

BEHAVIORAL CONTRAST AND PEAK SHIFT IN PIGEONS:
A RE-EVALUATION OF THE RESPONSE ADDITIVITY THEORY
OF BEHAVIORAL CONTRAST

By

BONNIE LYNN GROSSFLAM

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Approved by:

Jerome Friedman
Major Professor

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Behavioral contrast and the peak shift are both phenomena which result from discrimination training. The first free operant study of contrast in pigeons was conducted by Reynolds (1961a) who found that on multiple schedules of reinforcement the rate of responding increases from the nondifferential baseline rate in the presence of one stimulus (S1) when that stimulus is correlated with a variable interval (VI) schedule of reinforcement and a second stimulus (S2) is correlated with extinction or timeout. Differential reinforcement of other behavior (DRO), on the other hand, when correlated with S2 did not produce increased responding in the presence of S1. Reynolds (1961a) described behavioral contrast as "a change in the rate of responding during the presentation of one stimulus in a direction away from the rate of responding prevailing during the presentation of a different stimulus" (p. 69).

The peak shift was first described by Hanson (1959) who noted that when a stimulus generalization test follows intradimensional discrimination training with a mult VI-EXT schedule, the peak of the post-discrimination gradient (PDG) is displaced away from S+ in the direction away from S-. Employing monochromatic stimuli, Hanson found that the magnitude of the peak shift depends upon the difference between S+ and S-. The probability of obtaining a peak

shift and the magnitude of the peak shift increase as the spacing along the stimulus continuum between S+ and S- decreases (until the subjects can no longer discriminate S+ from S-).

More recent investigations have shown that behavioral contrast occurs in situations other than those described by Reynolds. Whereas Reynolds' (1961a) procedure involved a shift from mult VI VI to mult VI EXT, Bloomfield (1966) shifted from single stimulus VI (S1) to mult VI EXT and obtained similar contrast effects. Behavioral contrast also occurs in mult VI-FR schedules (Bloomfield, 1967a), when reinforcement is delayed in one component of a multiple schedule (Keller, 1970; Richards, 1972; Wilkie, 1971), in schedules in which the S- component is correlated with punishment (Brethower & Reynolds, 1962), in schedules in which timeout (darkening of the response key) is the negative stimulus (Friedman & Guttman, 1965; Sadowsky, 1973), and in schedules in which blackout (darkening both chamber and response key) is the negative stimulus (Sadowsky, 1973). Lattal (1970), contrary to Brethower and Reynolds (1962), did not obtain behavioral contrast with shock, but the pigeons' histories of punishment prior to the experiment may have influenced the results.

Likewise, the peak shift occurs on continua of monochromatic stimuli (Dysart, Marx, Mclean, & Nelson, 1974; Hanson, 1959; Terrace, 1968), line angles (Bloomfield,

1967c; Winton & Beale, 1971), circle diameter (Wildemann & Holland, 1973), and tones (Jenkins & Harrison, 1962). A peak shift occurs when S- is of the same type that produces contrast: extinction (Hanson, 1959), decreased reinforcement frequency (Dysart et al., 1974; Guttman, 1959; Terrace, 1968), shock (Grusec, 1968; Terrace, 1968), and shorter reinforcement duration (Mariner & Thomas, 1969).

Theoretical Explanations of Behavioral Contrast

Reynolds (1961a,b) postulated two necessary conditions for the appearance of behavioral contrast. He suggested that a change in the rate of reinforcement prevailing during the presentation of S- is a necessary condition for the formation of behavioral contrast. However, as stated earlier, Bloomfield (1966) found behavioral contrast when the schedule was shifted from single stimulus to mult VI EXT. In this situation the rate of reinforcement during the S- trials was never changed and, therefore, this serves as evidence contradictory to Reynold's notion.

Reynolds' notion that a decrease in response rate is necessary during S- in order for behavioral contrast to occur has also come into question. Halliday and Boakes (1974) observed behavioral contrast in two schedules in which there was no reduction in response rate to S-. In one case S- was response-independent reinforcement and in the other S- was an extinction component very different from the VI component (errorless). Koder and Rilling

(1976) also found behavioral contrast with errorless discrimination learning. These results are in conflict with those of Terrace (1963) who did not observe behavioral contrast with errorless learning and concluded that responding to S- is a necessary condition for contrast. The reason for these discrepant findings is unclear.

Terrace (1966b) suggested that both behavioral contrast and the peak shift occur when there is a change for the worse in one component of a multiple schedule. The aversiveness of stimuli correlated with nonreinforced responding or a reduction in response rate causes an emotional effect which leads to an increased rate of responding to S+. Terrace feels that response suppression is necessary in order for behavioral contrast and the peak shift to occur and cites as evidence for this position his finding that these two phenomena are absent during errorless learning (Terrace, 1963, 1964). However, as stated earlier, other researchers (Halliday & Boakes, 1974; Kodera & Rilling, 1976) have found behavioral contrast associated with an errorless discrimination. Terrace (1968) observed that although not all of his pigeons exhibited behavioral contrast and the peak shift, they either demonstrated both or neither. He feels that these two phenomena always occur together. There is much evidence (as enumerated earlier) which supports this idea.

Amsel (1962) explained behavioral contrast in terms of

frustration. The frustration effect (FE) is "the carried-over, enhancing effect of nonreward on the vigor of immediately following behavior" (p. 308). More recently, Amsel (1971) has suggested that when trials follow each other in rapid succession, the frustrative effects of nonreward should operate to increase the level of responding to an immediately succeeding S+ and this accounts for contrast. If the trials are spaced, however, the temporary frustration effects should diminish and no contrast occur. These are indeed the results which have been observed. Contrast occurs only in discrimination training situations which employ relatively short intertrial intervals.

A theory resembling that of Terrace was advanced by Premack (1969). According to this theory, a change in preference results in behavioral contrast. When there is an increase in the aversiveness associated with one component of a multiple schedule, the relative preference for the other component intensifies and an escalation in rate of responding occurs. Contrast occurs only if S- is capable of generating inhibition. However, Premack's theory is vague in that it does not really explain how this change in preference produces contrast.

The most recently proposed explanation of behavioral contrast is the response additivity theory advanced by Gamzu and Schwartz (1973). They suggest that behavioral contrast in an operant discrimination occurs when elicited

pecks (autopecks) are added onto the operant baseline. This can also be thought of as the addition of responses involving response-reinforcer (operant) and stimulus-reinforcer (Pavlovian) contingencies.

According to the response additivity theory, only a response which can be autoshaped can produce a contrast effect. In support of this idea, Westbrook (1973) did not obtain behavioral contrast when pigeons pressed a bar by foot and Hemmes (1973) obtained behavioral contrast when pigeons key-pecked but not when they treadle-pressed on a mult VI EXT schedule. However, McSweeney (1975) did notice behavioral contrast when pigeons treadle-pressed on a concurrent schedule and Bushnell and Weiss (1980) did obtain both a peak shift and a small behavioral contrast effect when pigeons pressed a treadle. The Bushnell and Weiss study used a response-reset dependency in S- (i.e., S- is not terminated until a specific amount of time elapses without a response) and, since this may have increased the aversiveness of S-, the appearance of behavioral contrast is evidence in support of Terrace's and Premack's views.

According to the additivity theory, it would also be predicted that contrast would occur only when the discriminative stimulus is located on the operant manipulandum. This restriction is necessary because autoshaping occurs only with localized stimuli. In support of this notion,

Schwartz (1973) found that key-pecking was initiated and maintained when the key color was a signal for food but not when a tone was a signal for food. However, control of key-pecking which had been established with the key color could be transferred to a tone and subsequently maintained by the tone. The noteworthy observation is that although pecking which was autoshaped with a localized stimulus could be transferred to a diffuse stimulus, pecking cannot be autoshaped in the presence of a diffuse stimulus.

Schwartz (1975) did in fact observe behavioral contrast when the stimulus was located on the response key but not when the stimulus was a houselight or tone. Similarly, Redford and Perkins (1974) found behavioral contrast when the stimuli were located on the key but not when they were houselights. However, the Redford and Perkins study had a problem since there was no evidence that the birds discriminated. On the other hand, Farthing (1976) did obtain behavioral contrast with auditory stimuli when a response-reset dependency was used in S-. Westbrook (1973) did likewise obtain a small amount of behavioral contrast with tones.

Evidence in support of the additivity theory was obtained by Boakes, Halliday, and Poli (1975). They superimposed free reinforcement on behavior maintained by a response-dependent multiple schedule and response rate increased in that component. They concluded that these

results support the assumption of the additivity theory that contrast results from an interaction between behavior maintained by response-reinforcer and stimulus-reinforcer contingencies.

Keller (1974) measured response rate to both an operant key and a signal key during discrimination training. The finding of no behavioral contrast on the operant key but a small amount of behavioral contrast on the signal key appears to lend support to the response additivity theory of behavioral contrast since this theory states that behavioral contrast results from a stimulus-reinforcer relationship. In a similar experiment, however, Williams and Heyneman (1981) did obtain behavioral contrast on the operant key when a separate signal key was used. They employed two operant keys in order to ensure stimulus control by the signal key during the baseline phase. During baseline, the signal key indicated on which operant key responses would be reinforced. This procedure made it necessary for the subjects to spend the same amount of time observing the signal key during both baseline and discrimination training. In Keller's (1974) experiment, on the other hand, the subjects only needed to observe the signal key during the discrimination and this interfered with responding during that phase. Therefore, when changes in the stimulus control relation between baseline and discrimination training were eliminated, behavioral

contrast occurred; this is evidence against the additivity theory of behavioral contrast.

Schwartz and Williams (1972) discovered that key-peck durations with an omission procedure are different from those with a response-dependent procedure. With an omission procedure, short duration (<20 msec) key-pecks occur while pecks two to five times longer in length are emitted on operant schedules of reinforcement. This suggests that there might be two different classes of key-peck: short duration pecks controlled by stimulus-reinforcer contingencies and long duration pecks controlled by response-reinforcer contingencies. Bearing this in mind, Schwartz, Hamilton, and Silberberg (1975) measured response duration to both an operant key and a signal key during discrimination training. The duration of responses on the signal key was substantially shorter than those on the operant key. However, since there was no behavioral contrast when the rates on the two keys were summed and most signal key responding occurred just after a stimulus change, Schwartz et al. (1975) concluded that additivity theory may account only for transient contrast. These results must be interpreted with caution since, as described earlier, Williams and Heyneman (1981) did obtain behavioral contrast with a two operant key procedure. It should also be noted that a change-over delay (COD) was used and that there was no response duration difference without a COD. Whipple and

Fantino (1980) measured the duration of key-pecks in the unchanged component of a discrimination. After a baseline phase of nondifferential reinforcement, the pigeons were given discrimination training. Although behavioral contrast was present, the average duration of the key-pecks did not change. Assuming that there are two kinds of pecks then according to additivity theory, the average duration should have decreased based on the assumption that response-independent and response-dependent pecks are added together during behavioral contrast. The fact that it did not is evidence against the theory. However, Perkins (in press) hypothesizes that there are not two different kinds of pecks. Rather, the briefer pecks may result when the peck was intended to just miss the key. If this is indeed the case and additivity theory is correct, it is still difficult to see why it is the long duration pecks which increase in frequency during behavioral contrast and not these accidental brief pecks.

Theoretical Explanations of Peak Shift

In addition to Terrace's theory of both behavioral contrast and peak shift, two other theories have been proposed to account for the peak shift. Spence's (1937) theory is similar to that of Terrace's. Spence (1937) developed a theory of what was later called intradimensional discrimination learning to account for transposition. Transposition is observed when a subject responds

more often to a novel stimulus which is displaced from S+ in a direction away from S- in a simultaneous discrimination. This theory can be applied as well to successive discrimination experiments. It includes five basic assumptions: (1) there is an increase in the excitatory tendency to respond to S+ as a result of reinforcement, (2) there is a generalization of excitation around S+, (3) an inhibitory tendency is produced by extinction of responding to S-, (4) there is a generalization of inhibition around S-, and (5) the predicted response to a stimulus is obtained from the algebraic summation of these excitatory and inhibitory tendencies. It follows from these postulates that response rate to S+ in the PDG is less following discrimination training than with single-stimulus training. This last derivation is the only one which is not supported empirically.

James (1953) proposed an explanation of transposition based on Helson's adaptation-level theory (1958). This theory may also be adopted to account for the peak shift. According to adaptation-level theory, the response to any stimulus is determined by the position of the stimulus within a series of other stimuli and based upon the adaptation level at that point. The adaptation level is derived from the weighted average of all stimuli along the dimension. That is, all stimuli affect the perception of

any given stimulus. Discrimination training along the spectral continuum causes stimuli past S+ in the direction away from S- to appear more positive and stimuli past S- in the direction away from S+ to appear more negative. This explanation does predict the peak shift.

The present study is an attempt to test the response additivity theory of behavioral contrast. This study also examines the relationship between behavioral contrast and the peak shift and some of the conditions under which they occur. According to additivity theory, behavioral contrast should manifest itself only in situations conducive to autoshaping. In the pigeon, the only response which has been found to autoshape is key-pecking and only when the stimuli are located on the key. The response additivity theory would be unable to explain the occurrence of behavioral contrast with pigeons in the presence of a response other than key-pecking and/or a stimulus not located on the operant manipulandum. The attempts made thus far in manipulating the stimulus and response in this manner have met with conflicting results. A non-key-pecking response not yet used in the study of behavioral contrast is ring-pulling. Like treadle-pressing, ring-pulling is not influenced by the stimulus-reinforcer relationship. Although diffuse monochromatic stimuli have been used before, they have always been houselights. Here light from a slide projector which projects through filters

of specific wavelengths and illuminates the entire chamber is used. This method makes it possible to use stimuli of a sufficient number of different wavelengths for the administration of a generalization test. Both Terrace (1968) and Bloomfield (1969) have suggested that there is a relationship between behavioral contrast and the peak shift. If this is indeed the case, they should both occur in the same situations and with the same subjects and a theory which purports to explain one should also be able to account for the other. Since additivity theory makes no attempt to explain the peak shift, a confirmation of a relationship between these two phenomena presents a real problem for this theory. Therefore, stimulus generalization tests were given to all pigeons following discrimination training. In addition, this may be the first study to test the effects of discrimination training upon the shape of the stimulus generalization gradient when diffuse monochromatic stimuli are employed.

Before the major part of the study could be conducted, it was necessary to determine whether the selected method for presenting a diffuse monochromatic stimulus would exert control over a pigeon's behavior. Since it has been shown (Heinemann & Rudolf, 1963) that there is weaker stimulus control with a diffuse than with a localized stimulus and that stimulus control is enhanced by differential reinforcement (Jenkins & Harrison, 1960), it was decided to

give interdimensional discrimination training between a monochromatic light (555 nm) (S+) and a white light (S-) in Experiment 1. A generalization test of wavelength conducted in extinction was administered at the conclusion of discrimination training. Both key-pecking and ring-pulling groups were used.

Experiment 2, likewise, employed both key-pecking and ring-pulling groups. The pigeons were first trained to discriminate between two monochromatic stimuli--555 nm (S+) and either 531 or 573 nm (S-)--and then given a generalization test. Since diffuse stimuli were used, the demonstration of behavioral contrast in either group would be strong evidence against the response additivity theory. The presence of behavioral contrast in the ring-pulling group would prove especially troublesome for those who believe that the addition of autopecks and operant pecks is the sole explanation of behavioral contrast.

Experiment 3 served as a control for the behavioral contrast found in Experiment 2. The operant response was key-pecking and the stimuli were located on the key. Discrimination training was given between 555 nm (S+) and 576 nm (S-). Behavioral contrast is predicted in this situation regardless of theoretical orientation. The presence of behavioral contrast here but not in Experiment 2 would be evidence in favor of the response additivity theory of behavioral contrast.

EXPERIMENT 1

The purpose of this experiment was to ascertain whether a diffuse monochromatic stimulus located on the walls of the operant conditioning chamber would exert control over responding.

