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A Study of Behavioral Contrast Using Multiple Discriminative Stimuli

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A STUDY OF BEHAVIORAL CONTRAST
USING MULTIPLE DISCRIMINATIVE STIMULI

by

Gary M. Stoynoff

A Thesis
Submitted to the
Faculty of The Graduate College
in partial fulfillment
of the
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Gary M. Stoynoff

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INTRODUCTION

A variable-interval (VI) reinforcement schedule is one in which an organism's first response is reinforced after a variable interval of time since reinforcement availability or delivery has passed. Response rate during a VI schedule is typically very stable and moderate. When reinforcement for responding is withheld (extinction (EXT) schedule), response rate decreases to the level existing prior to reinforcement.

A multiple schedule is one in which two or more components alternate in a fixed or random order; each component is associated with a different stimulus and there may or may not be a different schedule of reinforcement associated with each component. One type of multiple schedule is called a nondifferential schedule. Here the reinforcement schedule during each component is the same as that in all the other components. Therefore, the only difference between the components is the stimulus which denotes which component the organism is currently responding in. When responding is reinforced on a VI schedule in each component, the schedule is referred to as a multiple VI,VI schedule of reinforcement. As with a single VI schedule, reponse rate during the multiple VI,VI schedule with equal reinforcement frequencies in each component tends to be stable and moderate.

The other type of multiple schedule is referred to as a differential schedule. The components in this schedule have different reinforcement schedules associated with them. Most commonly, one component is associated with extinction; if responding is reinforced on a VI schedule during the other component, the schedule is referred to as a multiple VI, EXT schedule. The stimulus which denotes which component is currently active is called a positive stimulus (S+) if responses are reinforced in that component and a negative stimulus (S-) if responses are extinguished during the component. This schedule is also referred to as discrimination training.

When an organism is initially trained on a nondifferential schedule (e.g., multiple VI 1, VI 1) and in later sessions the schedule is changed to a differential schedule (e.g., multiple VI 1, EXT), one effect of this change is a decrease in response rate in the stimulus which became an S-. Another effect of this schedule change is an increase in response rate above the multiple VI 1, VI 1 baseline rate in the S+, the component which had no change in reinforcement frequency (i.e., the unchanged component). Reynolds (1961a) has termed this effect "positive behavioral contrast" and he has defined it as an increase in response rate in the unchanged component which occurs concurrently with a decrease in response rate in the changed component of a multiple schedule. Schwartz (1975) has described a similar effect but in the opposite direction when reinforcement frequency is increased in the changed component, rather than decreased as is the case with positive behavioral contrast, and he has termed this effect "negative behavioral contrast". For example, if an organism is trained on a nondifferential schedule (e.g., multiple VI 3, VI 3) and is later changed to a differential schedule (e.g., multiple VI 3, VI 1), response rate in the changed component increases with a concurrent decrease in response rate in the unchanged component.

The amount of positive behavioral contrast has been shown to be directly related to a number of variables, among them the physical similarity between the S+ and the S-. In Catania and Gill's (1964) experiment, three pigeons received discrimination training in which the discriminative stimuli consisted of 16 successively illuminated lamps arranged in a vertical row. Lamps 1-8 (the top 8 lamps) were the S+s and lamps 9-16 (the bottom 8 lamps) were the S-s. An FI 1-min schedule was in effect during the S+ presentations. The sequence of stimulus presentations was random within the S+s and S-s, but alternated between S+ and S-. Their results showed that the highest average response rates were emitted during the illumination of lamps 7 and 8 (S+s adjacent to the S-s) and that response rates were lower to lamp 9 (S- adjacent to the S+s) than to lamps 10, 11, and 12 (S-s farther from the S+s). The lowest rates occurred to lamps 13-16 (S-s farthest from the S+s). These results were transient, appearing after a week of discrimination training and lasting approximately two to three weeks. No baseline data were shown in the report on this experiment and thus contrast was not actually demonstrated; however, the experiment does suggest that contrast may be positively related to the similarity between the S+s and S-s.

Farthing (1974), in a systematic replication of Catania and Gill's experiment, obtained similar results using different line orientations as the discriminative stimuli. Farthing used six pigeons who were first given extensive training on a nondifferential schedule involving 12 line orientations from vertical (tilt 1) clockwise through horizontal (tilt 12) in 8.18° steps. After 30 to 36 sessions of nondifferential training with a multiple VI 30-sec schedule in each stimulus, discrimination training was introduced. Tilts 1-6 were S+s and tilts 7-12 were S-s for half of the birds; the situation was reversed for the other half. Positive behavioral contrast was demonstrated and, during the first several discrimination training sessions, the highest average response rate was typically to one of the S+s closer to the S-s rather than farther away. With further discrimination training (beyond session 10), this effect diminished. Negative behavioral contrast was not demonstrated and response rates in the S-s simply decreased with distance from the S+s for all sessions.

Malone (1975), also using different line orientations as the discriminative stimuli, showed some results similar to those of Farthing (1974) and Catania and Gill (1964). Using four pigeons as subjects, one-minute stimulus presentations of four line orientations (90°, 60°, 30°, and 0°) were arranged in a fixed sequence with 49 presentations of each stimulus per session. The order of stimuli was randomized with the restriction that each line orientation preceeded itself and each other line orientation equally often and that the same line orientation appeared during no more than two consecutive presentations. Nondifferential training consisted of a VI 1-min schedule in all line orientations for 18-20 sessions. Following this, discrimination training was introduced; this consisted of a VI 1-min in two line orientation (90° and 60° for Group 1 and 30° and 0° for Group 2) and extinction in the other two line orientations.

Discrimination training lasted for 20-22 sessions. All subjects demonstrated positive behavioral contrast and two of the subjects' results were consistant with the data of Farthing (1974) and Catania and Gill (1964) in that higher average response rates were seen in the S+ region closer to the S- region. In addition, Malone showed that the same two birds also demonstated the analogous negative contrast effect. For example, when reinforcement was given during the 30° and 0° line orientations and responding was extinguished during the 90° and 60° line orientations, higher average response rates were seen during the 30° line orientation than the 0° line orientation while lower average response rates were seen during the 60° line orientation than the 90° line orientation. The other two subjects showed little difference in response rates within the S+ and S- sets. The experiment was repeated in the same manner using 75°, 60°, 45°, and 30° line orientations and similar results were obtained. Three of the four subjects showed higher average response rates during the S+ closer to the S- region and lower average response rates during the S- closer to the S+ region. The three subjects that showed the positive effects were not the same three subjects that showed the negative effects. These effects, when present, were greater in magnitude in the second experiment and the increase in magnitude was assumed to be caused by the decrease in discriminability of the stimuli involved.

Unlike the above studies which used a single subject design, Kodera and Rilling (1976) used a group design. This experiment was aimed primarily at the relation between the number of errors (responses to the S-) in discrimination training and positive behavioral contrast. Pigeons were given baseline training in which only one stimulus component was available. Sixty-second presentations of a green key light were accompanied by a VI 30-sec reinforcement schedule; the key light was red during delivery of the reinforcer. Successive presentations of the S+ were separated by a three-sec blackout. Daily baseline sessions terminated after 25 S+ presentations. The principle distinction between baseline and discrimination training consisted of the interpolation of a stimulus correlated with extinction (S-) between successive presentations of the S+. The relation between the similarity of the S+ and S- and behavioral contrast was obtained in a comparison between a group trained with a green S+ and a dark S- and a group trained with a green S+ and a red S-. The group trained with the red S- (more similar to green than dark) produced more behavioral contrast.

Another, perhaps related, type of interaction between components of a multiple schedule has been called local behavioral contrast (Malone and Staddon, 1973). Positive local contrast is characterized by a higher response rate during an S+ when preceeded by an S- than when preceeded by itself; this has been demonstrated in several experiments (Catania and Gill, 1964; Nevin and Shettleworth, 1966; and Malone and Staddon, 1973). Negative local contrast is characterized by a lower response rate during an S- when preceeded by an S+ than when preceeded by itself; Malone and Staddon (1973) have demonstrated this effect.

