5	0	0	0	0	0	0	1	2	2	9	4	2
	45°L	11	10	3	11	8	3	0	0	0	10	4	4	6	12	12	9
	30°L	2	1	3	6	3	0	0	0	23	26	2	14	1	8	9	14
	15°L	15	7	8	1	5	9	0	0	44	4	16	0	11	16	7	2
	0°	31	20	19	21	24	35	0	24	47	47	48	50	38	64	57	37
	15°R	3	28	17	21	9	20	0	0	1	2	10	2	0	19	32	3
	50°R	0	1	1	2	0	2	2	0	0	0	0	0	0	3	2	0
	45°R	6	0	0	0	1	0	0	0	0	0	0	2	0	0	1	1
	60°R	0	0	3	0	1	0	0	0	1	0	0	0	0	0	0	0
	75°R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

		C : #8860								C : #8943							
Presentation		1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
Stimulus	90°	0	0	0	0	0	0	0	0	19	6	11	17	11	21	10	8
	75°L	0	0	0	0	0	0	0	0	19	0	6	2	16	1	9	3
	60°L	0	0	0	0	0	0	0	0	10	13	25	27	13	11	16	8
	45°L	0	0	0	11	0	0	0	0	18	16	27	24	14	34	19	14
	30°L	5	4	1	0	3	0	0	0	32	23	18	34	27	29	11	26
	15°L	0	0	0	0	1	0	0	0	31	27	35	37	24	32	9	26
	0°	32	39	40	61	43	0	0	0	69	53	56	57	53	50	62	58
	15°R	3	0	0	27	47	0	0	0	0	8	2	0	0	0	0	1
	30°R	0	0	0	1	1	0	0	0	27	17	20	18	15	16	9	9
	45°R	0	1	0	0	2	0	0	0	9	26	13	19	8	22	16	8
	60°R	0	0	0	0	0	0	0	0	27	2	5	9	11	6	0	3
	75°R	0	0	0	0	0	0	0	0	6	8	8	11	9	3	4	3

C : #8447

Presentation		1	2	3	4	5	6	7	8
Stimulus	90°	0	0	0	0	0	0	0	0
	75°L	0	0	0	0	0	0	0	0
	60°L	0	0	0	0	0	0	0	0
	45°L	0	0	0	0	0	0	0	0
	30°L	1	0	0	1	0	0	2	0
	15°L	0	26	28	6	3	0	0	0
	0°	30	36	40	42	37	0	0	0
	15°R	27	36	36	36	33	0	0	0
	30°R	0	21	4	4	1	0	0	0
	45°R	1	0	0	0	0	0	0	0
	60°R	3	0	0	0	0	0	0	0
	75°R	0	0	0	0	0	0	0	0

C : #8588

1	2	3	4	5	6	7	8
2	0	3	0	0	0	0	11
50	1	2	0	0	1	2	0
3	8	0	4	7	8	7	1
12	0	0	13	18	9	4	7
46	25	21	33	6	20	19	15
61	49	36	63	34	16	31	31
59	63	65	56	51	73	61	63
59	49	64	56	56	43	69	55
31	36	12	40	13	18	2	5
29	40	24	40	40	39	38	39
39	1	6	0	12	0	0	1
18	0	0	9	0	0	0	0

C : #7433

Presentation		1	2	3	4	5	6	7	8
Stimulus	90°	5	0	2	0	0	0	0	0
	75°L	9	0	6	1	2	2	0	0
	60°L	1	4	0	0	0	0	0	0
	45°L	4	4	2	3	1	0	0	0
	30°L	16	9	8	1	1	4	0	1
	15°L	23	12	16	6	13	0	1	0
	0°	30	32	26	34	23	10	31	13
	15°R	28	19	24	16	20	0	5	34
	30°R	17	25	13	13	0	0	0	2
	45°R	21	15	9	0	5	1	9	2
	60°R	12	1	0	0	3	0	0	0
	75°R	0	5	0	0	0	0	0	0

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