Method

Subjects

Six experimentally naive pigeons were maintained at 75% of their free-feeding weights throughout the experiment. Water and grit were available at all times in the home cages.

Apparatus

All experimentation was conducted in an operant chamber with standard relay programming equipment located in an adjacent room. The chamber was made of 3/4 in plywood and had internal dimensions of 32 cm x 26 cm x 43.5 cm. The ceiling, floor, and three of the walls were painted white. The fourth wall was made of .4 cm thick white Plexiglass. A 5.2 cm x 6.4 cm opening which allowed access to a grain hopper was located 5 cm above a wire mesh floor in the center of the wall opposite the Plexiglass wall. A Grason Stadler response key was also mounted on this wall directly above the food hopper 17.5 cm from the

floor. The response key was transilluminated by a white light projected from an Industrial Electronics display cell equipped with No. 44 miniature lamps. A brass ring which hung on a black wire 3 cm from the ceiling in a corner 6.5 cm from the food hopper wall and 6 cm from the wall opposite the door served as the operant manipulandum for the ring-pulling group. The ring had an outer diameter of 2.2 cm and an inner diameter of 1.7 cm. The ring was removed for the key-pecking group and the key was covered with white tape for the ring-pulling group. Key-pecks or ring-pulls were followed by feedback in the form of a click. Noise from a ventilation fan which was continually present in the chamber served to mask extraneous noises. Light from a slide projector, located 96 cm from the chamber, shone through the Plexiglass wall and provided constant diffuse illumination in the chamber except during reinforcement periods when a magazine light operated. The key light was also extinguished during reinforcements for the key-pecking group. Bausch and Lomb monochromatic filters having peak wavelengths of 519, 531, 542, 555, 563, 573, and 581 nm, which were mounted in front of the slide projector, constituted the stimulus source. (See Figure 1.)

Procedure

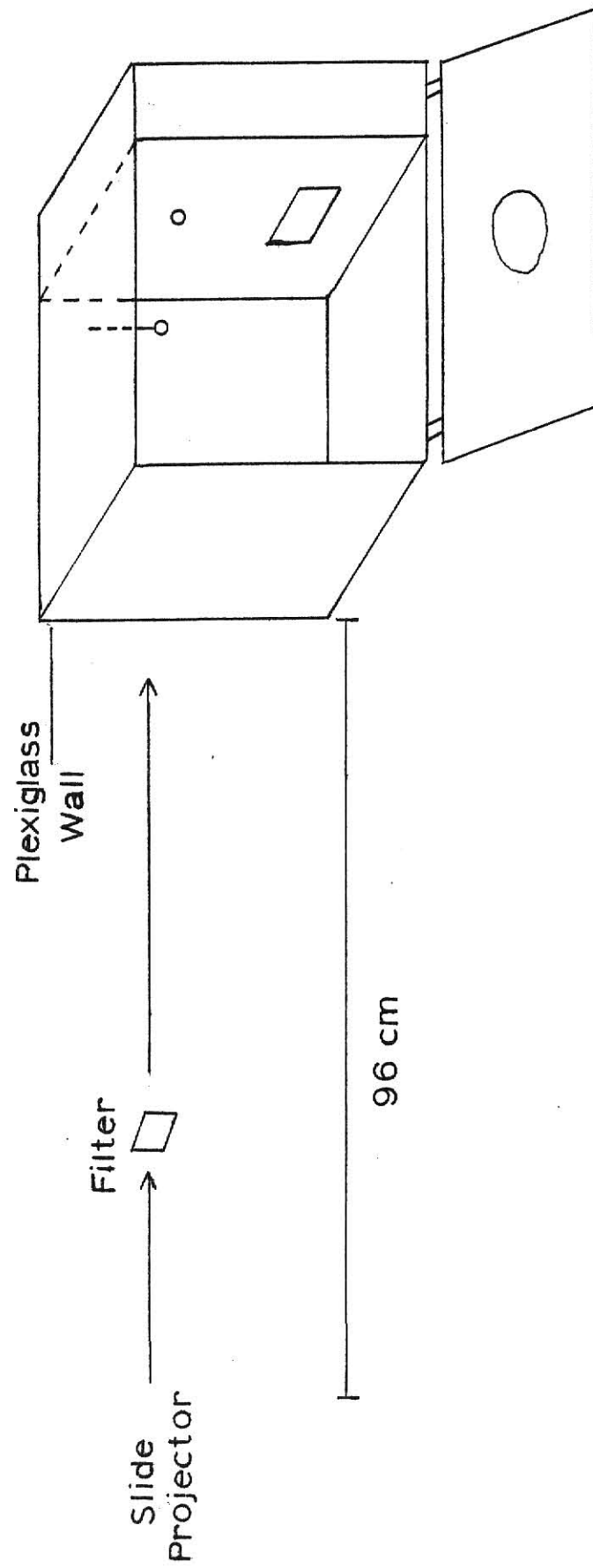
The subjects were randomly assigned to two groups, a key-pecking group (KP) and a ring-pulling group (RP), with three subjects in each group.

Figure Caption

Figure 1. Schematic diagram of the apparatus used in Experiment 1.

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Preliminary training. A stimulus of wavelength 555 nm was used throughout this stage. On the first day, all birds were magazine trained and then hand-shaped to either peck the key or pull the ring. When the desired response was established, 30 additional reinforcements on a continuous reinforcement (CRF) schedule were given. On Day 2, the subjects were again given 30 reinforcements on a CRF schedule. On Day 3 and on Day 4, the birds received 30 reinforcements on a VI 10-sec schedule and on a VI 20-sec schedule, respectively. On Day 5, they were placed on a VI 30-sec schedule (range = 17-sec - 52-sec) for 15 1-min stimulus periods separated by 10-sec blackouts.

Phase 1 (Discrimination training). The pigeons were placed on a mult VI 30-sec EXT schedule with 555 nm (S+) and a white light (S-). Each daily session consisted of 30 1-min stimulus periods separated by 10-sec blackouts. The two stimuli were alternated in a quasi-random order with the restrictions that each stimulus be presented a total of 15 times and no stimulus be presented more than twice in succession. This schedule remained in effect for a minimum of 15 days with the requirement that the average discrimination index (DI) for the last five days be at least .85.¹

Phase 2 (Stimulus generalization test). On the next day, 10 1-min periods of discrimination training identical to those of Phase 1 were given to each subject. This was

immediately followed by the administration of a generalization test conducted in extinction. The test consisted of seven stimuli (519, 531, 542, 555, 563, 573, and 581 nm) presented in five different random sequences in a counter-balanced design for a total of 35 1-min periods separated by 10-sec blackouts. Each bird received a different sequence in order to prevent systematic sequence effects across birds.

Results and Discussion

Preliminary training and Phase 1

All birds in the KP group were key-peck trained in one day. One bird in the RP group (83) was ring-pull trained the first day but the other two birds (91 and 92) required two days to acquire the response.

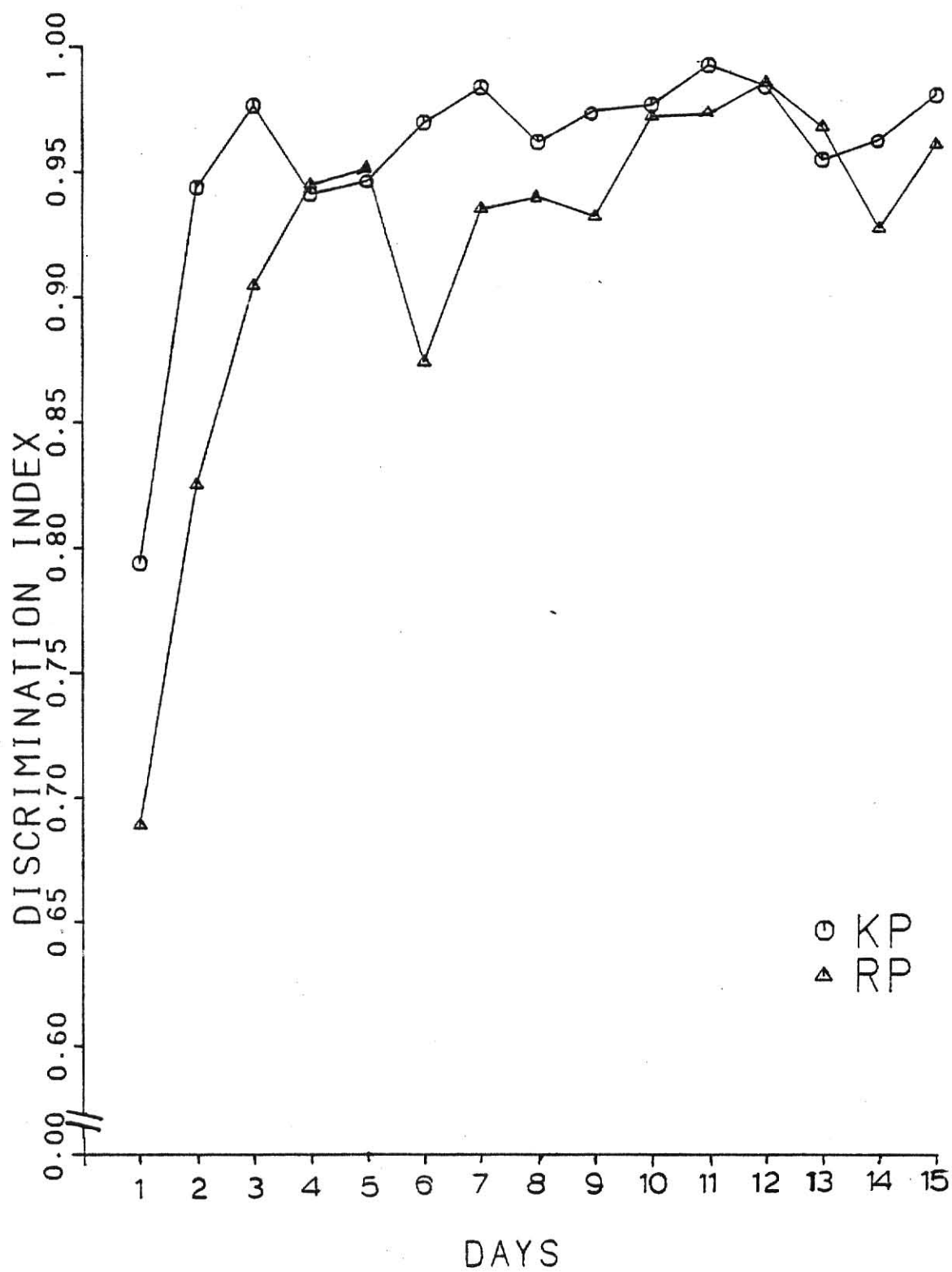
Every subject in each group remained on discrimination training (Phase 1) for 15 days. The discrimination was acquired quite rapidly by both groups. The asymptotic level of discrimination was reached by the third day of training. This high level of discrimination was maintained throughout the remainder of the training period. The mean DIs for the last five days of training for the KP and RP groups averaged across birds were 97.43 (range = 93.26 - 99.65) and 96.24 (range = 92.18 - 99.33), respectively. This performance indicates that the stimulus did indeed exert control over the subject's behavior.

Acquisition rates plotted in terms of DI scores for both groups are depicted in Figure 2. A repeated measures analysis of variance (Groups x Days) of these DI scores indicated that a significant difference existed between the two groups, $F(1,4) = 9.36$, $p < .05$. The KP pigeons started with higher DI scores and reached asymptote faster than did the RP pigeons. DI scores also increased with days, $F(14,56) = 8.65$, $p < .0001$. The mean overall response rates during S+ in terms of responses per minute were 100.23 for the KP group and 20.83 for the RP group. These means are significantly different, $F(1,4) = 56.55$, $p < .003$. Rate of responding during S+ increased over days, $F(14,56) = 2.42$, $p < .02$. The mean overall response rates during S- in terms of responses per minute were 4.35 for the KP group and 1.90 for the RP group. These means are not significantly different. Rate of responding during S- decreased over days, $F(14,56) = 3.70$, $p < .001$.

The finding that the KP pigeons learned the discrimination faster than did the RP pigeons can be explained by noting that the KP birds responded at rates much faster than those of the RP birds. Therefore, although response rates to S- did decline at the same rate, the S+ response rates for the two groups are disparate and the subjects with the greater S+ response rates (i.e., the KP pigeons) would be expected to have higher DI scores. This accounts for the statistically significant difference in acquisition

Figure Caption

Figure 2. Mean discrimination index scores plotted as a function of days for subjects in each group during Phase 1 of Experiment 1.



rates reflected in Figure 2.

Phase 2

Another test of stimulus control is the shape of the generalization gradient produced after interdimensional discrimination training between a monochromatic stimulus (555 nm) (S+) and a white light (S-). The post-discrimination gradients (PDGs) are presented in Figures 3 and 4 for the KP and RP groups, respectively. The response rate for the mean PDG for both groups did peak at S+ and decremental generalization gradients were obtained with wavelengths progressing further away from S+. The gradients for all of the birds in the KP group peaked at 555 nm (S+). In terms of area under the gradients, however, two of the three birds (82 and 90) did show a preference for the longer wavelengths. The gradients of two of the three RP birds (83 and 92) peaked at 555 nm (S+); the other (91) peaked at 563 nm. Although one subject (92) produced a fairly symmetrical gradient about 555 nm (S+), the other two (83 and 91) also showed a preference for the longer wavelengths.

This preference for the longer wavelengths may be indicative of a natural preference for some colors over others. Several researchers (e.g., Oppenheim, 1968; Tracy, 1970) have found that ducklings have pecking preferences for wavelengths within the green region of the spectrum. It seems reasonable to presume that perhaps pigeons also

Figure Caption

Figure 3. Mean and individual stimulus generalization gradients for the stimulus generalization tests conducted during Phase 2 of Experiment 1 for subjects in Group KP.