Malone and Staddon (1973) have shown local contrast effects with S-s differing in similarity to the S+. Six pigeons were trained to peck a circular key which was transilluminated with one of eight different line orientations: 90° (vertical), 78°, 66°, 54°, 42°, 30°, 18°, and 6°. Stimuli were presented for one minute and were arranged in a fixed sequence of five blocks of 10 stimuli, randomized within blocks with the restriction that the 90° stimulus appeared three times per block and all other stimuli once per block. A time out, in which no reinforcement was given and no stimuli appeared on the response key, separated blocks. A keypeck reset a timer governing the length of the time out period. Initially, the timer was set at 5 seconds and was gradually increased to 20 sec during the first few sessions. This time out period was used to facilitate control over pecking by the line orientations on the response key. Nondifferential training consisted of a multiple VI 1-min, VI 1-min schedule for 22 sessions for one group and 23 sessions for the other group. Discrimination training consisted of a multiple VI 1-min, EXT schedule for 91 sessions for the first group and 24 sessions for the second group with reinforcement given only during the 90° line orientation. Behavioral contrast was exhibited in all subjects. There was no evidence of greater negative behavioral contrast in the presence of S-s close to the S+ relative to that in the S-s farther away from the S+; i.e., no differential effects of the S+-S- similarity were obtained. Positive and negative local contrast effects were observed; i.e., the rates in the S+ were higher when the S+ was preceeded by an S- than when preceeded by itself and the rates in the S- were lower when the S- was preceeded by the S+ than when preceeded by itself. However, the similarity of the preceeding S- to the S+ had no effect on the S+ response rate. No data were presented to indicate whether or not the similarity of the preceeding S+ to the S- had an effect on the S- response rate. They did find, however, that the response rate in S_x- was lowest when S_x- was preceeded by an S- closer to the S+ than itself, intermediate when S_x- was preceeded by itself, and highest when S_x- was preceeded by an S- farther from the S+ than itself. For example, the response rate in the 30° line orientation was lower when preceeded by the 78° line orientation than when preceeded by the 6° line orientation.

In summary, studies of positive behavioral contrast typically show that the response rate in the S+ is an increasing function of the degree of similarity between the S+ and S-. This effect appears in the first few days of discrimination training and tends to disappear after approximately 10 to 21 days of discrimination training (Catania and Gill, 1964; Farthing, 1974; and Kodera and Rilling, 1976).

Studies of negative behavioral contrast are less consistant. One study showed evidence that response rate in the S- is a decreasing function of the degree of similarity between the S+ and S- (Catania and Gill, 1964). However, two studies failed to find differential response rates as a function of the similarity between the S+ and S- (Farthing, 1974; and Malone and Staddon, 1973). When it appears, this effect is also transient (Catania and Gill, 1964).

Only one study has provided data concerning the relation between the amount of local contrast to the degree of similarity between the

S+ and S-. Malone and Staddon (1973) found that the degree of similarity between the S+ and the preceeding S- had no effect on response rate to the S+. No data were presented to indicate whether or not the similarity of the preceeding S+ to S- had an effect on response rate in the S-. They did find, however, that response rate in S_x- was lowest when S_x- was preceeded by an S- closer to the S+ than itself, intermediate when S_x- was preceeded by itself, and highest when S_x- was preceeded by an S- farther from the S+ than itself.

The present study is a systematic replication of the Malone and Staddon (1973) study with three main differences. The Malone and Staddon study used a blackout period between blocks of stimulus presentations in order to facilitate control over responding by the line orientations. The present experiment used a blackout period between pairs of stimulus presentations. It was felt that this condition afforded a better analysis of local contrast effects by minimizing the unsystematic effects of previous stimulus presentations upon responding in the first of a pair of stimuli. In other words, to make a precise analysis of the effects of the first stimulus of a pair upon the response rate during the second stimulus of a pair of stimuli, it might be beneficial to make certain that responding during the first stimulus is not affected (or is at least consistantly affected) by prior stimulation.

A second difference between the Malone and Staddon study and the present study involved the discriminability of the stimuli. Malone and Staddon used eight line orientations with a 12° difference between line orientations. The present study used four line orientations with a 30° difference between line orientations. Both studies, however, used only one S+ and the rest S-s.

The last main difference is in the frequency and duration of stimulus presentation. The S+ occurred in three out of ten stimulus presentations (the remaining presentations being S-s) and each stimulus duration was one minute in the Malone and Staddon study. In the present study, the S+ occurred during one-half of the stimulus presentations and lasted for only 30 seconds. The S-s occurred during the other half of the stimulus presentations and were also 30 seconds in duration.

METHOD

Subjects

Four experimentally-naive barren-hen White Carneaux pigeons, approximately 6 years of age, were maintained at 75% (±15 g) of their free-feeding body weights. Each subject was individually housed in a constantly illuminated, temperature- and humidity-controlled room with water and grit always available in the home cage. Purina Pigeon Grain was used for the maintenence of body weight and as the reinforcer.

Apparatus

Two sound attenuated Lehigh Valley Electronics pigeon test chambers, with interior measurements of 35 cm high X 32 cm wide X 35 cm deep, were used. A 35 cm X 35 cm aluminum intelligence panel formed one end of the chamber; it contained two clear Plexiglas response keys, located behind 2.5 cm diameter holes which were situated 7.0 cm on each side of the panel's midline and 23.0 cm above the floor. Only the left response key was used; the right response key remained dark and inoperative throughout the experiment. The left response key required a minimum force of 0.2 N (20.0 g) to be operated and could be transilluminated with 0.2 cm wide by 2.5 cm long white lines of differing orientations on a dark surround or by a green or red light. The stimuli were provided by an Industrial Electronics Engineers one-plane readout stimulus projector (series 10) and G.E. 12 volt bulbs (#1815). The red and green lights were produced by means of Kodak wratten filters. A 5 cm X 6 cm aperature, centered between the two response keys and 11 cm above the chamber floor, allowed access to a raised food magazine during reinforcement periods; the aperature was illuminated by a 28 volt white light bulb. White noise was presented by a speaker located behind a 7.5 cm aperature, situated 10.5 cm above the chamber floor and 5.0 cm from the right edge of the intelligence panel; the noise was produced by a Grason-Stadler white noise generator (model 901B). Additional masking noise was presented by a ventilating fan located behind an aperature in the wall opposite the intelligence panel. Dim general illumination was produced by a G.E. 7.5 watt houselight bulb centered on the intelligence panel and 31.0 cm above the chamber floor. Programming and recording of experimental events was accomplished by a Digital PDP-8L computer which was isolated in a separate room.

Procedure

Experimental sessions were usually conducted 7 days per week.

Preliminary training

During Session 1, each subject was trained to eat from the food magazine and to peck a green left response key by the method of successive approximations. Reinforcement during keypeck training consisted of approximately 5 sec access to grain. All subjects were reliably keypecking within 1 hour of the beginning of keypeck training.

Session 2 consisted of a continuous reinforcement (CRF) schedule, in which each keypeck produced 3 sec access to grain, and lasted until 60 responses had occurred. Throughout the session, the response key was transilluminated with the red stimulus except when reinforcement was available, at which time it was dark.

During Session 3, new stimuli were introduced which consisted of 90° (vertical), 60°, 30°, and 0° (horizontal) orientations of a white line on a dark surround. Stimulus duration was 30 sec and the stimuli were selected randomly with equal probability. The reinforcement schedule was the same in all the stimuli. During the first part of the session, a Fixed Ratio 5 (FR 5) schedule of reinforcement was in effect in which every fifth keypeck response produced 3 sec access to grain. This schedule lasted until 10 reinforcements were obtained at which time the schedule changed to a VI 10 sec schedule. All VI schedules were programed in accordance with the suggestions of Fleshler and Hoffman (1962) and stimulus selection and duration remained the same as before. The VI 10 sec schedule remained in effect until 20 reinforcers were obtained at which time a VI 30 sec schedule went into effect. This schedule lasted until 30 reinforcers were obtained at which time the subjects were returned to their home cages.

Session 4 started with the VI 30 sec schedule which lasted until 20 reinforcers had been obtained. Then a VI 60 sec schedule went into effect and lasted until 40 reinforcers were obtained.

Session 5 started with the VI 60 sec schedule which lasted until 20 reinforcers had been obtained. Then a VI 90 sec schedule went into effect and lasted until 40 reinforcers were obtained.

Sessions 6-10 consisted of a continuation of nondifferential training on the VI 90 sec schedule with sessions lasting until 60 reinforcers were obtained.

Phase 1

During Phase 1, 30 sec black out (B.O.) periods were introduced between pairs of stimulus presentations (i.e., each 30 sec B.O. period was followed by two 30 sec stimulus presentations). During the B.O. periods, all lights were off and reinforcer availability was cancelled. The VI schedule clock stopped as soon as the B.O. period was scheduled and began once the B.O. period had terminated. Also at this time, the probability of each stimulus occurrence was changed. The 90° line orientation was presented with a probability of 0.50; the remaining line orientations (60°, 30°, and 0°) were presented with a probability of 0.167 each so that the summ of their probabilities equalled 0.50. This, in effect, produced 16 different combinations of two successive stimulus presentations, each combination being separated by a 30 sec B.O. period. The probability of two successive 90° line orientations occurring was 0.25. The probability of the 90° line orientation preceeded or followed by a 60°, 30°, or 0° line orientation was 0.0835 of which there were six possible combinations; 90°/60°, 90°/30°, 90°/0°, 60°/90°, 30°/90°, and 0°/90°. The probability of a 60°, 30°, or 0° line orientation preceeded or followed by a 60°, 30°, or 0° line orientation was 0.027889 of which there were nine possible combinations; 60°/60°, 60°/30°, 60°/0°, 30°/60°, 30°/30°, 30°/0°, 0°/60°, 0°/30°, and 0°/0°. The duration of stimulus presentations was 30 sec, as in preliminary training. This phase lasted 80 sessions.

After 24 sessions of nondifferential training, Subjects 2 and 3 were consistantly responding differentially to the line orientations. A CRF schedule during each line orientation was intoduced to these subjects on Days 25-26; 30-35; and 38-43 in an attempt to decrease the amount of differential responding. The multiple VI, VI schedule was reintroduced on Days 28-29 and 36-37 to determine if a discrimination still existed. On Day 46, the multiple VI, VI schedule remained in effect until the end of Phase 1. Sessions were not conducted on Days 27, 44, 45, 68, and 108.

Phase 2

In Phase 2 of the experiment, a multiple VI, EXT schedule was introduced; responding during the 60°, 30°, and 0° line orientations was extinguished while all other aspects of the experiment remained the same. If reinforcement was obtained within the last 3 sec of the VI component, it was terminated upon the onset of the EXT component. The VI schedule clock was running only during the presentation of the 90° line orientation. This phase lasted 36 sessions.

All sessions during Phase 1 and 2 terminated after 160 stimulus presentations throughout the experiment.

RESULTS

Overall response rates and contrast effects

Figures 1 through 4 show response rate as a function of number of days in each of the four line orientations (90°, 60°, 30°, and 0°) for Subjects 1, 2, 3, and 4, respectively. Response rates were averaged over two-day periods by summing the average daily response rate in each stimulus and dividing by two. A vertical dashed line separates Phase 1 (multiple VI, VI) and 2 (multiple VI, EXT). Sessions were not conducted on Days 27, 44, 45, 68, and 108 so the data points here represent only one day. Continuous reinforcement training was conducted on days 25-26, 30-35, and 38-42 for Subjects 2 and 3 and no data points are shown for these sessions.

Subject 1's response rate was stable during Phase 1 and no consistant difference in rates in the different line orientations was evident. After the change to Phase 2, Subject 1's response rate during the S-s (60°, 30°, and 0°) gradually decreased over the first 10 days and remained under 5 responses per min for the rest of Phase 2. Responding during the S+ (90°) increased slightly and fluctuated above the Phase 1 response rate for most of Phase 2. It is questionable whether or not this increase can be termed behavioral contrast. After a break in the experiment (Day #108), responding during the S+ decreased and remained at the Phase 1 rate.

Subject 2's response rate was also stable during Phase 1 but was differential with respect to line orientation. Generally, response rate decreased monotonically as a function of line orientation with

Figure 1: Overall response rate in each line orientation as a function of the number of days for Subject 1.

FIGURE 1

SUBJECT 1

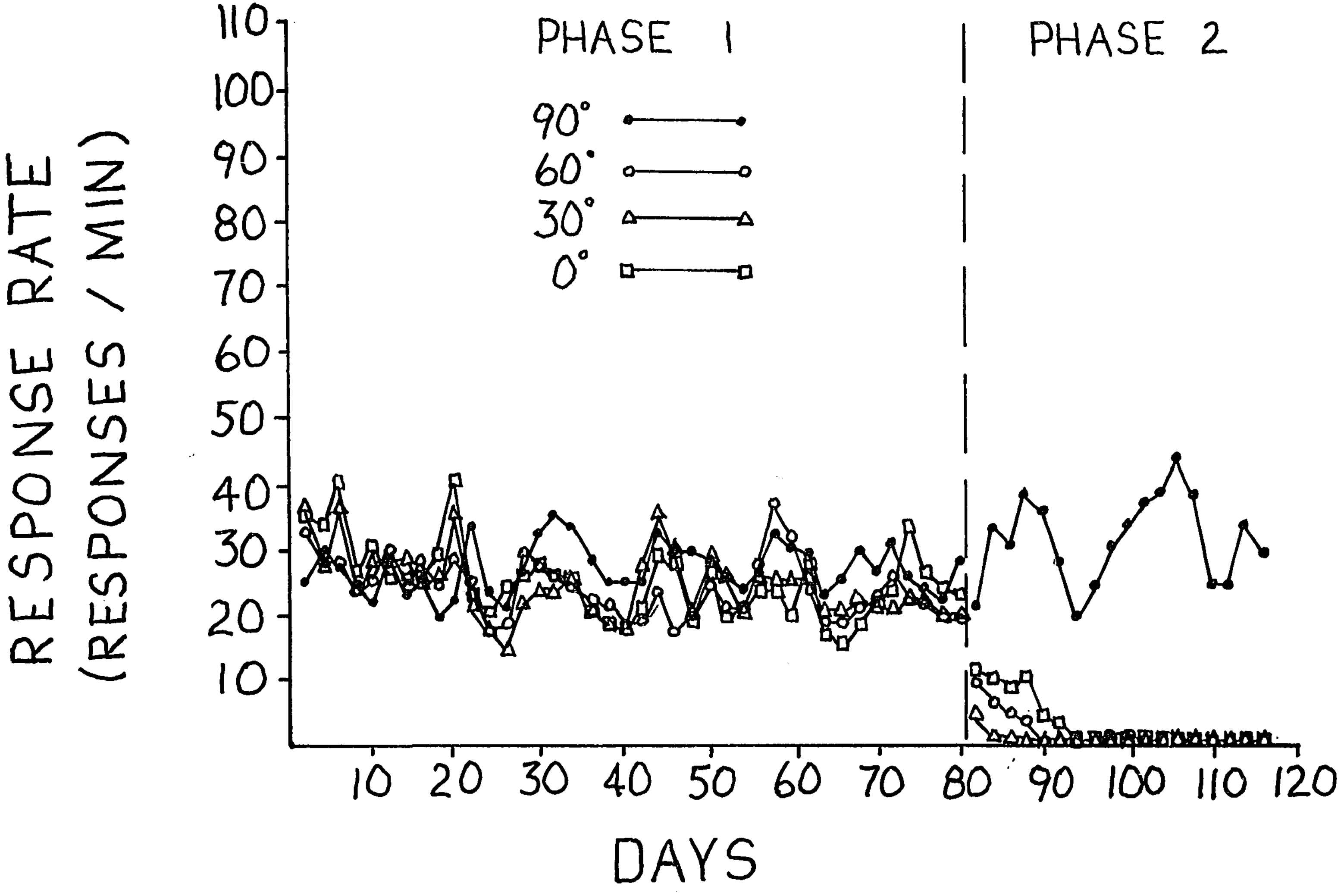


Figure 2: Overall response rate in each line orientation as a function of the number of days for Subject 2.