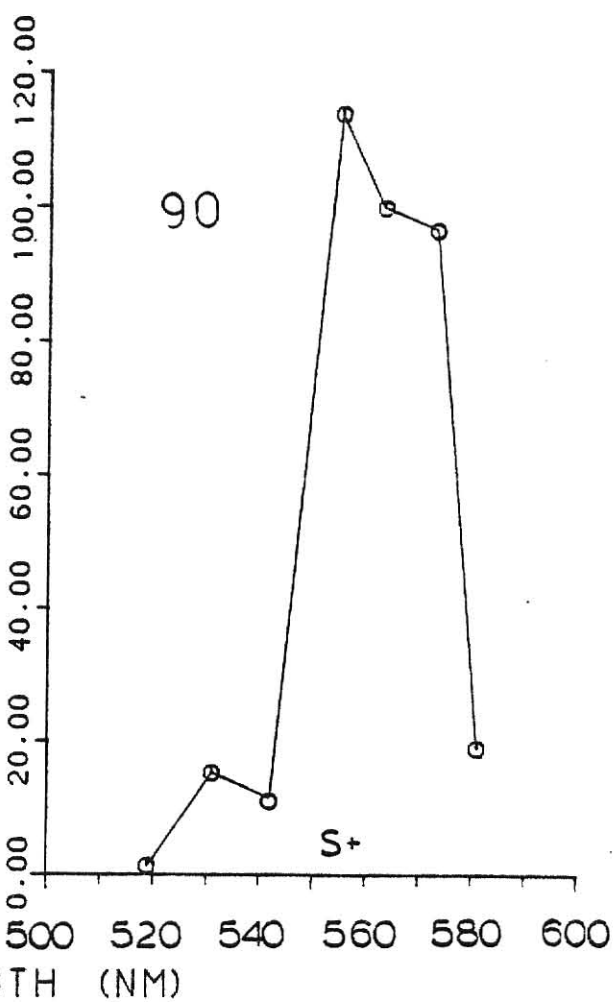
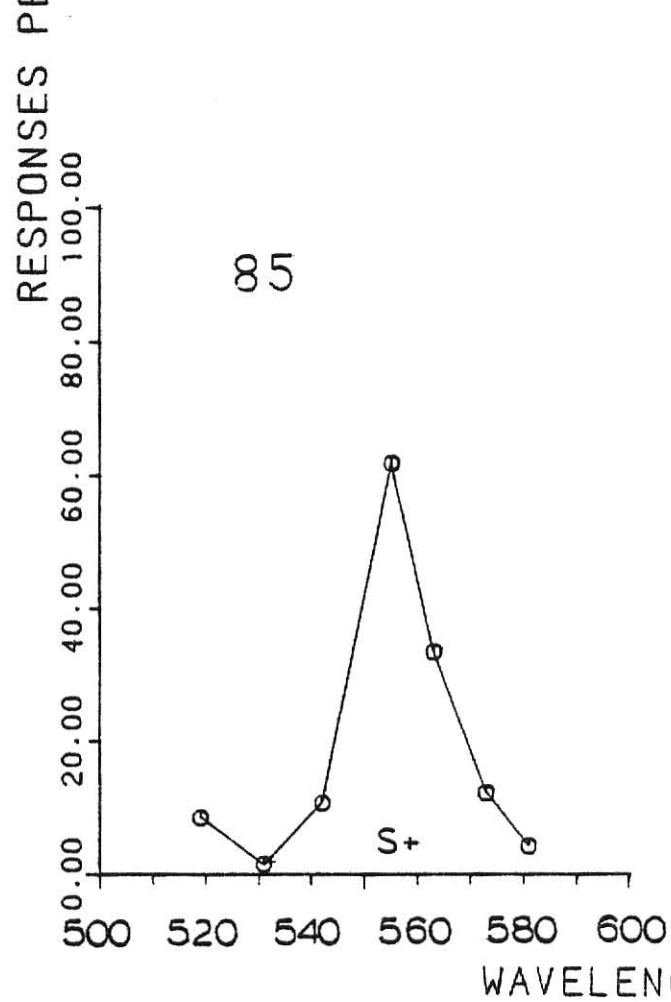
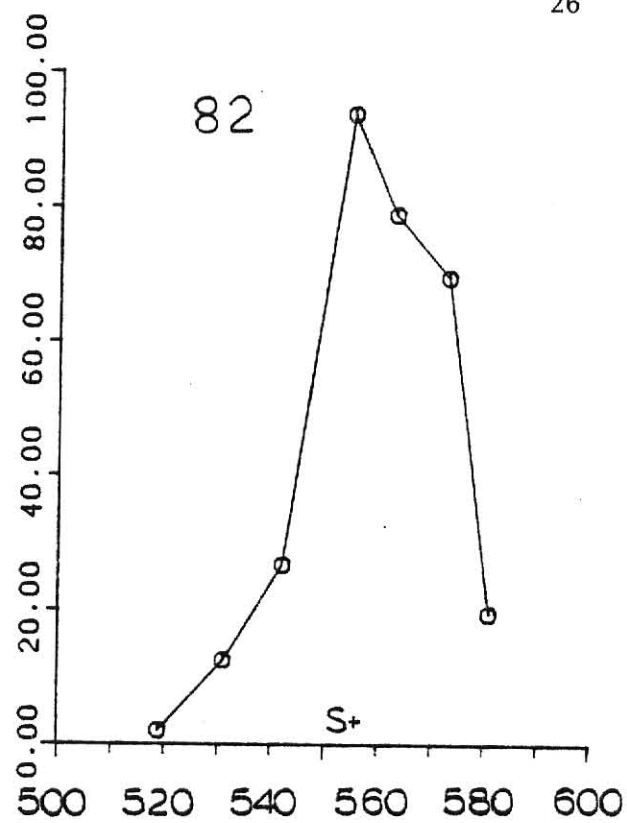
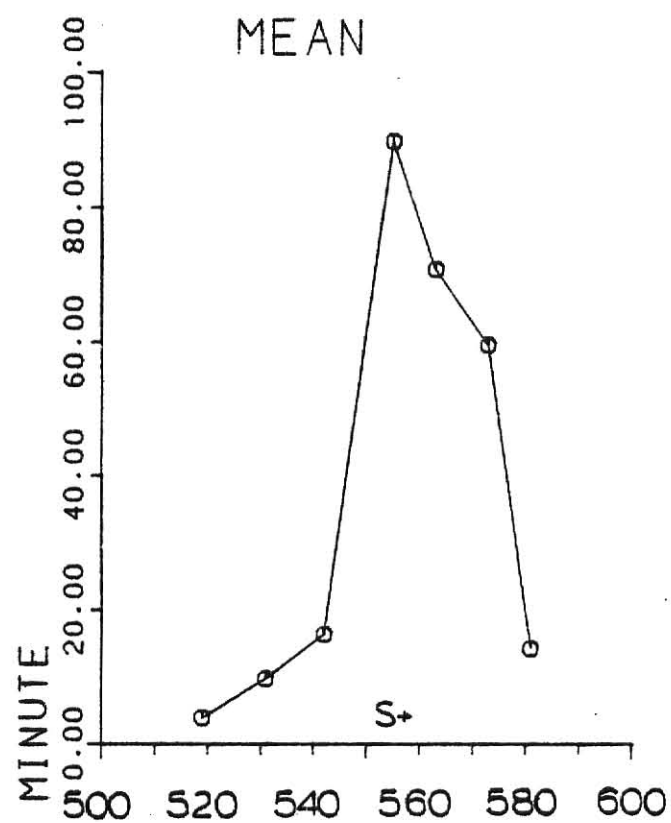
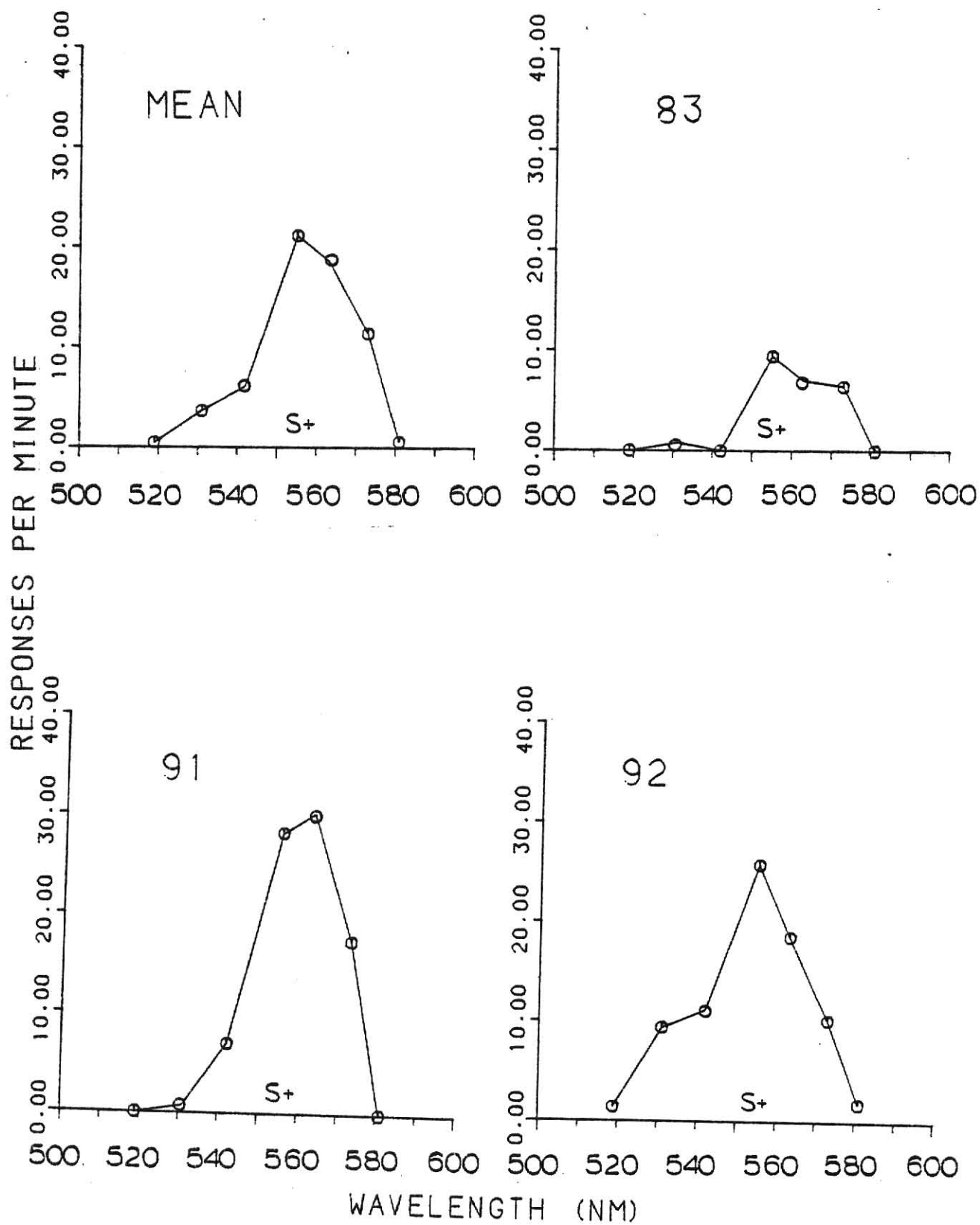


Figure Caption

Figure 4. Mean and individual stimulus generalization gradients for the stimulus generalization tests conducted during Phase 2 of Experiment 1 for subjects in Group RP.



have color preferences. The results obtained here suggest that there may be a tendency to prefer those wavelengths in the yellow-orange region of the spectrum. The interdimensional discrimination training given here did not entirely eliminate this predilection. Despite this observation, there is no doubt that the chromatic stimulus dimension did exert control over the pigeon's responding.

In conclusion, this experiment has demonstrated that diffuse monochromatic stimuli which are located on the walls of the operant conditioning chamber do exert control over the subject's behavior.

EXPERIMENT 2

Since it has been established that the chosen method for presenting diffuse monochromatic stimuli does exert control over behavior (Experiment 1), behavioral contrast and the peak shift may now be studied using this procedure. In this experiment, the effects of intradimensional discrimination training between diffuse monochromatic stimuli on changes in response rate during discrimination training and on the PDG are investigated. Both key-pecking and ring-pulling groups are employed.

Method

Subjects

Fourteen experimentally naive pigeons were maintained at 75% of their free-feeding weights throughout the experiment. Water and grit were available at all times in the home cages.

Apparatus

The operant chamber was the same as that used in Experiment 1.

Procedure

The subjects were randomly assigned to four groups, two key-pecking groups, KP(A) and KP(B), and two ring-pulling groups, RP(A) and RP(B), with four subjects in each

A group and three subjects in each B group.

Preliminary training. A stimulus of wavelength 555 nm was used throughout this stage. Preliminary training was identical to the first four days of preliminary training of Experiment 1.

Phase 1 (Nondifferential training (ND)). All pigeons were then placed on a mult VI 30-sec VI 30-sec schedule. Each daily session consisted of 16 1-min stimulus periods separated by 10-sec blackouts. The two stimuli (555 and 573 nm for the A groups and 555 and 531 nm for the B groups) alternated in a quasi-random order with the restrictions that each stimulus be presented a total of eight times and no stimulus be presented more than twice in succession. Responses during both stimuli were reinforced equally. This schedule remained in effect until a stable rate of responding was maintained for five consecutive days in the presence of both stimuli. Average rate of responding on the last five days constituted the baseline.

Phase 2 (Discrimination training (TD)). This stage consisted of a mult VI 30-sec EXT schedule. Each daily session consisted of 30 1-min stimulus periods separated by 10-sec blackouts. The stimuli used in the VI 30-sec and EXT components were 555 nm (S+) and either 573 nm (A groups) or 531 nm (B groups) (S-), respectively. The two stimuli were alternated in a quasi-random order with the restrictions that each stimulus be presented a total of 15

times and no stimulus be presented more than twice in succession. This schedule remained in effect until two criteria were met. First, a stable rate of responding must have been maintained for the last five days for both stimuli. Second, the average DI for those five days must have been at least .85.¹

Phase 3 (Stimulus generalization test). This stage was similar to Phase 2 of Experiment 1, with the exception that a 10-min session identical to Phase 2 of this experiment instead of Phase 1 of Experiment 1 preceded the generalization test.

Phase 4 (Discrimination training (TD)). This is a repetition of Phase 2.

Phase 5 (Nondifferential training (ND)). This is a repetition of Phase 1.

Results

Preliminary Training and Phase 1

All birds in the KP groups were key-peck trained in one day. Four birds in the RP groups (52, 64, 69, and 74) were ring-pull trained the first day. Two RP pigeons (56 and 89) required two days and one (81) required three days to acquire the response.

Five other pigeons were successfully trained to pull the ring but had to be eliminated from the experiment after 2, 7, 14, 17, and 38 days on ND. Each of these subjects

either responded for only a portion of each daily session and/or did not respond at all on some days. One bird would stop responding after several instances of tripping on its tail. It had a habit of holding its tail down, and this would result in the tail getting caught in the grating on the floor. This behavior persisted despite trimming the tail feathers.

One bird in Group RP(B) (64) had been responding at a low rate and missing many reinforcements while on ND despite the fact that it had been continuously manipulating the ring. It was decided to reshape the criterion response. Over a period of two days, between Days 8 and 9 of ND, the response was reshaped and the schedule was gradually changed from CRF to mult VI 30-sec VI 30-sec (ND). This procedure succeeded in re-establishing the response.

The mean number of days on ND was 17.57 (range = 8 - 32) for the KP birds and 21.71 (range = 11 - 34) for the RP birds. The specific number of days spent by each subject in every phase of the experiment are shown in Table 1.

Behavioral Contrast

Rates of responding for every subject for Phases 1, 2, 4, and 5 of the experiment are presented in Figures 5-8. As can be seen in the figures, six of seven KP pigeons (55, 60, 65, 75, 76, and 79) exhibited an increased rate of responding in the presence of S+ during discrimination

Table 1
Number of Days in Each Phase
for Pigeons in Experiments 2 and 3

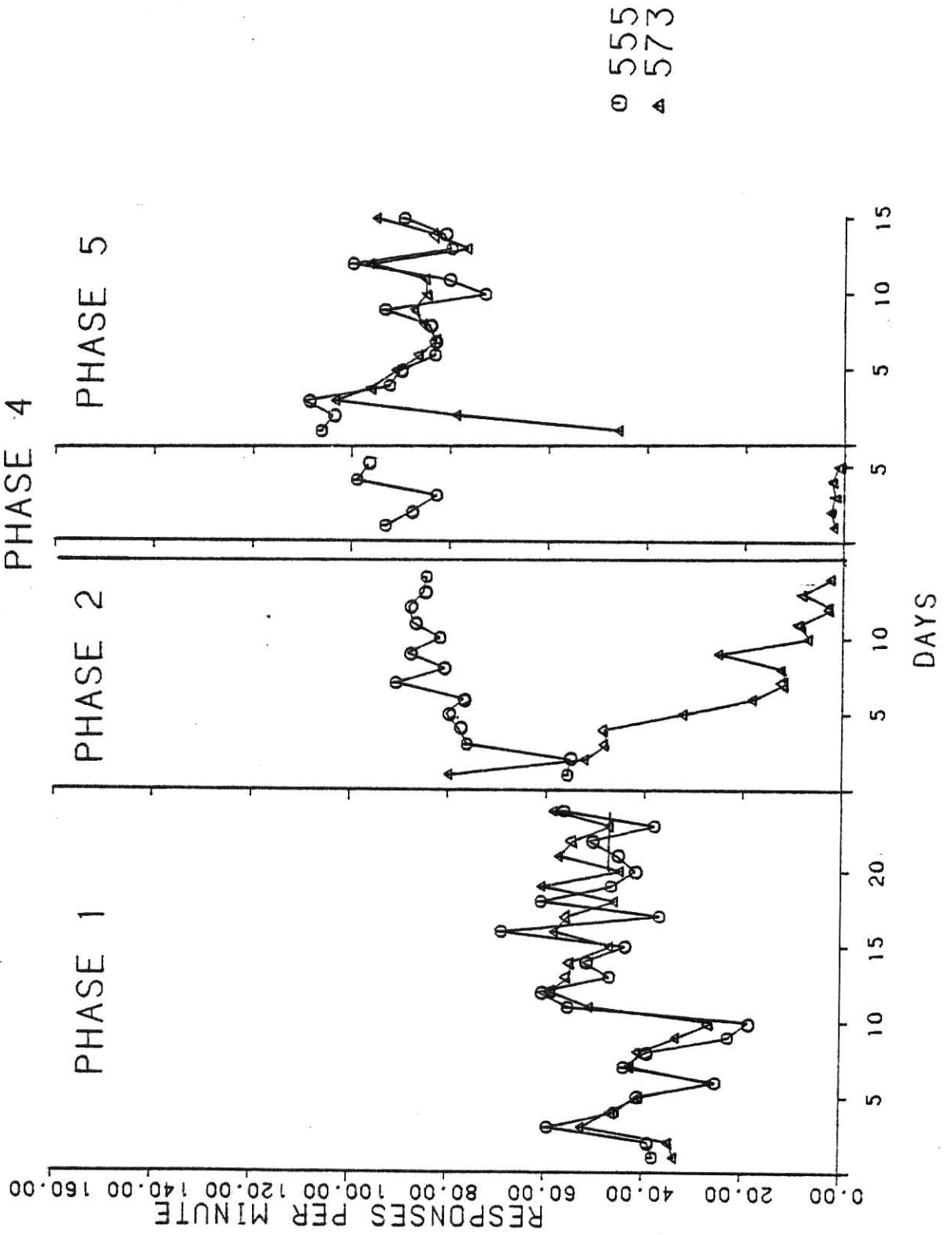
Group	Subject	Phase					Total
		1	2	3 ^a	4	5	
Experiment 2							
KP (A)	55	24	14		5	15	58
	58	17	33		5	7	62
	60	13	19		19	15	66
	65	8	25		7	24	64
KP (B)	75	11	12		9	11	43
	76	32	24		6	10	72
	79	18	28		16	9	71
RP (A)	52	17	30		14	20	81
	56	15	29		5	18	67
	69	34	18		5	7	64
	74	19	24		6	9	58
RP (B)	64	26	20		6	10	62
	81	30	12		6	17	65
	89	11	13		5	23	52
Experiment 3							
	59	29	40	21			90
	62	23	30	43			96
	66	35	38	9			82
	67	14	36	23			73

^aThe stimulus generalization test was conducted in Phase 3 of Experiment 2.