FIGURE 2

SUBJECT 2

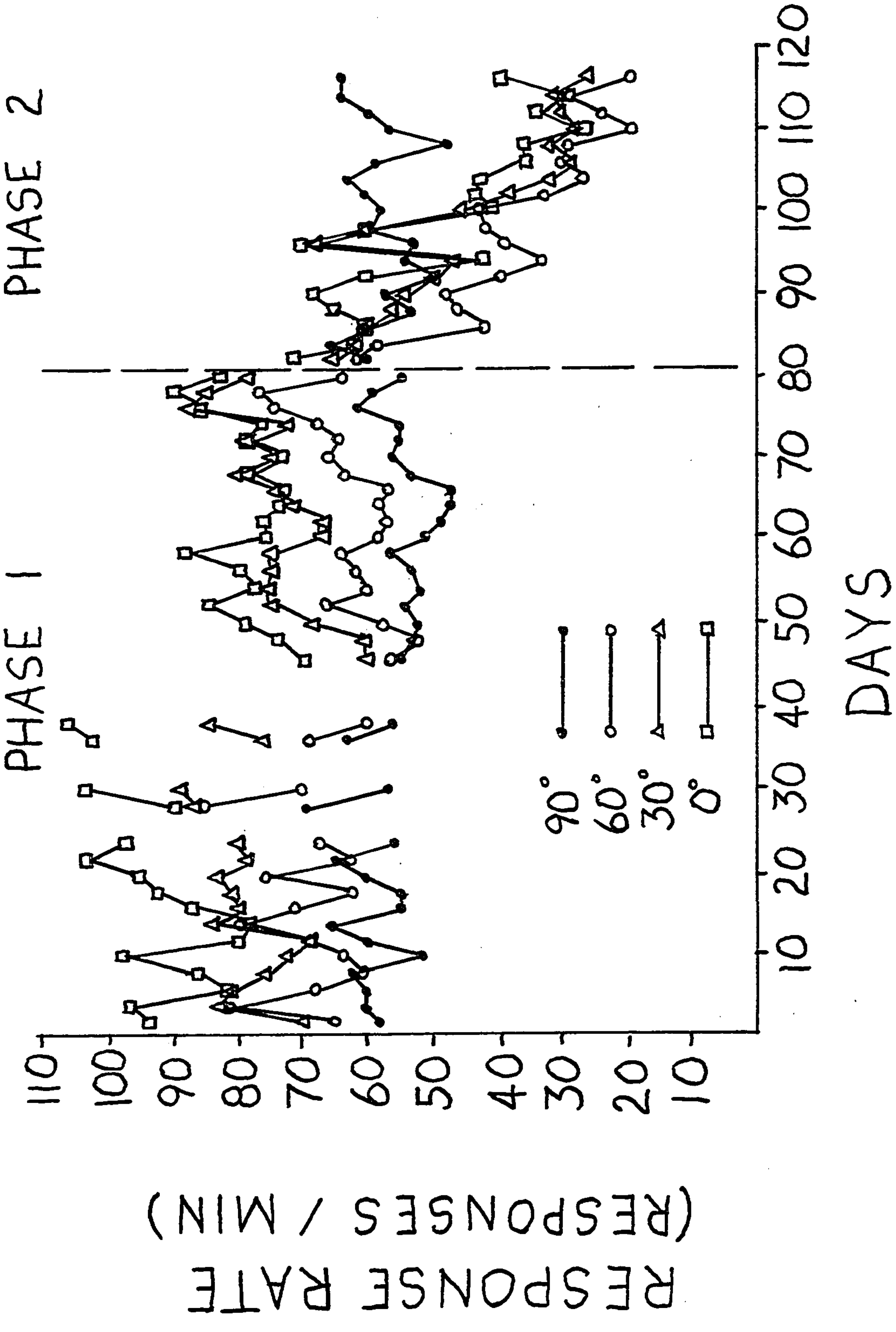


Figure 3: Overall response rate in each line orientation as a function of the number of days for Subject 3.

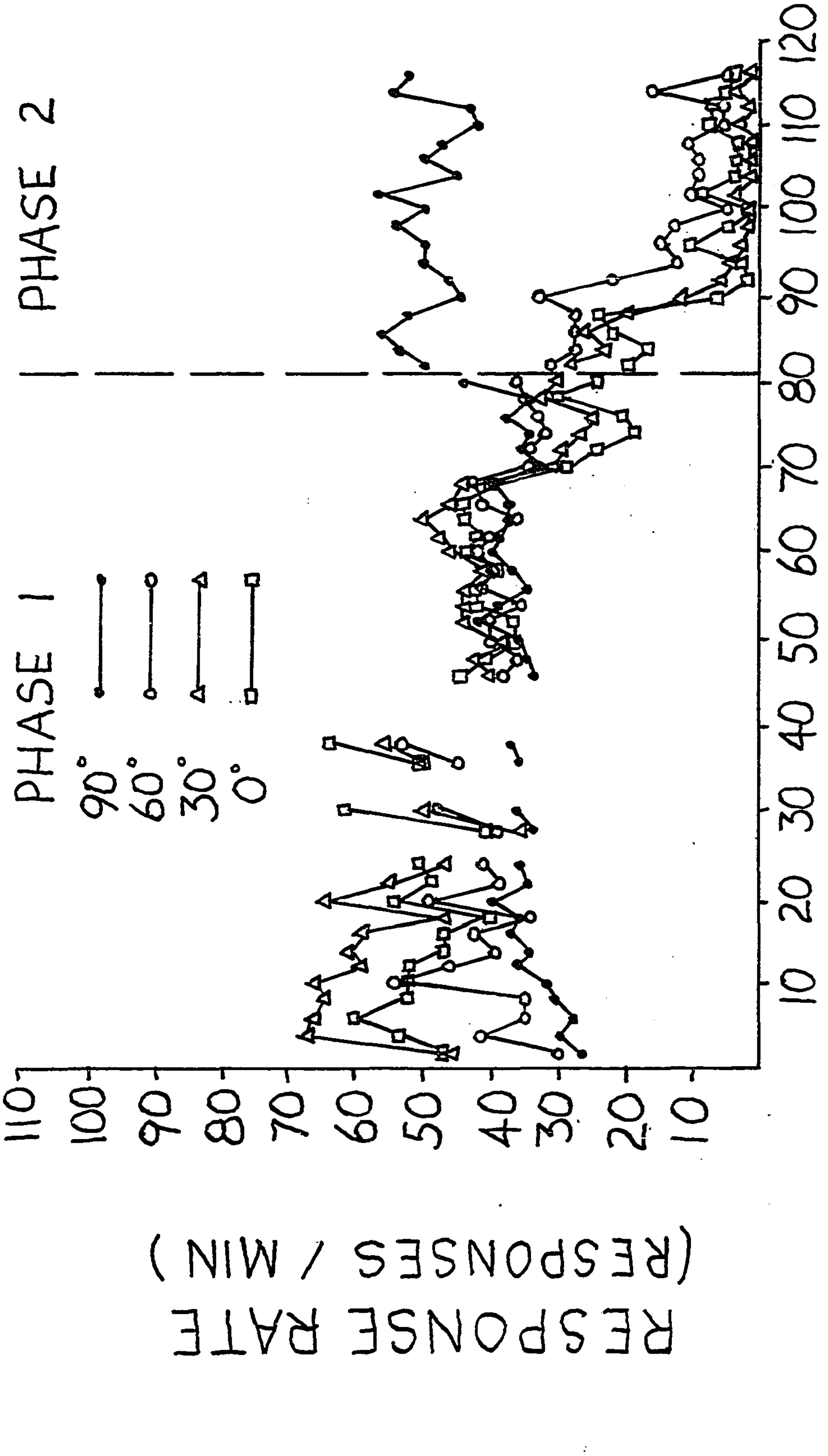
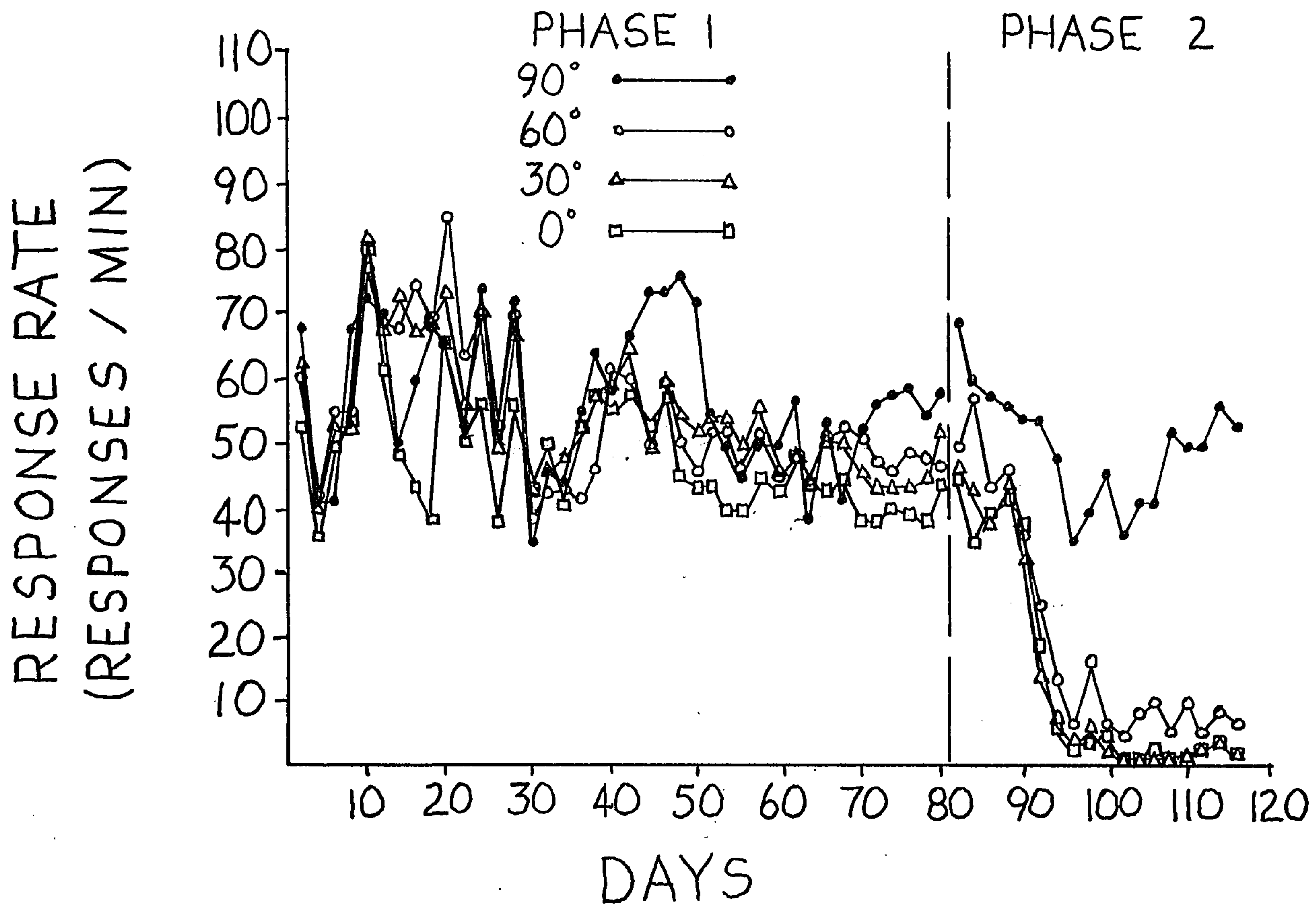


FIGURE 3
SUBJECT 3

Figure 4: Overall response rate in each line orientation as a function of the number of days for Subject 4.

FIGURE 4

SUBJECT 4



the highest rate in the 0° line orientation and the lowest rate in the 90° line orientation. After the CRF training procedure was initiated, differential responding decreased but was still evident. Once Phase 2 was instituted, response rates during the S-s slowly decreased in an orderly manner. Response rates during the S+ and the S-s did not diverge until after 20 sessions of discrimination training. Responding during the S+ remained at the Phase 1 level throughout Phase 2 and no behavioral contrast was evident.

Subject 3's response rates were initially differential with respect to line orientation with the highest rate in the 30° line orientation and the lowest in the 90° line orientation. The introduction of the CRF procedure resulted in a decrease in the response rate variability and differential responding. After a break in the experiment (Day #68), response rates again became differential in an orderly manner; generally, response rate increased monotonically as a function of line orientation with the highest rate in the 90° line orientation and the lowest rate in the 0° line orientation. It should be noted, however, that the response rate during the 90° line orientation was stable throughout Phase 1. After the change to Phase 2, response rates during the 60°, 30°, and 0° line orientations slowly decreased and, after 12 days of discrimination training, remained below 20 responses per min in all the S-s throughout the remainder of Phase 2. Response rate during the 90° line orientation remained above the Phase 1 level throughout Phase 2. This is an example of behavioral contrast.

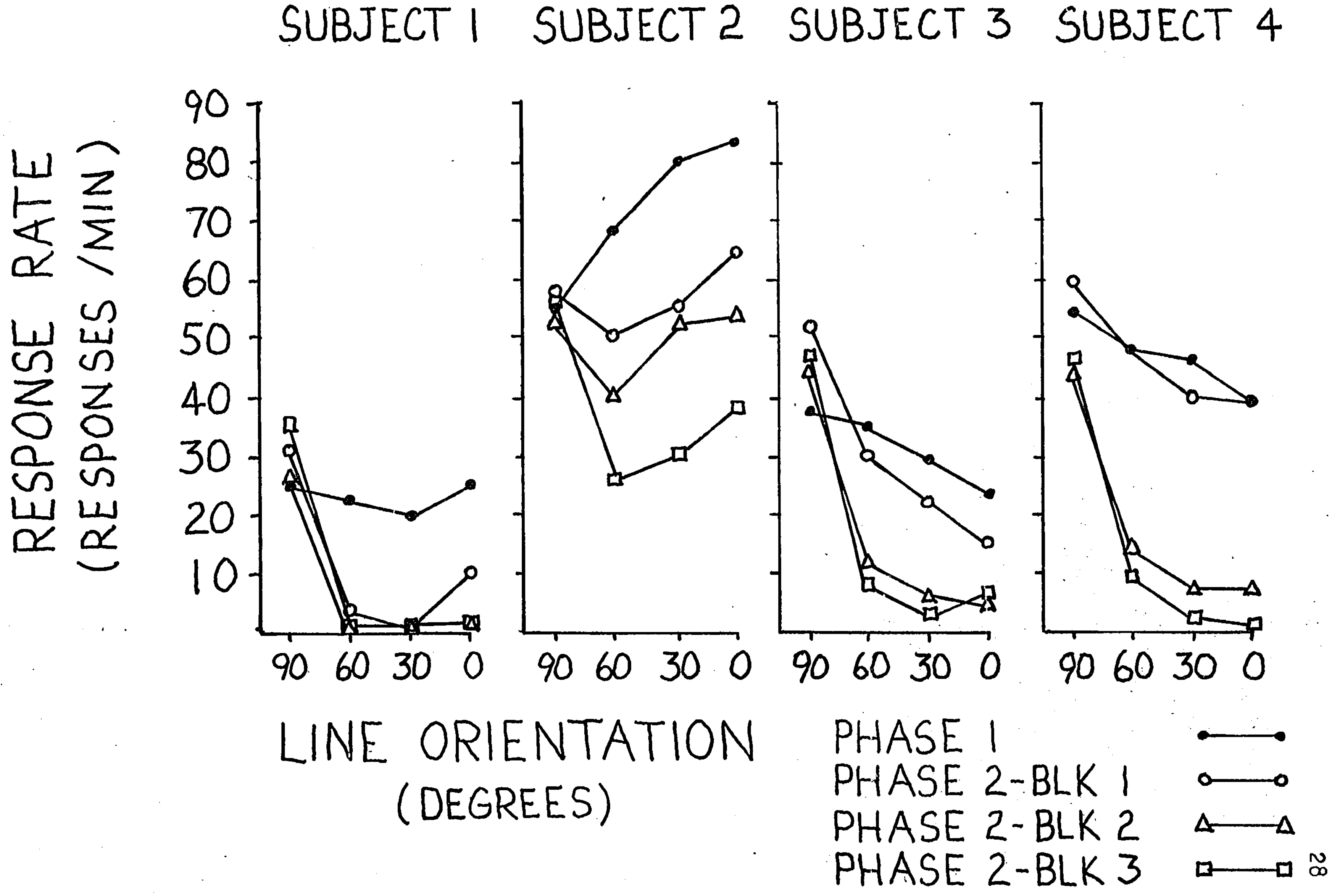
Subject 4's response rates were initially unstable during Phase 1 with no consistant differential responding with respect to line orientation. Response rates later became more stable but, toward the end of Phase 1, after a break in the experiment (Day #68), differential responding with respect to line orientation developed with the highest rate usually in the 90° line orientation and the lowest response rate in the 0° line orientation. After the change to Phase 2, response rates during the S-s slowly decreased. Response rate during the S+ increased sharply on the first day of discrimination training and then slowly decreased. Later in discrimination training, response rate during the S+ increased again.