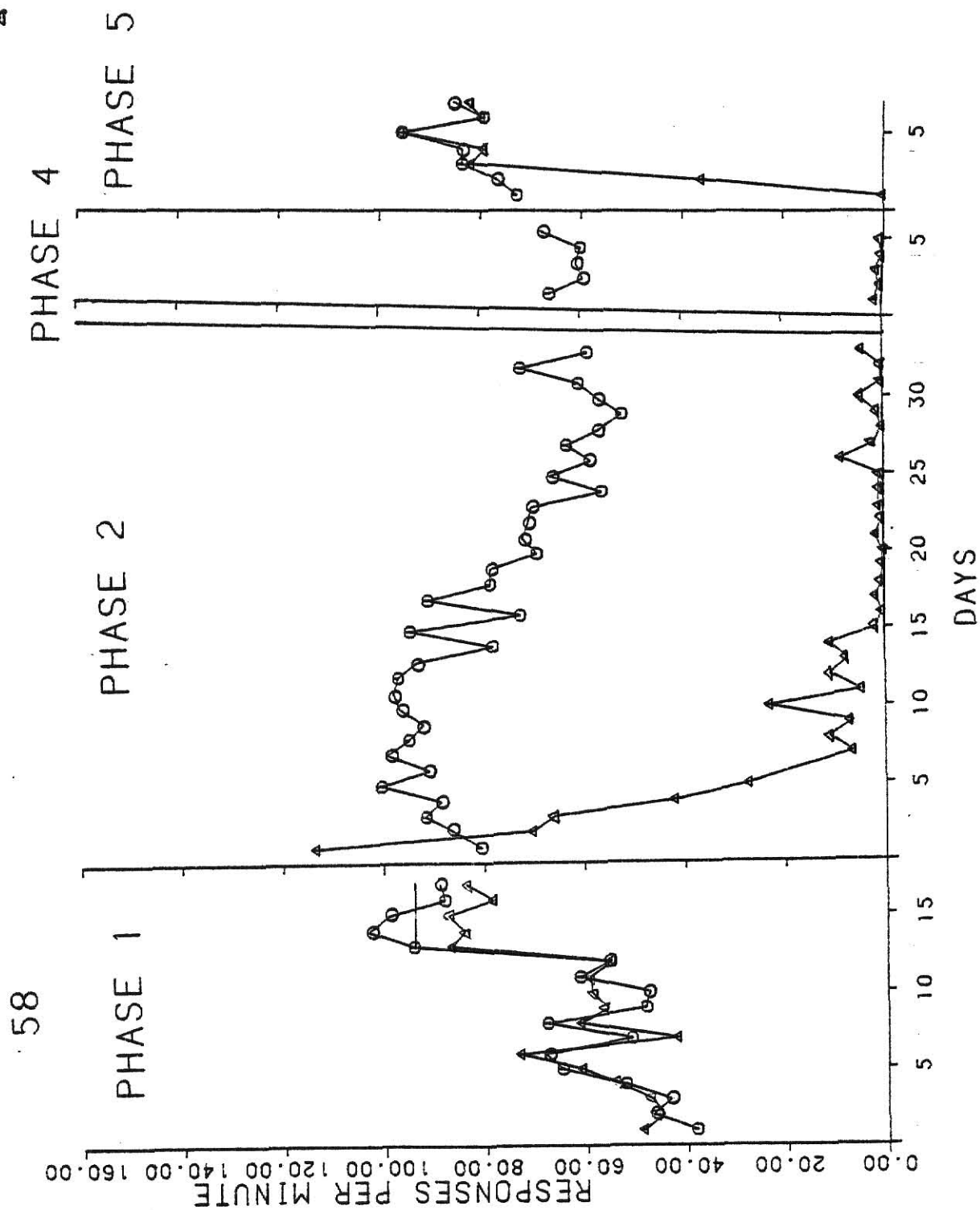
Figure Caption

Figure 5. The rates of key-pecking in the presence of 555 and 573 nm during Phases 1, 2, 4, and 5 for subjects in Group KP(A) of Experiment 2. The horizontal line through the last five days of Phase 1 denotes the mean response rate for 555 nm and represents the baseline. The two vertical lines separating Phases 2 and 4 indicate the placement of the stimulus generalization test (Phase 3).

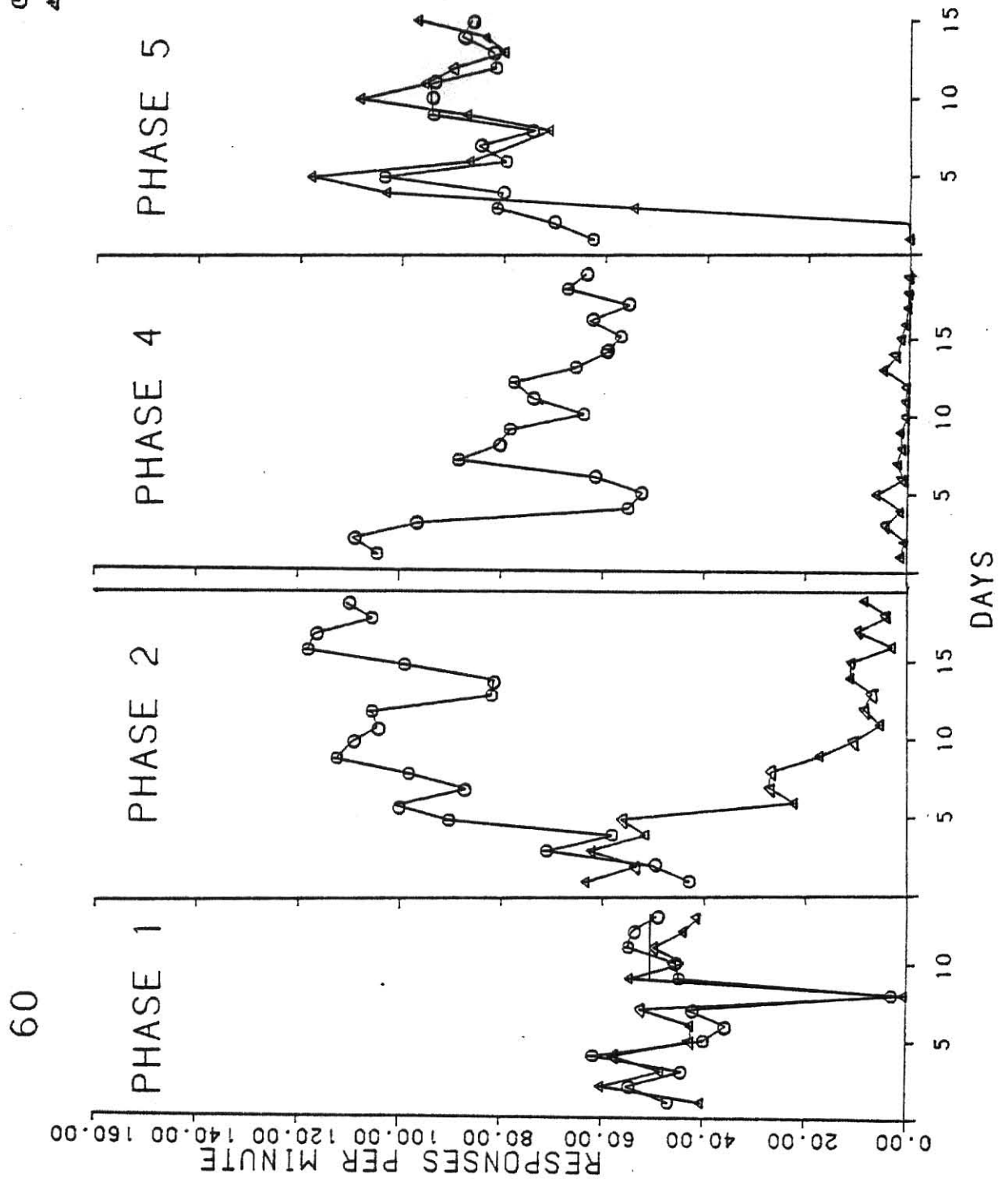
55



○ 555
▲ 573



○ 555
▲ 573



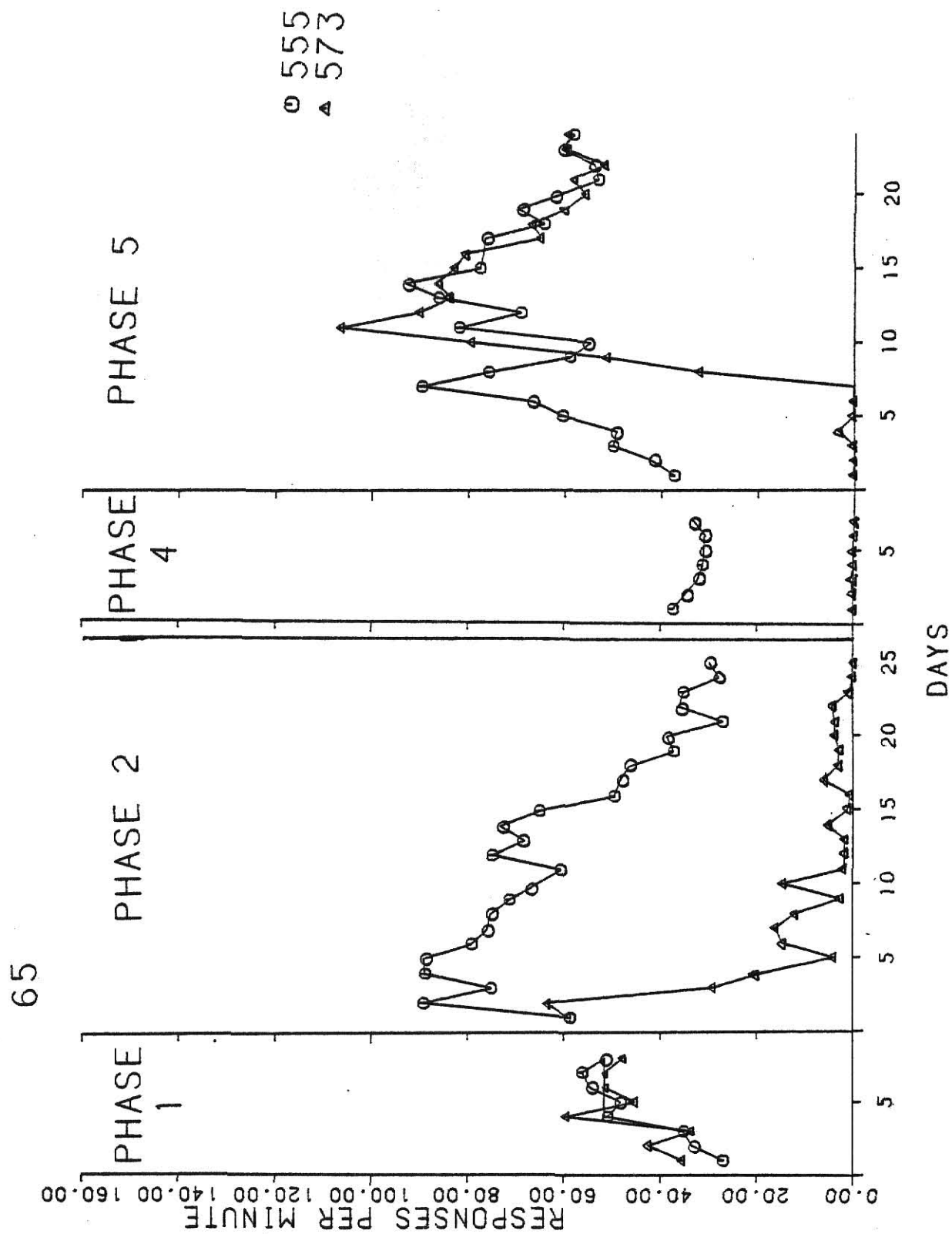
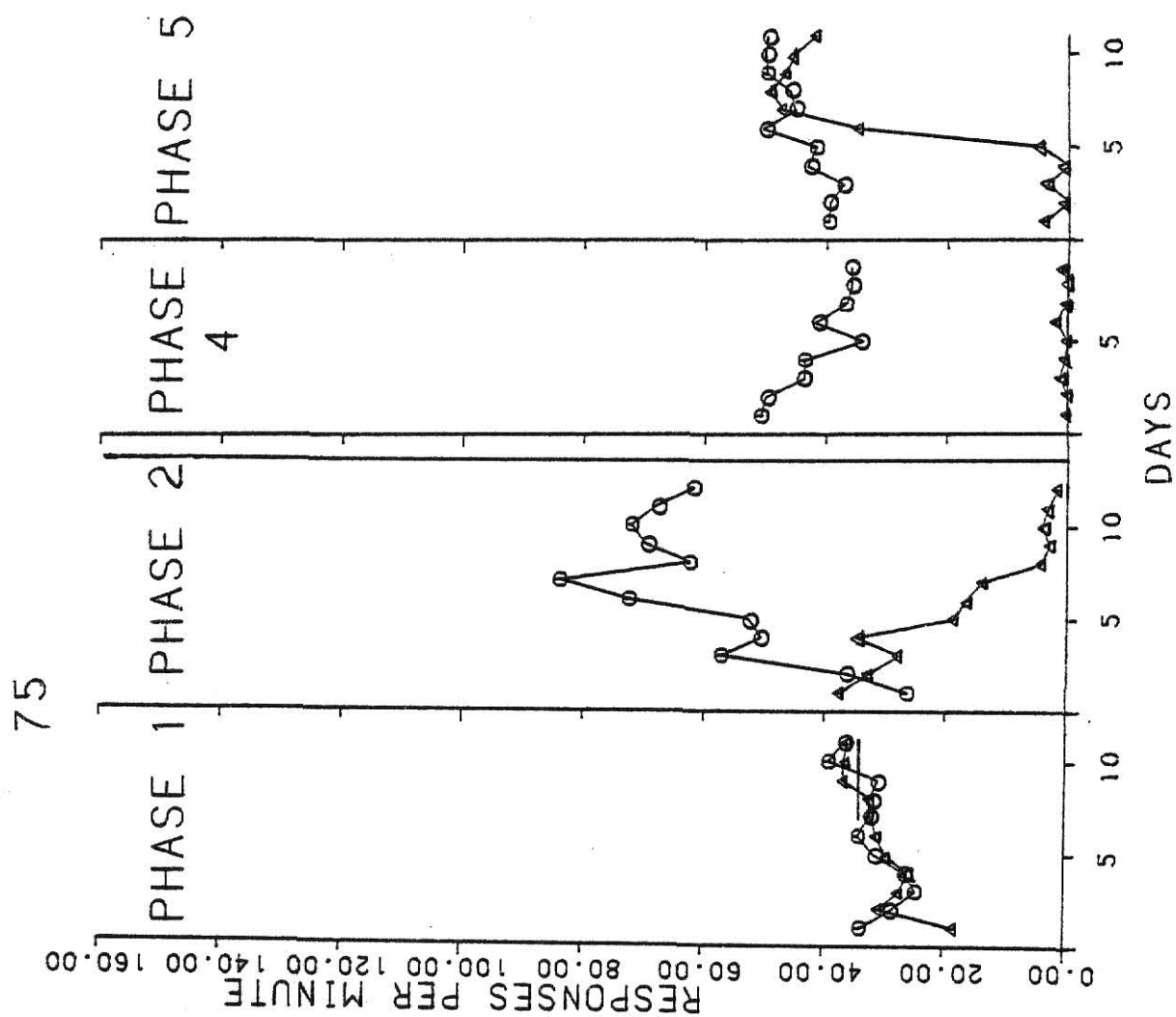
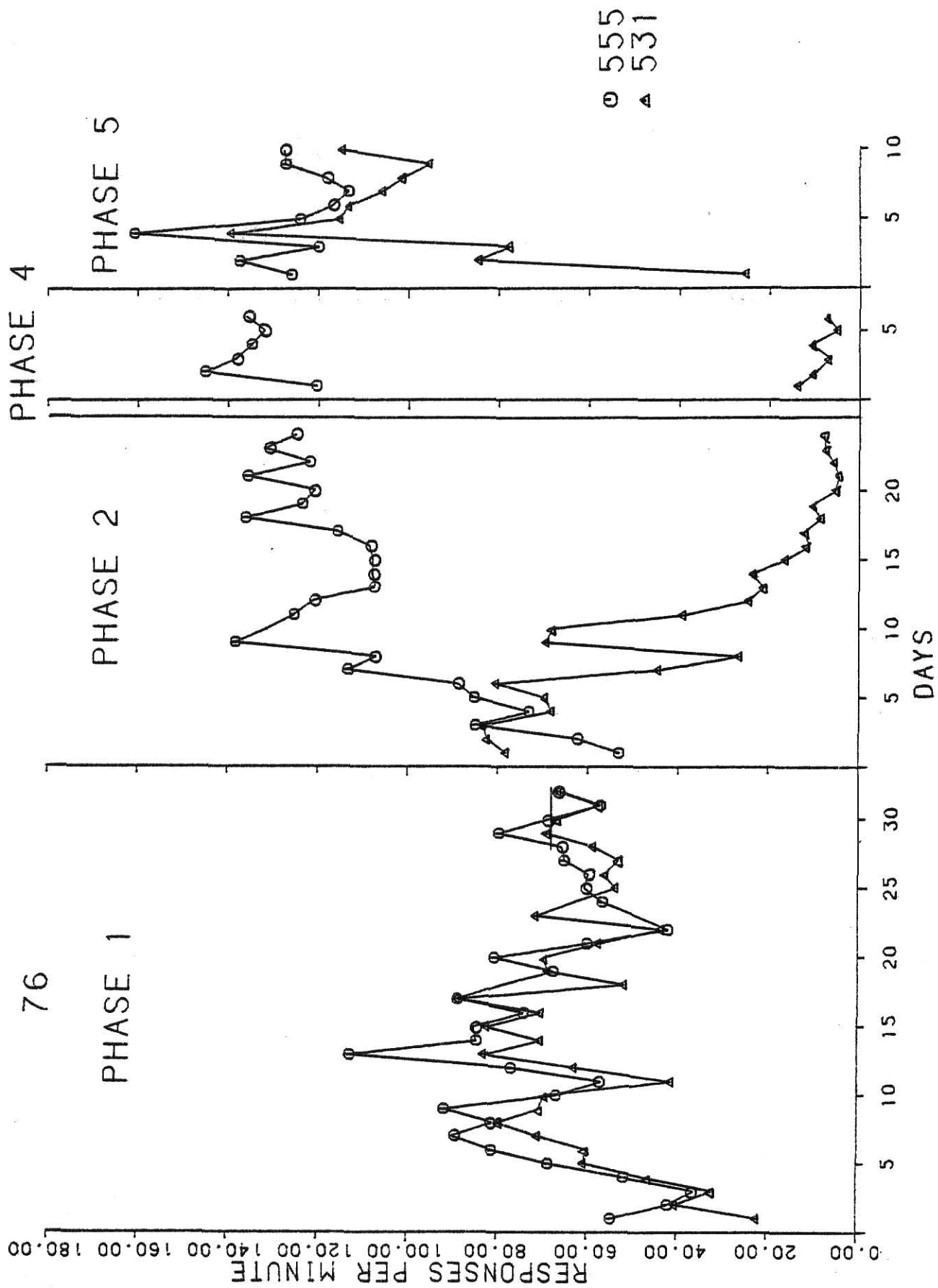