Figure 5 shows mean maintained generalization gradients for individual subjects for Phases 1 and 2. Each gradient was obtained by summing daily response rates in each line orientation and dividing by the number of days (10) in each block. The filled circles represent mean response rates in each of the four line orientations during the last 10 days of Phase 1. The open circles, triangles, and squares represent mean response rates in each of the four line orientations for the first, second, and third blocks of 10 sessions of Phase 2, respectively. Response rate during the last 10 days of Phase 1 was nondifferential for Subject 1 only. Subject 2's response rates were differentially affected by line orientation with the highest rate in the 0° line orientation and the lowest rate in the 90° line orientation. Subjects 3 and 4 also showed differential responding with the highest in the 90° line orientation and the lowest rate in the 0° line orientation.

It can be seen that the change from Phase 1 to 2 produced a slight but permanent increase in response rate in the 90° line or-

Figure 5: Maintained generalization gradients for each subject. Each set of axes represents the mean average response rate as a function of line orientation. The four functions per set of axes correspond to successive blocks of 10 days.

FIGURE 5


SUBJECT 1
SUBJECT 2
SUBJECT 3
SUBJECT 4
RESPONSE RATE
(RESPONSES /MIN)
90
80
70
60
50
40
30
20
10
90 60 30 0
LINE ORIENTATION
(DEGREES)
PHASE 1
PHASE 2-BLK 1
PHASE 2-BLK 2
PHASE 2-BLK 3

ientation for Subjects 1 and 3 but not for Subjects 2 and 4 who showed no change and only a slight transient increase, respectively. It should be noted that in the two cases where contrast was possibly demonstrated, the response rates in Phase 1 were relatively low; these two subjects had response rates below 40 responses per min while the other two subjects had response rates above 55 responses per min. Decreased responding to all other line orientations occurred for all subjects and all showed a discrimination. Subject 2's discrimination was, however, poor. Subject 2 was the only subject who showed the lowest response rate in the S- closest to the S+ with response rate increasing with distance from the S+.

Local contrast effects

Figures 6 through 9 show mean response rates as a function of the preceeding line orientation for Subjects 1, 2, 3, and 4, respectively. Each data point represents response rate in the second of a pair of stimulus presentations, the pairs being separated by a black out (B.O.). The line orientation in the first stimulus presentation of the pair is represented on the abscissa along with the blackout period. The line orientation in the second stimulus presentation of the pair, in which the response rate on the ordinate was recorded, is different for each set of axes. For example, all data points in the left-most set of axes represent response rate during the 90° line orientation; the points within one function correspond to the different line orientations which preceeded the ongoing 90° line orientation presentation. The data points represented above the blackout period (B.O.) are response rates during the 90° line orientation when it was preceeded by the blackout period; in other words, these data points are from the first stimulus in the stimulus pairs. Each data point represents the mean response rate, calculated by summing response rate over days and dividing by the number of days (10) in each block, during four successive blocks of 10 days. The filled circles represent responding during the last 10 days of Phase 1. The open circles, triangles, and squares represent responding in each of the four line orientations during the first, second, and third successive blocks of 10 days of Phase 2, respectively.

Figure 6 shows the results for Subject 1 and, as can be seen, preceeding line orientation had no effect upon subsequent response rate; however, response rate was lower when preceeded by a blackout period. Subject 1 shows a contrast effect which is indicated by the fact that most of the Phase 2 points within the 90° set of axes are above the Phase 1 points while all the points on the 60°, 30°, and 0° set of axes are below the Phase 1 points.

Figure 7, which represents the results of Subject 2, shows there was no effect of the preceeding line orientation or blackout upon response rate during the 90° line orientation and no positive behavioral contrast was demonstrated. There was, however, a differential effect upon response rate during the 60°, 30°, and 0° line orientations. Response rate in each S- was lower when preceeded by the S+ than when preceeded by any S-; the line orientation of the preceeding S- did not, however, make a difference. The lower rates

Figure 6: Response rate in each line orientation as a function of the preceeding line orientation for Subject 1. Each set of axes represents the mean average response rate during one of the four line orientations as a function of the preceeding line orientation. Each of the four functions per set of axes represents the mean response rate during successive blocks of 10 days.

FIGURE 6

SUBJECT 1

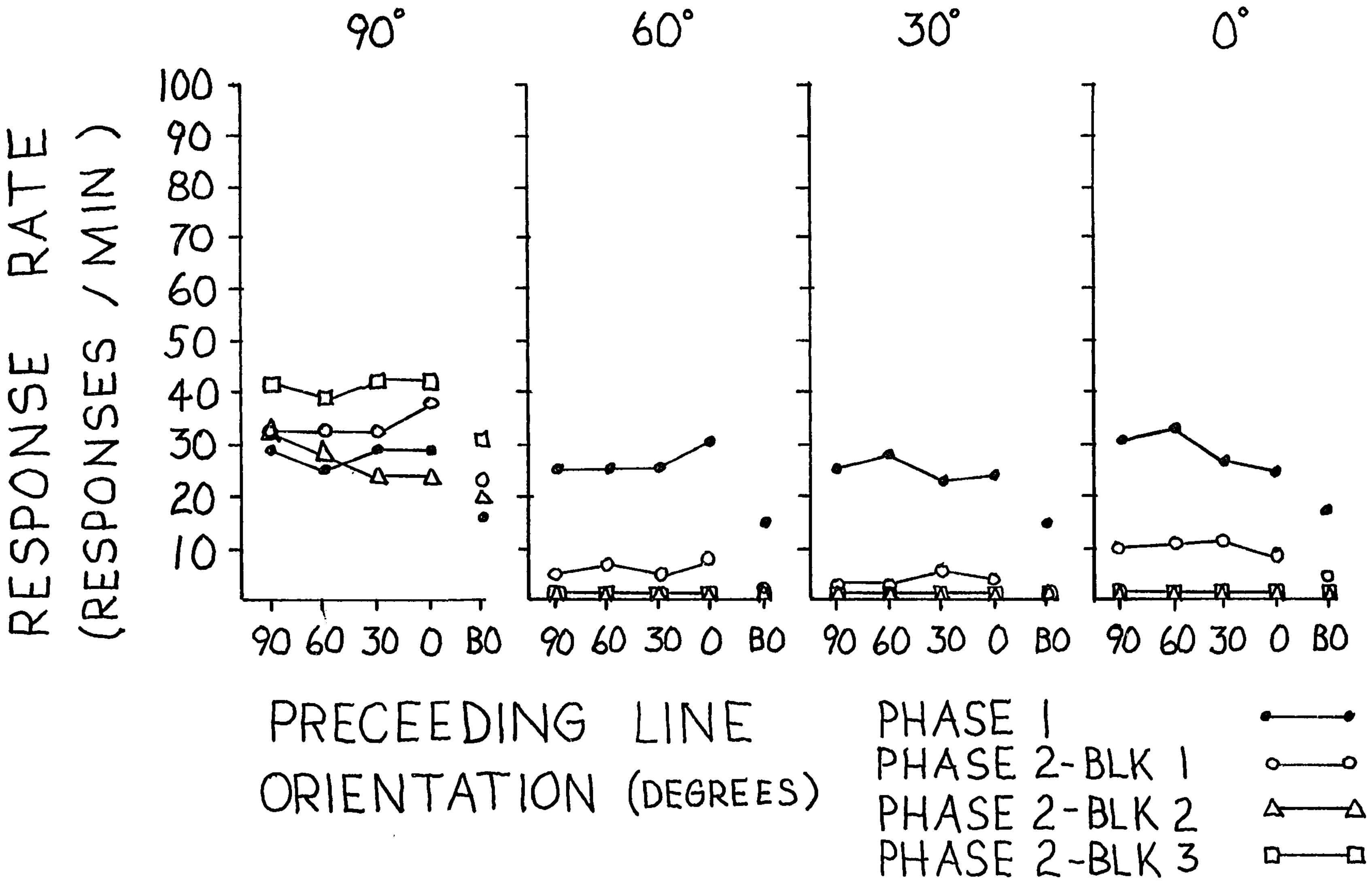
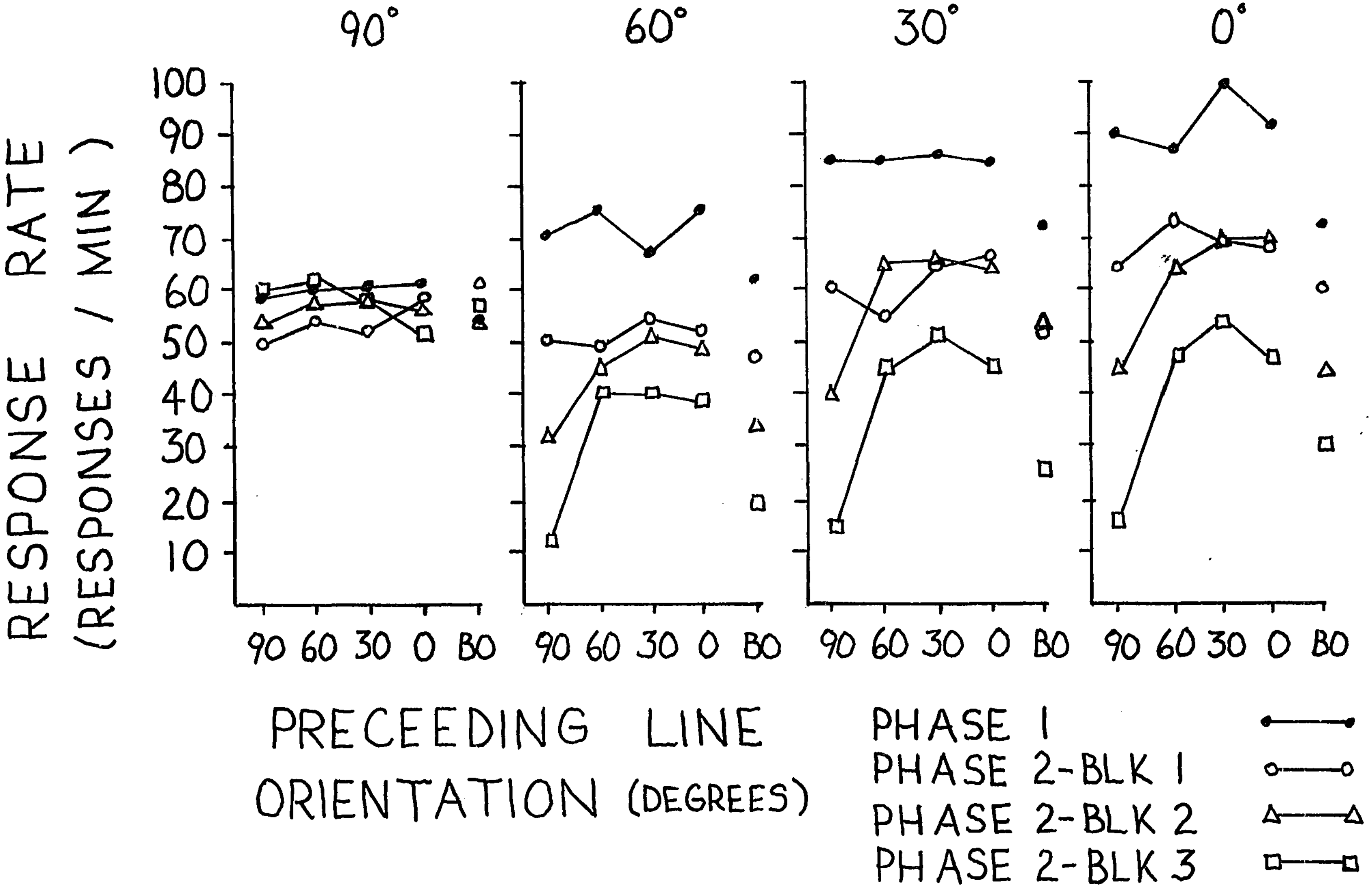


Figure 7: Response rate in each line orientation as a function of the preceeding line orientation for Subject 2. Each set of axes represents the mean average response rate during one of the four line orientations as a function of the preceeding line orientation. Each of the four functions per set of axes represents the mean response rate during successive blocks of 10 days.

FIGURE 7

SUBJECT 2



following the S+ constitute examples of negative local contrast. The absolute reduction in responding in the S- following the S+ relative to the rates in the S- following an S- is approximately the same for differing S-s. As with Subject 1, response rates in the 60°, 30°, and 0° line orientations after the blackout period were lower than when preceeded by an S-.

Figure 8, which represents the results of Subject 3, shows there was no differential effect of a preceeding line orientation upon the subsequent response rate in any line orientation. As can be seen, Subject 3 shows evidence of behavioral contrast as described for Subject 1. Subject 3's response rate following the blackout period was also usually lower than following a line orientation.

Figure 9, which represents the results of Subject 4, shows that the response rate in the 60°, 30°, and 0° line orientations were usually somewhat lower when preceeded by the 90° line orientation than when preceeded by an S- during the first and second blocks of Phase 2; this effect was probably not apparent in the third block because of a floor effect in which the response rates were near zero. A similar effect is shown for the 90° line orientation over the first block of Phase 2; the lack of effect in blocks 2 and 3 cannot be explained by a floor effect since the rates remained high. The line orientation of the preceeding S- did not produce differential effects. A small positive contrast effect is apparent only in the first block of Phase 2; this occurred only for S+ presentations following an S-. As with Subjects 1 through 3, response rates after the presentation of the blackout period were generally lower than

Figure 8: Response rate in each line orientation as a function of the preceeding line orientation for Subject 3. Each set of axes represents the mean average response rate during one of the four line orientations as a function of the preceeding line orientation. Each of the four functions per set of axes represents the mean response rate during successive blocks of 10 days.