Figure Caption

Figure 6. The rates of key-pecking in the presence of 555 and 531 nm during Phases 1, 2, 4, and 5 for subjects in Group KP(B) of Experiment 2. The horizontal line through the last five days of Phase 1 denotes the mean response rate for 555 nm and represents the baseline. The two vertical lines separating Phases 2 and 4 indicate the placement of the stimulus generalization test (Phase 3).



○ 555
 ▲ 531



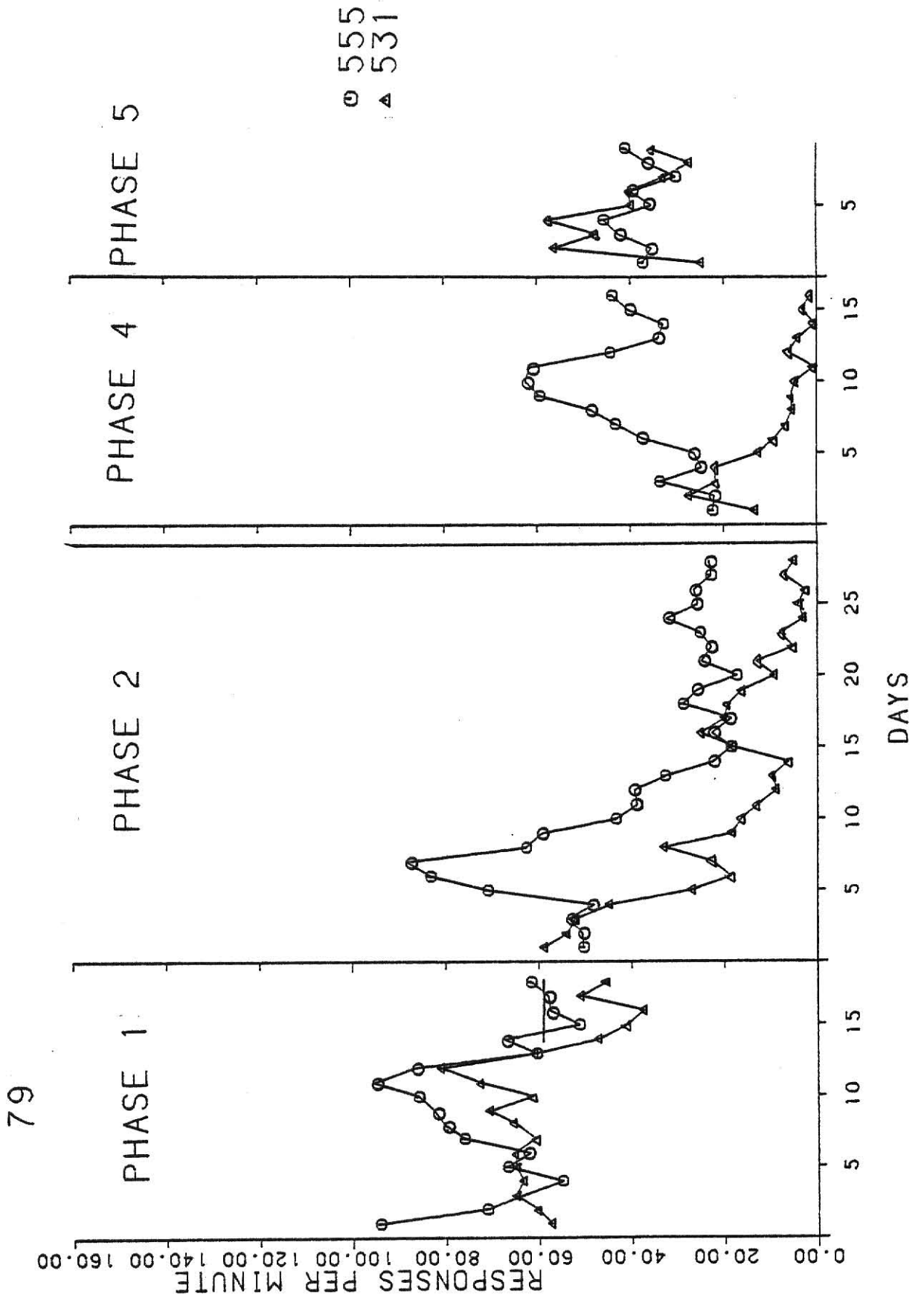
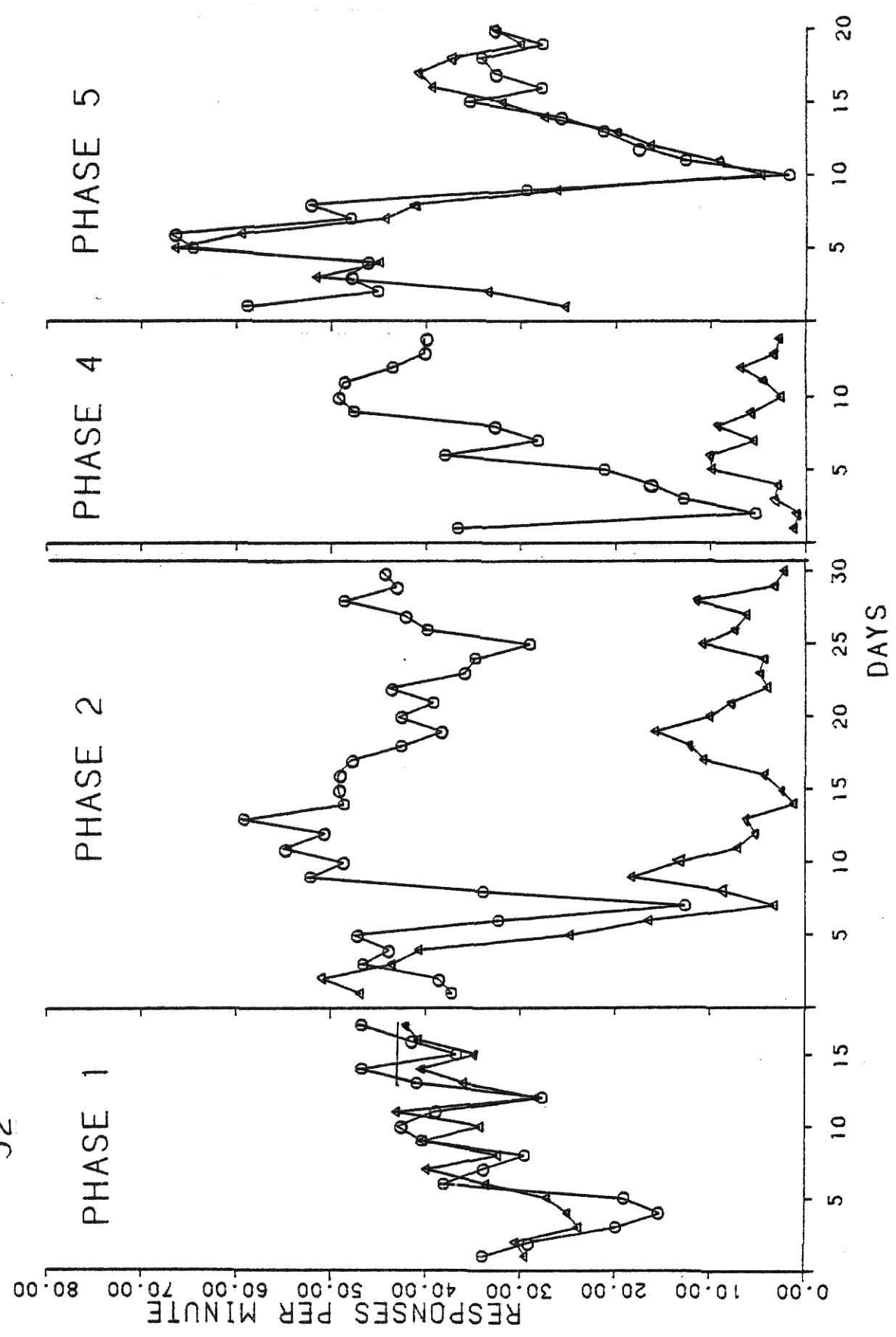


Figure Caption

Figure 7. The rates of ring-pulling in the presence of 555 and 573 nm during Phases 1, 2, 4, and 5 for subjects in Group RP(A) of Experiment 2. The horizontal line through the last five days of Phase 1 denotes the mean response rate for 555 nm and represents the baseline. The two vertical lines separating Phases 2 and 4 indicate the placement of the stimulus generalization test (Phase 3).