FIGURE 8

SUBJECT 3

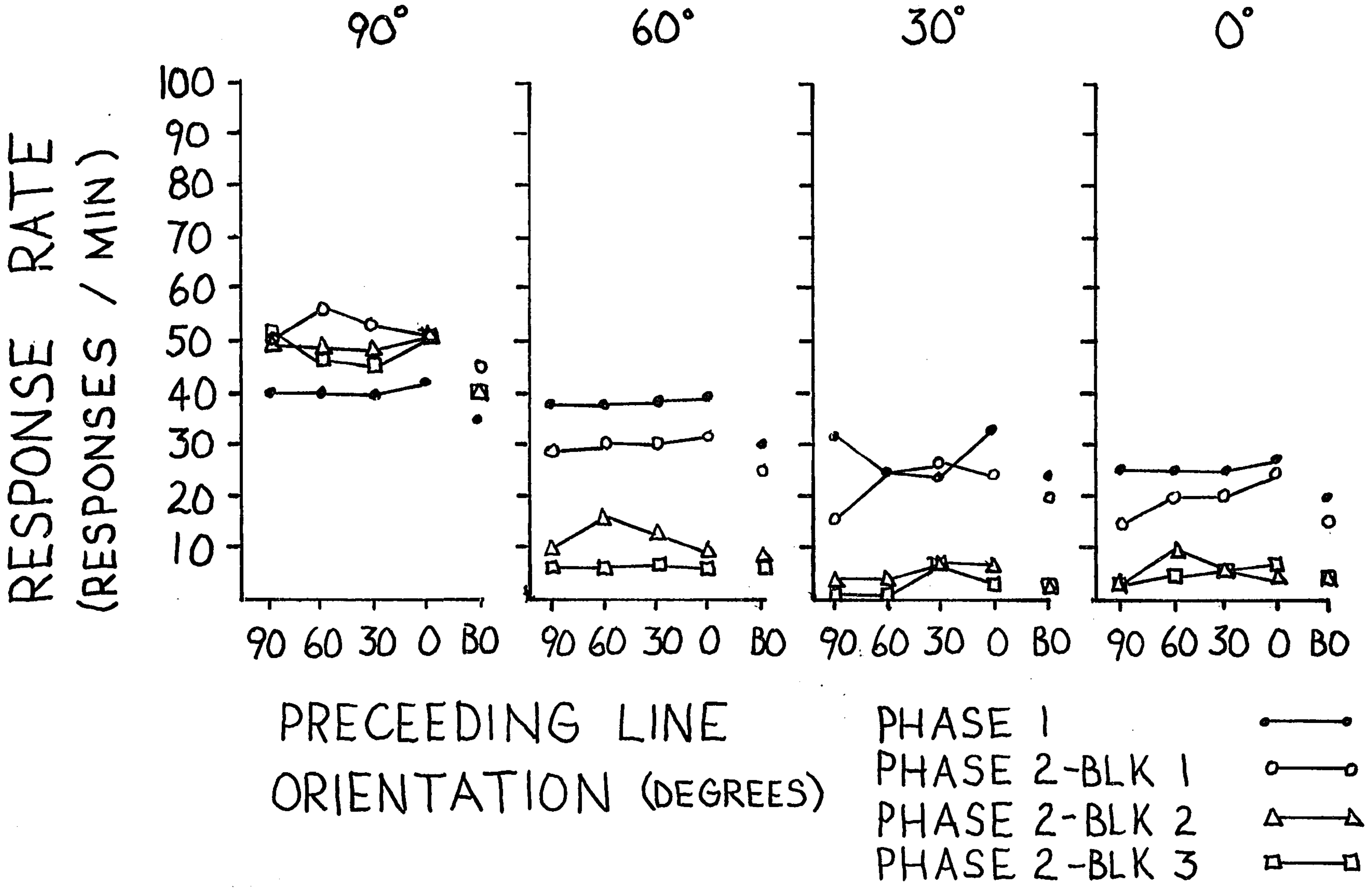
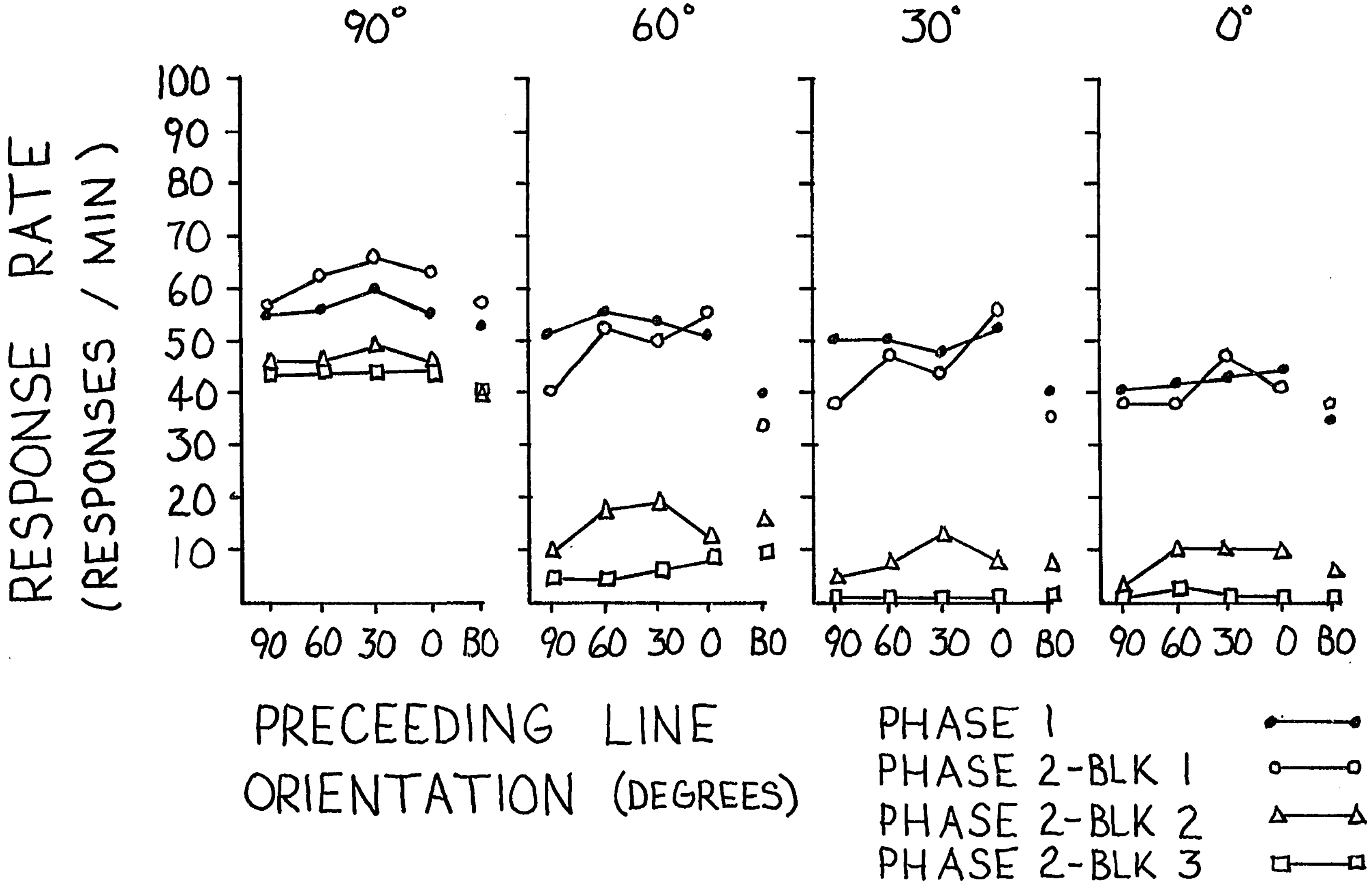


Figure 9: Response rate in each line orientation as a function of the preceeding line orientation for Subject 4. Each set of axes represents the mean average response rate during one of the four line orientations as a function of the preceeding line orientation. Each of the four functions per set of axes represents the mean response rate during successive blocks of 10 days.

FIGURE 9

SUBJECT 4



after line orientation presentations for all orientations.

DISCUSSION

The present study demonstrated little behavioral contrast when discrimination training was introduced. This was expected because the B.O. (all illumination in the chamber discontinued) between pairs of stimuli was introduced very early in nondifferential training prior to the addition of the S- stimuli (discrimination training). Sadowsky (1973) has shown that the introduction of a B.O., in which pigeons never respond, produces sustained positive contrast which lasts over many sessions. In Sadowsky's experiment when the B.O. was replaced with an S- (a stimulus on the response key in which responses are extinguished), little, if any, change in response rate to the S+ occurred. Taus and Hearst (1970) have also demonstrated that, as the duration of a B.O. is increased from zero to 30 sec, the response rate in the S+ increases. In the present study, the B.O. was introduced very early in training; it was thus impossible to demonstrate contrast due to the B.O. because of an inadequate length of the baseline period. It seems likely, however, that contrast effects were present during nondifferential training with the B.O. Thus, the addition of the S- stimuli would not be expected to have a strong effect.

The present study failed to demonstrate greater negative behavioral contrast (lower overall response rate) for the S- closest to the S+ relative to the S-s farther from the S+. This lack of effect confirms the two prior studies which have similarly failed (Farthing, 1974; and Malone and Staddon, 1973) and contradicts the study by Catania and Gill (1964) which seemed to demonstrate such an effect. The reason for the contradiction is not apparent, but it might be suggested that the effect obtained by Catania and Gill (which was small) was not reliable.

Like the study by Malone and Staddon (1973), the present study failed to demonstrate an effect of similarity of preceeding S- to S+ on S+ response rate. These results may imply that the effects of similarity of S- to S+ on S+ response rate are restricted to positive behavioral contrast (Catania and Gill, 1964; Farthing, 1974; and Malone, 1975) and do not occur in positive local behavioral contrast.

Negative local behavioral contrast (lower response rate in the S- following an S+ than following an S-) was demonstrated in two out of four subjects in the present study; the effect was strong in only one subject. The magnitude of the effect did not appear to be related to the degree of difference between the S+ and S-. Demonstration of this effect confirms the results of Malone and Staddon (1973). The reason for the failure to demonstrate the effect in the other two subjects is unknown, however.

The present experiment failed to demonstrate any effect of line orientation of the preceeding S- on S- response rate and this contradicts the results of Malone and Staddon (1973). Those authors demonstrated that response rate in S_x- is lowest when preceeded by an S- closer to the S+ than itself, intermediate when S_x- was preceeded by itself, and highest when S_x- was preceeded by an S- farther from the S+ than itself. Again, the reason for the discrepancy is not apparent.

The demonstration that response rate in the S+ was lower following B.O. than following an S- is in agreement with prior results using time outs (key light off but houselight on with extinction of responding). Veith and Rilling (1972) and Kodera and Rilling (1976) found that response rate was higher in S+ when preceeded by a time out. However, the finding of the present study that response rates in S-s were also lower following B.O. than following an S- was unexpected. No directly relevant study has been reported in the past, but one might make a prediction based upon Malone and Staddon's (1973) results. Since they found that S- rates increase with the distance of a preceeding stimulus from S+, one might expect that S- response rate in the present study would be higher following the B.O. than following an S- since the B.O. is the least similar to the S+. The results do not confirm this prediction. Another possible explanation may involve latency of response to the S-. Veith and Rilling (1972) found that the latency of response following time out is greater than that following an S- and they corrected their response rates for this. It is possible that the lower response rates in the S- following B.O. in the present study reflect longer latencies following B.O. The data to confirm or disprove this possibility are not available.

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