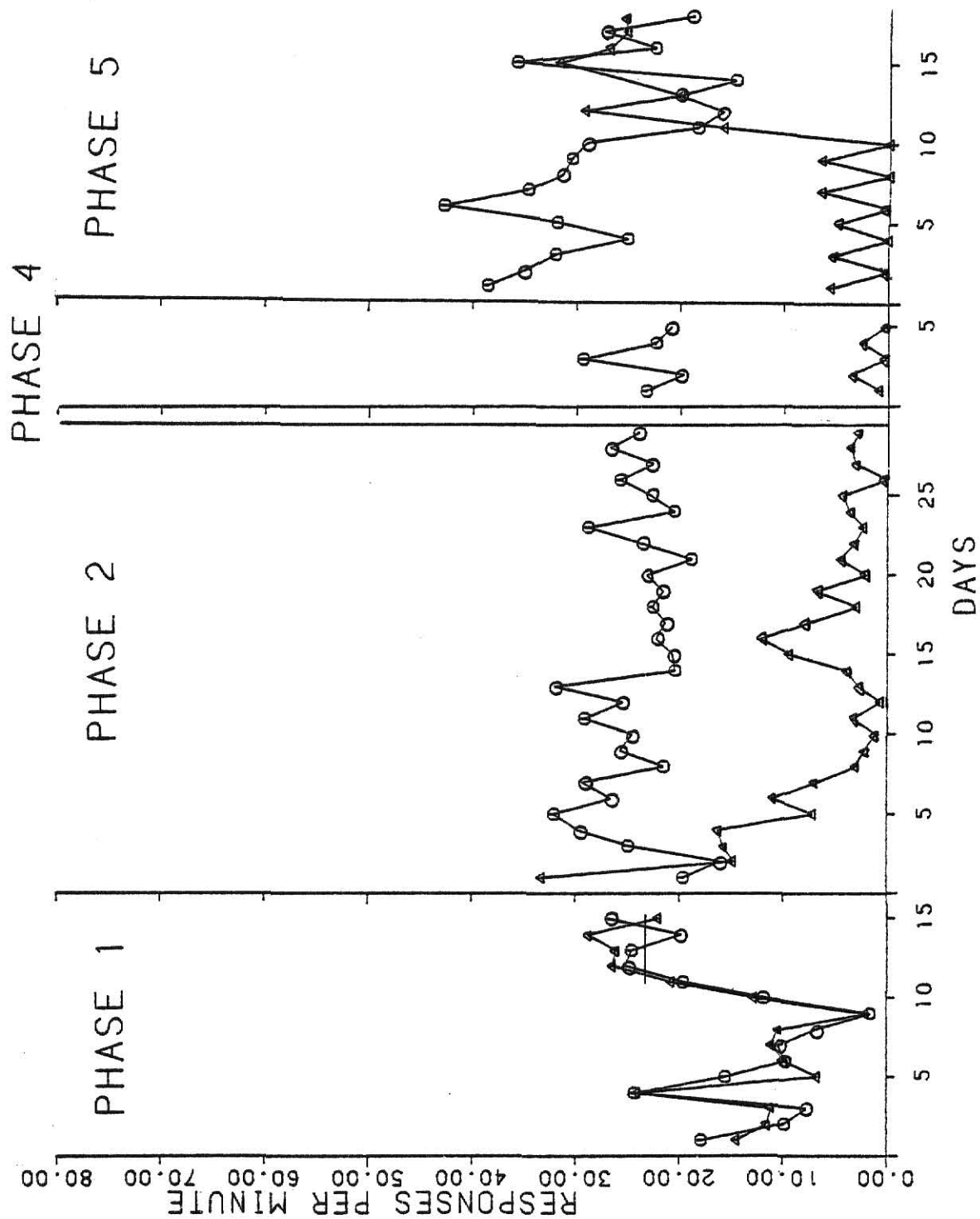
○ 555
▲ 573

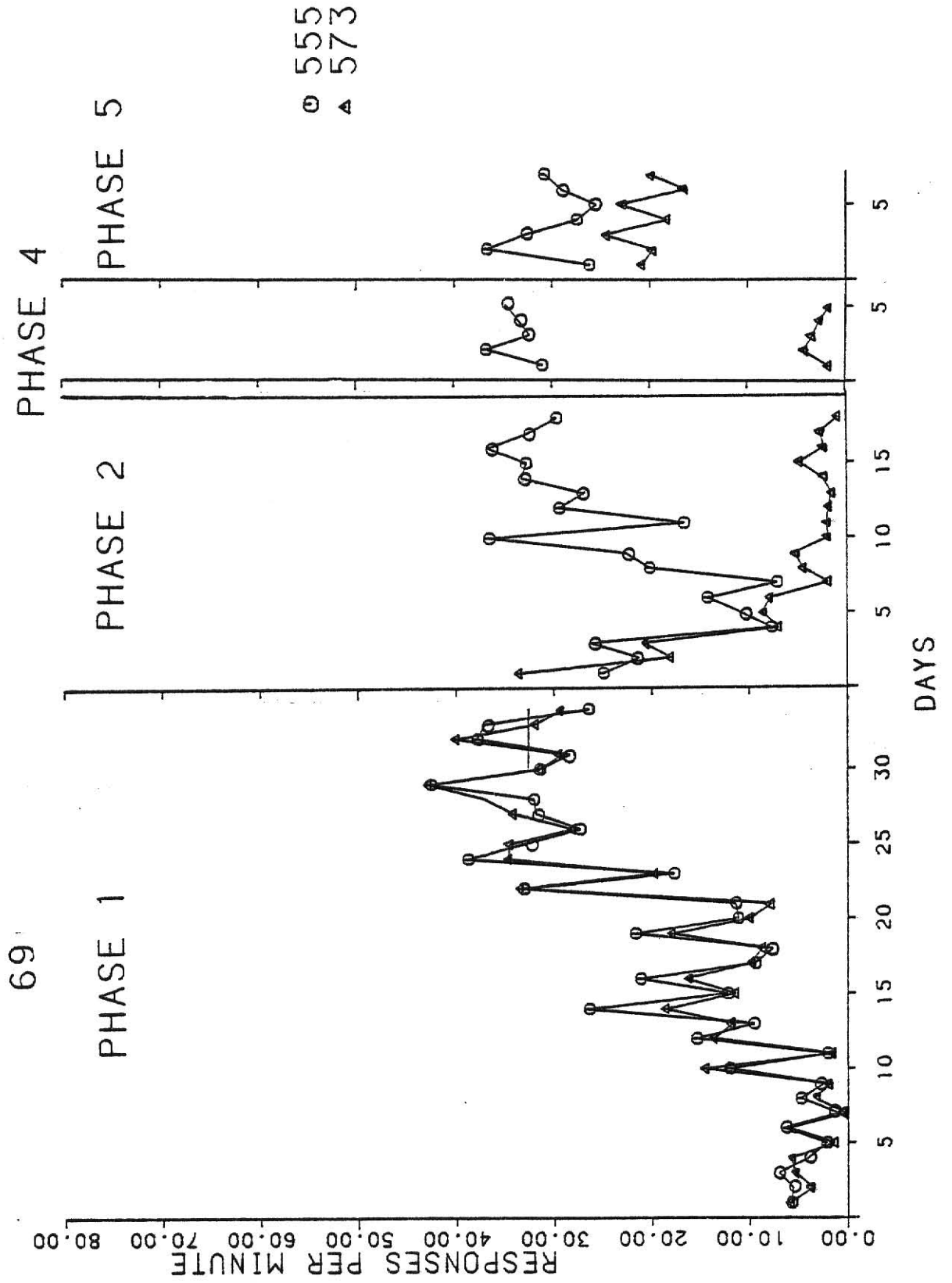
52



○ 555
▲ 573

56





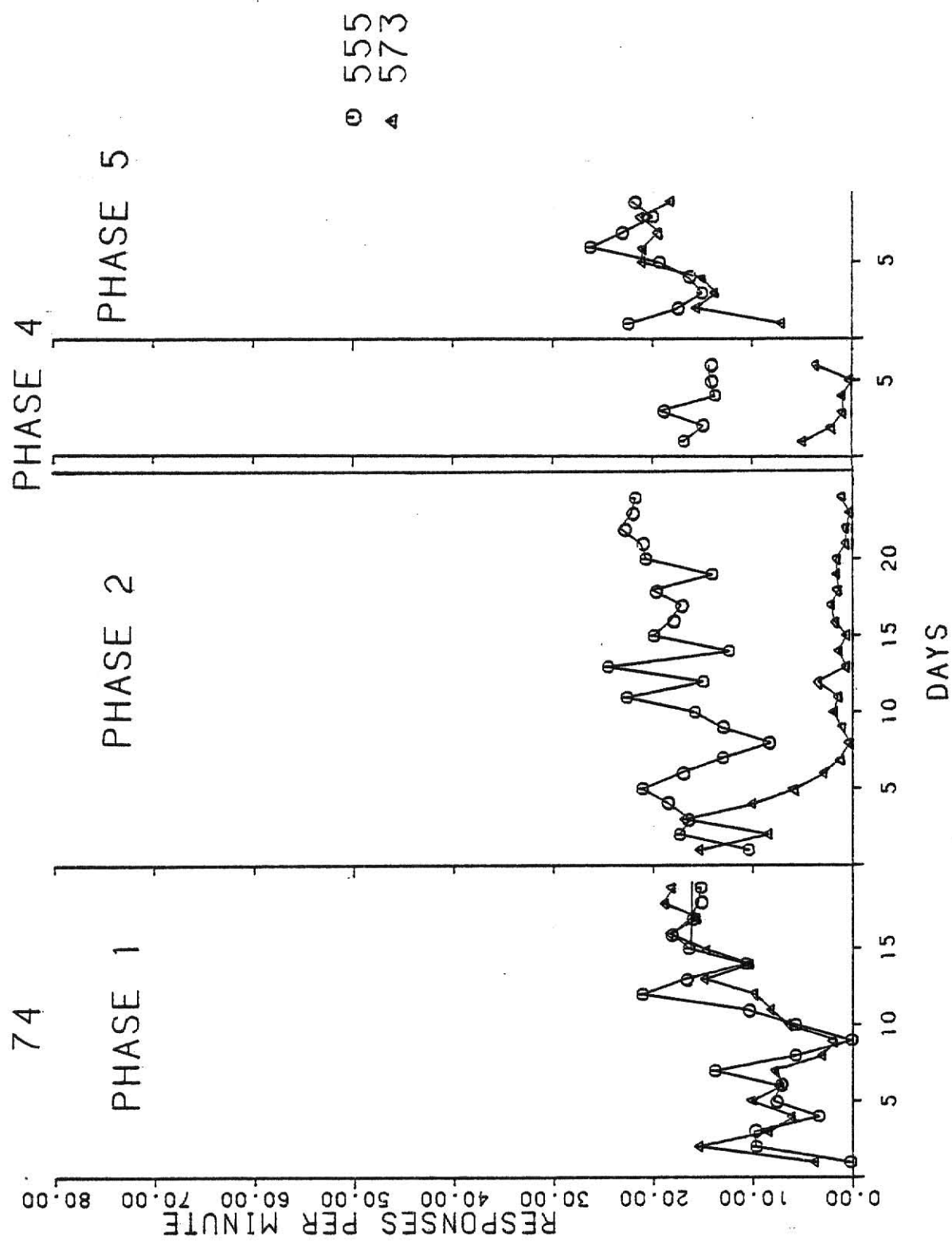
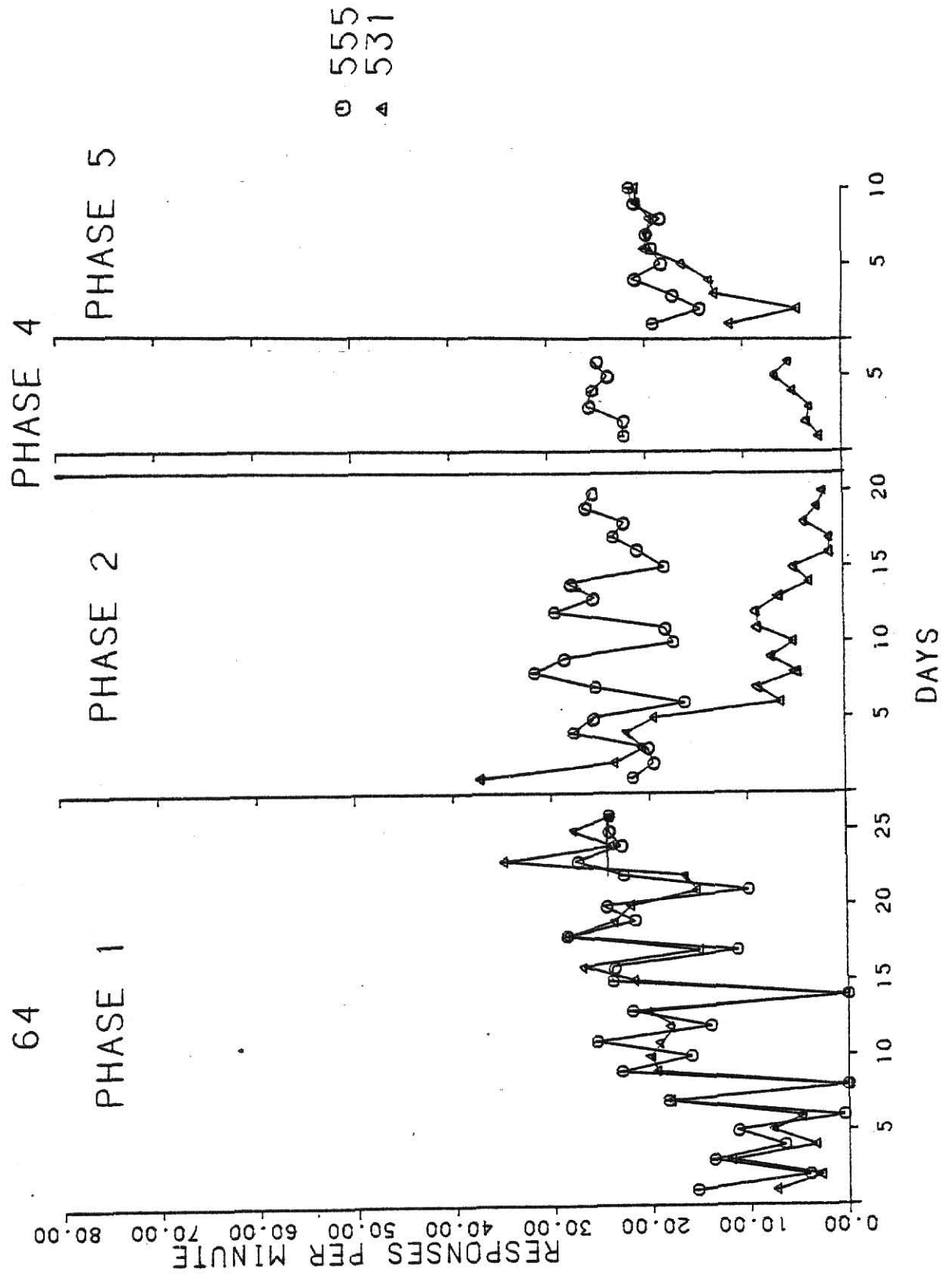
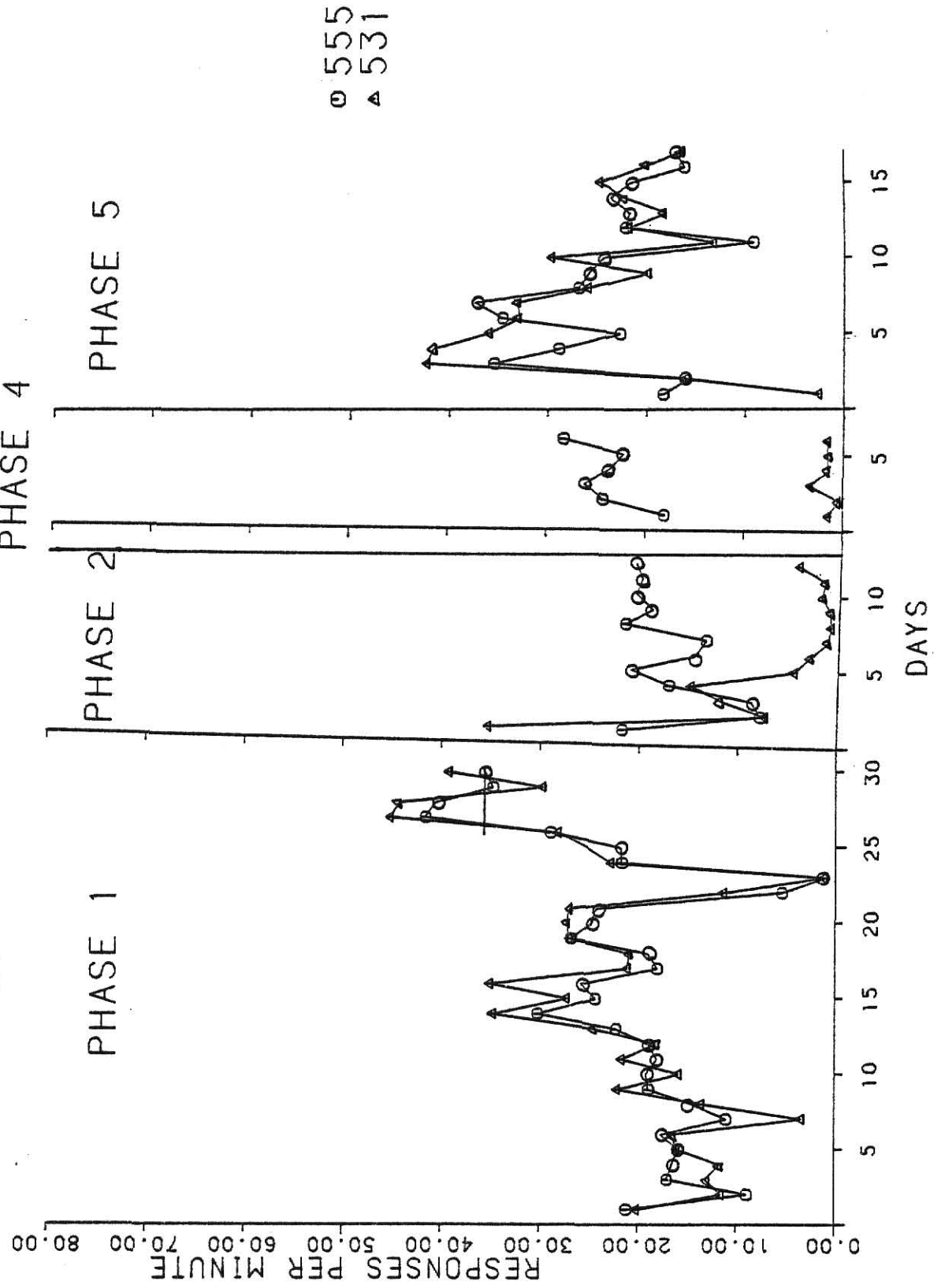


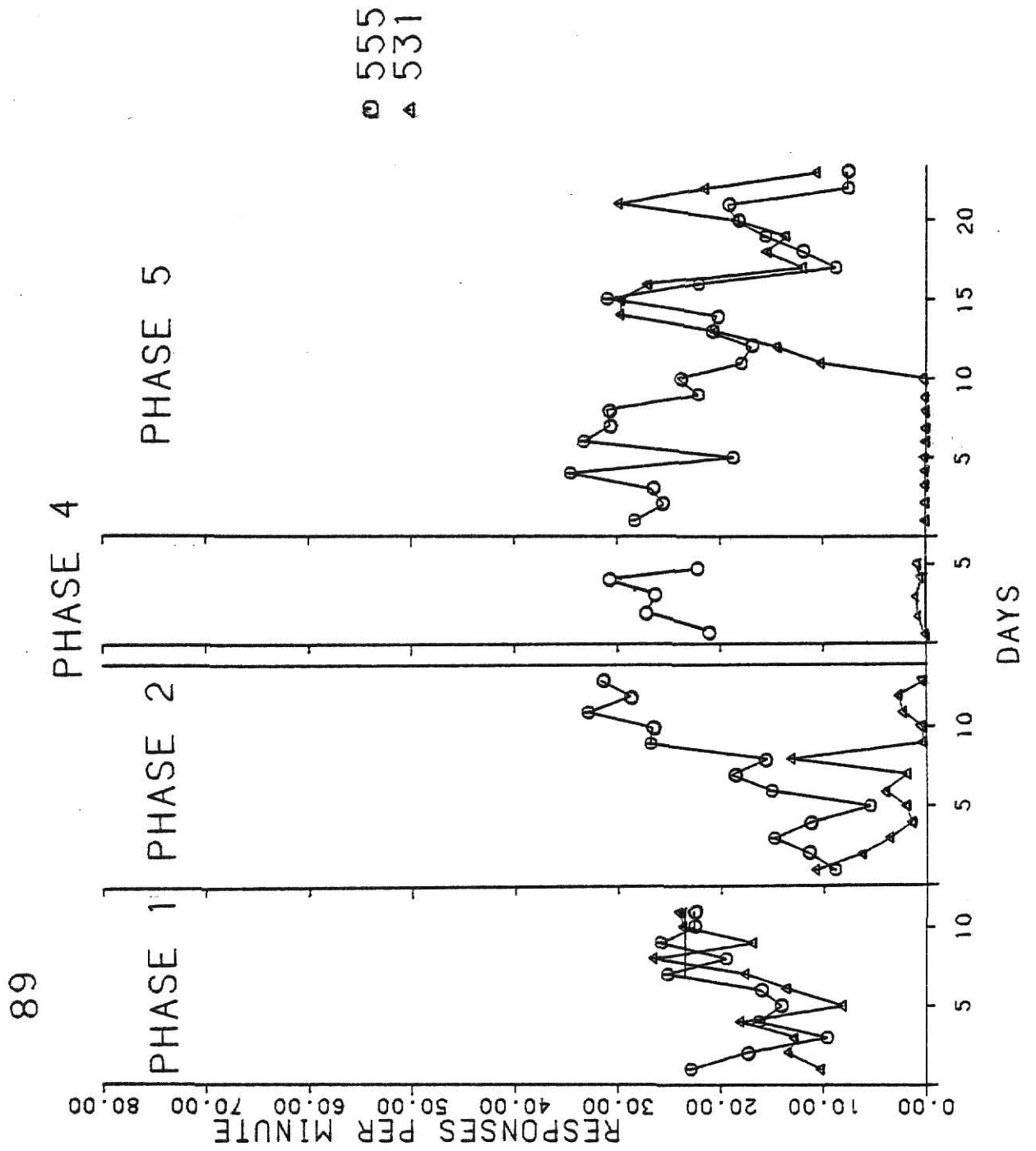
Figure Caption

Figure 8. The rates of ring-pulling in the presence of 555 and 531 nm during Phases 1, 2, 4, and 5 for subjects in Group RP(B) of Experiment 2. The horizontal line through the last five days of Phase 1 denotes the mean response rate for 555 nm and represents the baseline. The two vertical lines separating Phases 2 and 4 indicate the placement of the stimulus generalization test (Phase 3).



81





training (Phase 2) when compared with the last five days of baseline (Phase 1). It may be concluded that these pigeons did demonstrate behavioral contrast. The other pigeon (58) demonstrated no change in response rate when placed on TD. Of the six KP pigeons who demonstrated behavioral contrast, the response rates of four (60, 65, 75, and 79) returned to baseline level while they were still on TD. The other two subjects (55 and 76) retained the increased rates of responding throughout TD.

Five of seven RP pigeons (52, 69, 74, 81, and 89) showed a decrease in rate of responding when placed on TD when compared with baseline. This phenomenon is labeled as negative induction. There was no change in response rate for the other two pigeons (56 and 64). Four of the five RP pigeons (52, 69, 74, and 89) who demonstrated negative induction increased their response rates back up to the baseline level while on TD. The other subject (81) did increase responding after the initial decline but did not return to baseline.

An interesting phenomenon occurred, however, with respect to the RP subjects. It was observed that when response rate--as measured in ring-pulls--decreased, there was a corresponding increase in rate of pecking at the ring. As response rate returned to baseline level, rate of ring-pecking declined. This behavior was evident in all of those pigeons who showed a negative induction effect.

This, however, was not systematically investigated.

One of the KP pigeons (79) exhibited behavioral contrast followed by negative induction. During the negative induction stage, the bird was observed to peck rapidly at the wall to the left of the key during S+.

Every subject was placed back on ND (Phase 5). The two KP birds (55 and 76) whose response rates had remained at an increased level throughout TD did not change their response rates when returned to ND. The rates of responding of Birds 75 and 79, whose response rates had both returned to baseline level while on TD, stayed at that level after their return to ND. However, the other two birds (60 and 65) whose response rates had reverted to baseline level and the bird (58) who did not show behavioral contrast, actually increased their rates of responding when placed back on ND.

None of the RP pigeons exhibited any systematic changes in response rate from TD to ND. A special procedure needed to be used with Pigeon 89. For the first 10 days on ND, this subject had made zero responses in the presence of 531 nm. In order to reinitiate responding, it was decided to give it 30 reinforcements on a CRF schedule in the presence of 531 nm for one day. This method did successfully effect responding to 531 nm. However, due to a cracked beak, training was discontinued before the response rates stabilized on ND.

Peak Shift

Stimulus generalization tests were given to all subjects in Phase 3. PDGs for every bird and mean gradients for each of the four groups are presented in Figures 9-12. Four of seven KP pigeons (55, 65, 75, and 76) and six of seven RP pigeons (52, 56, 64, 69, 81, and 89) showed a peak shift.

Although Pigeons 60 of Group KP(A) and 79 of Group KP(B) did not demonstrate peak shifts, they did display large area shifts and interpolated peak shifts (i.e., if another stimulus point had existed between 555 and 542 or 563 nm it appears likely that the gradient would have peaked at that point). Terrace (1966c) found that some subjects who did not show a peak shift did show an area shift.

The RP(A) pigeon (74) who did not exhibit a peak shift did display an area shift. However, it should be noted that this subject responded during only eight of the 35 stimulus periods of the generalization test and, therefore, the reliability of the resulting gradient is questionable.

Peak shifts were obtained going in both directions; five of eight A group pigeons (52, 55, 56, 65, and 69) and five of six B group pigeons (64, 75, 76, 81, and 89) showed peak shifts. Two of the three .. group birds (60 and 74) and the B group bird (79) who did not have peak shifts did have area shifts.

Figure Caption

Figure 9. Mean and individual stimulus generalization gradients for the stimulus generalization tests conducted during Phase 3 of Experiment 2 for subjects in Group KP(A).

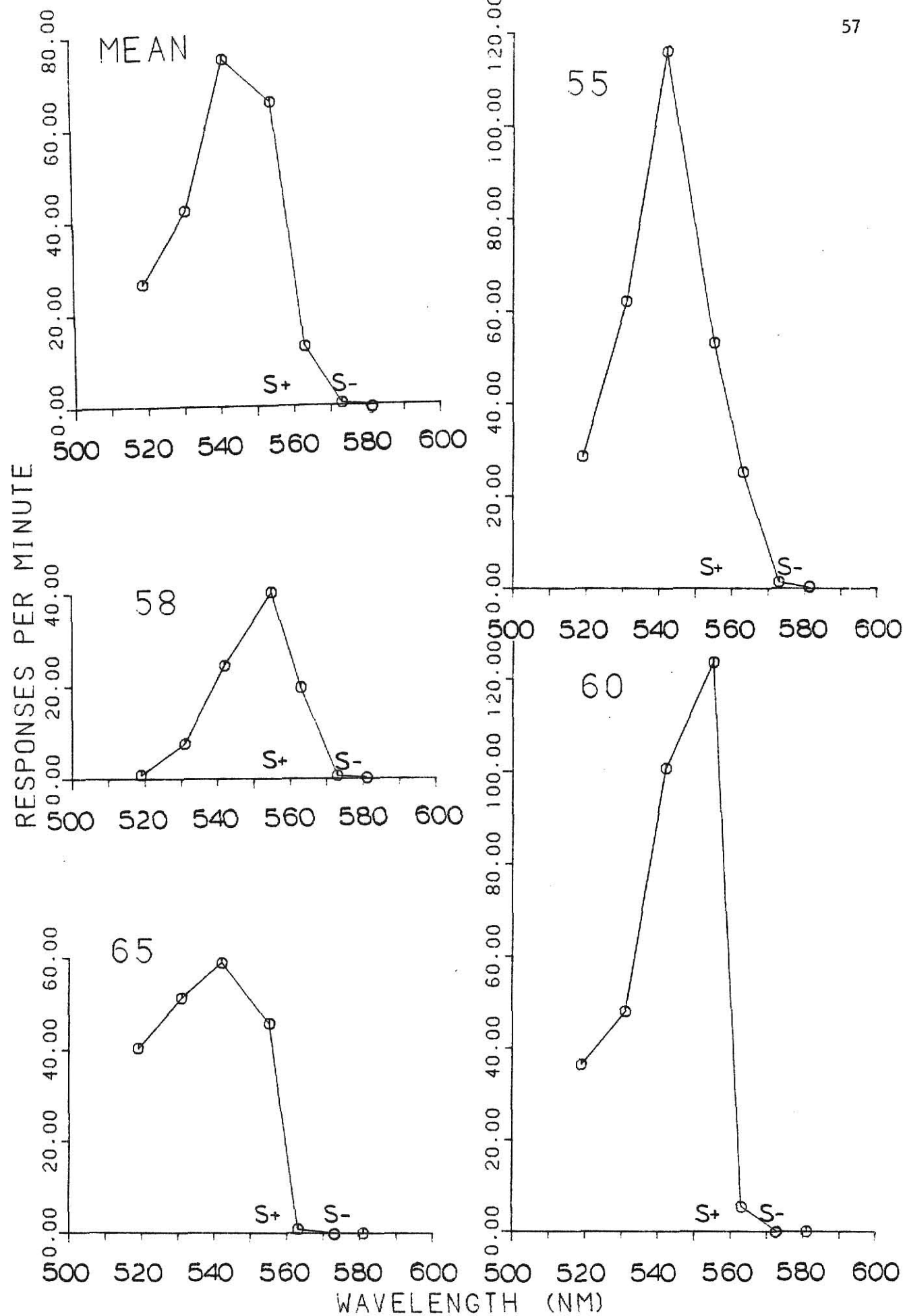
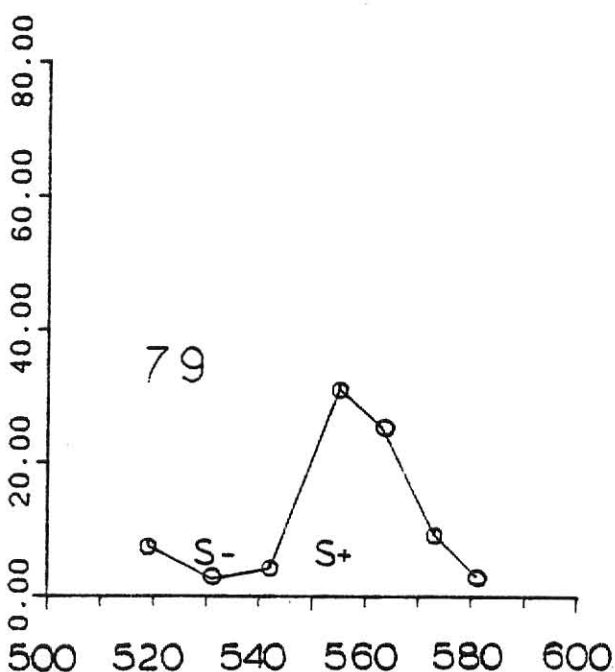
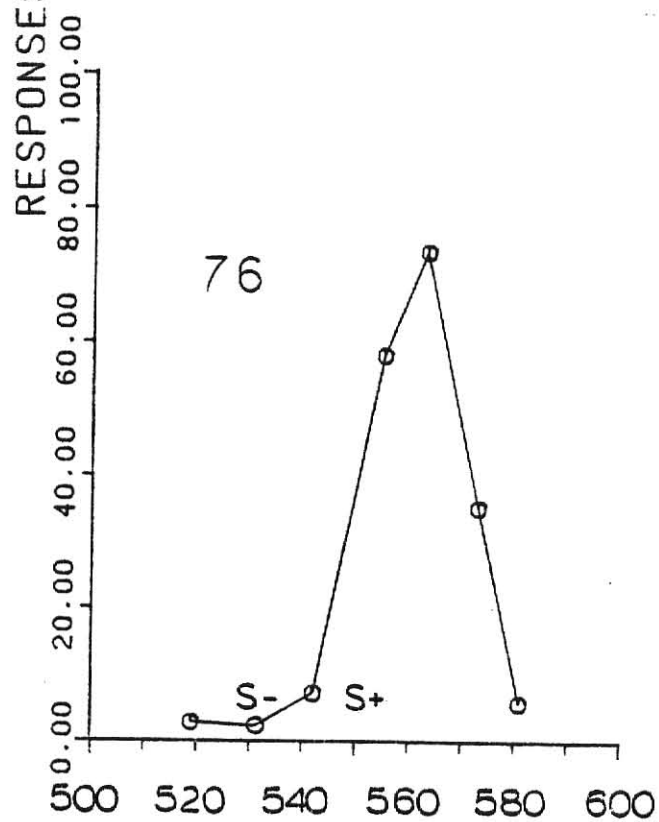
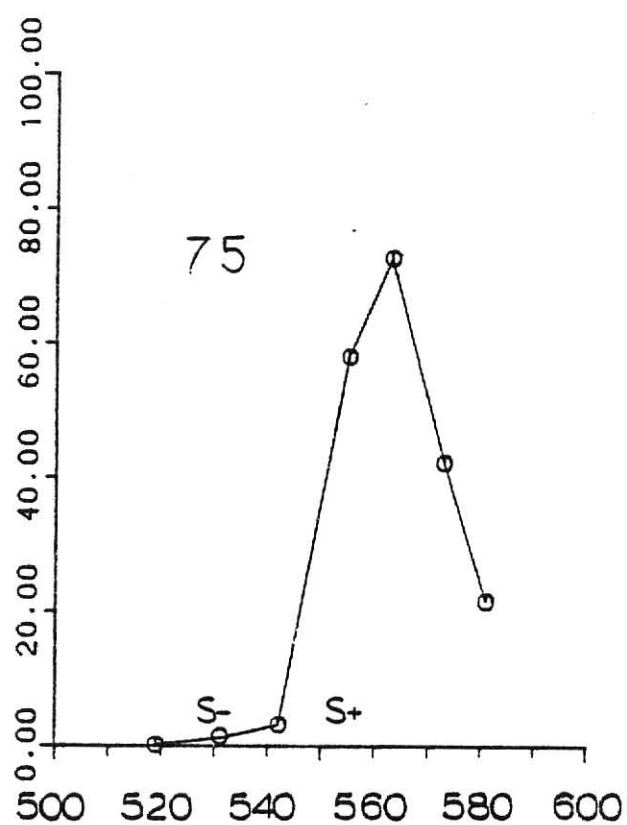
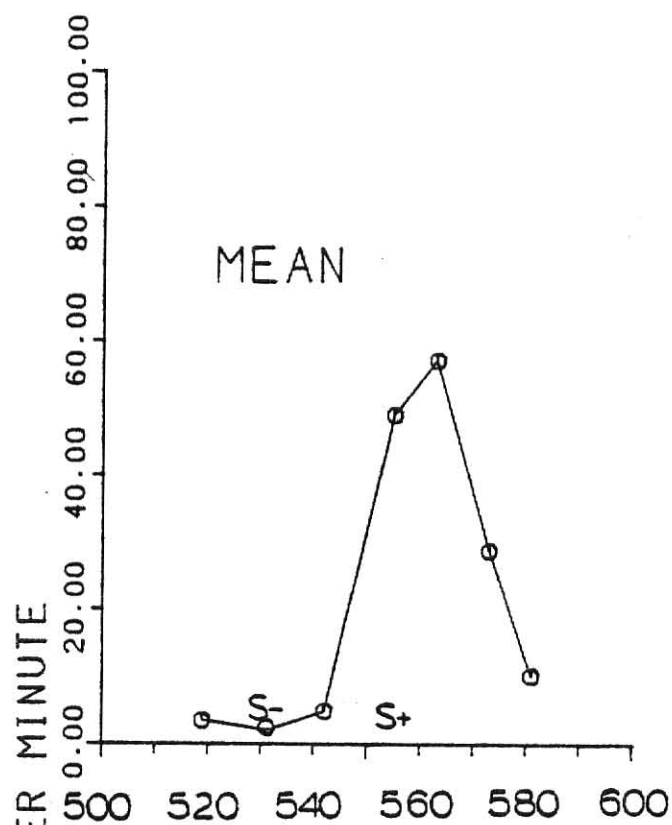


Figure Caption

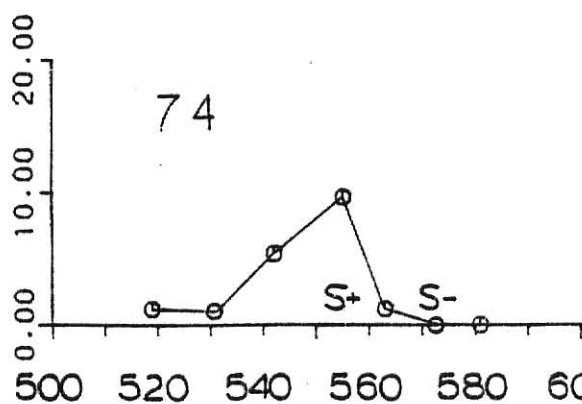
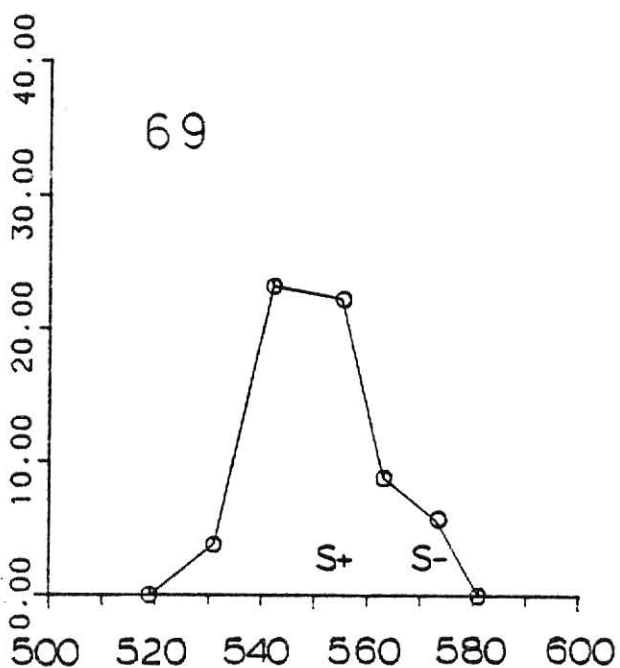
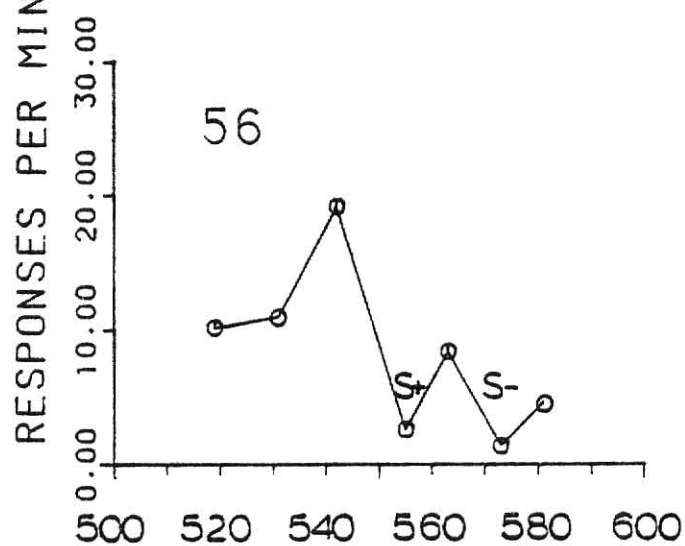
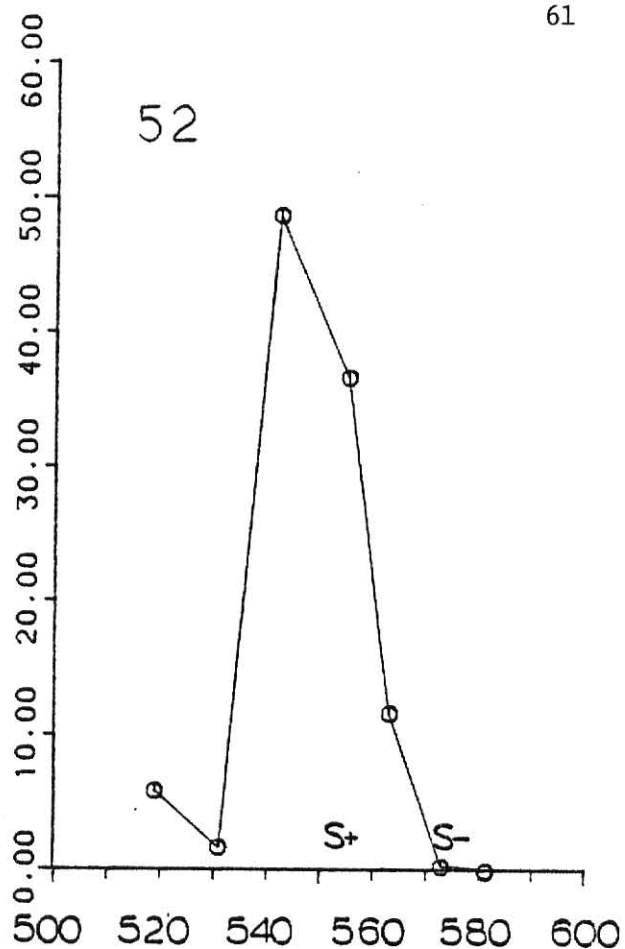
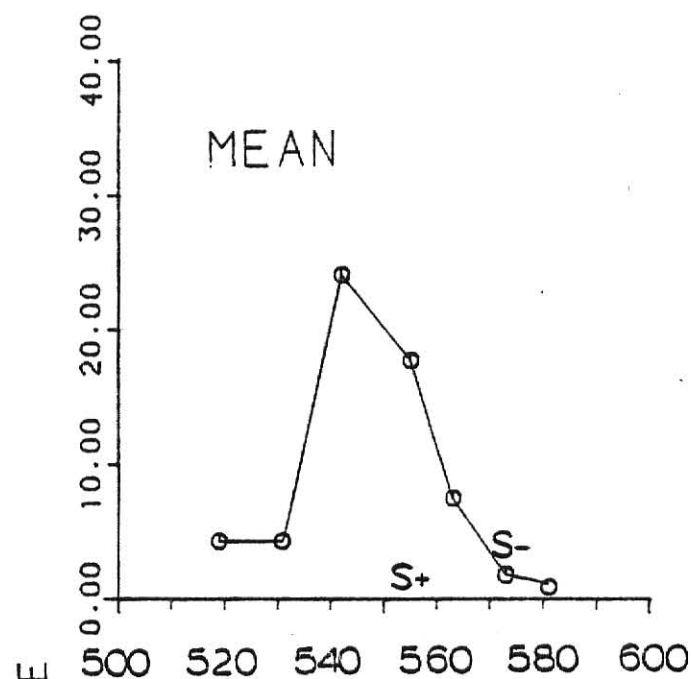
Figure 10. Mean and individual stimulus generalization gradients for the stimulus generalization tests conducted during Phase 3 of Experiment 2 for subjects in Group KP(B).



WAVELENGTH (NM)

Figure Caption

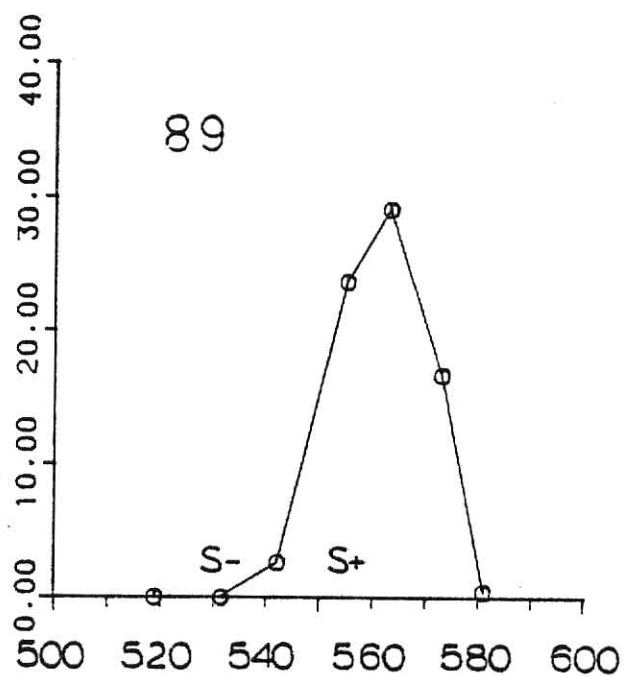
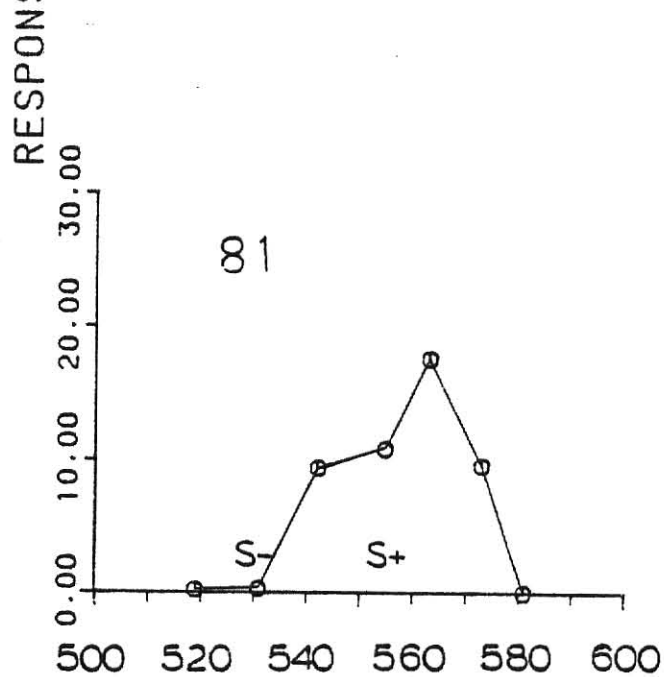
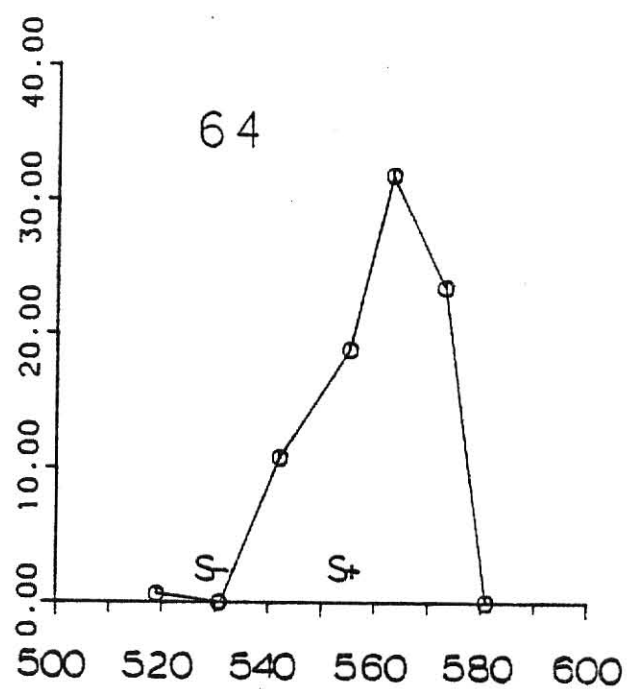
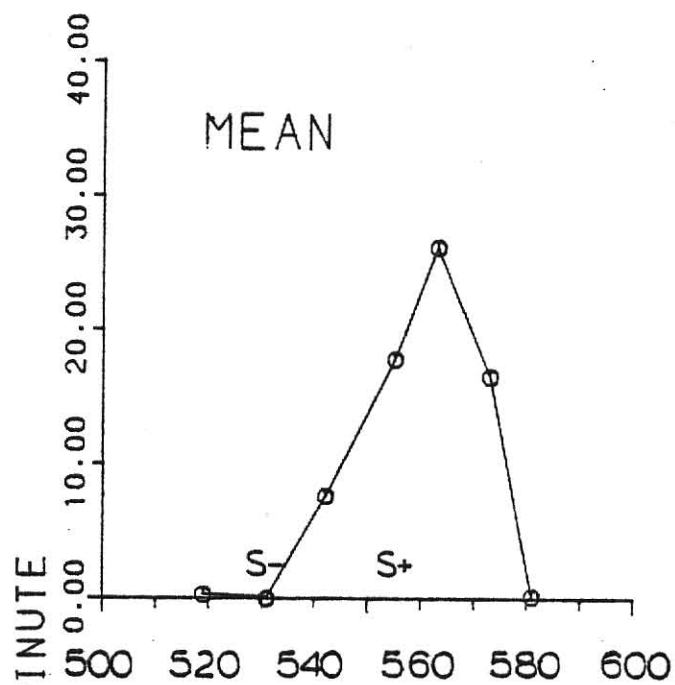
Figure 11. Mean and individual stimulus generalization gradients for the stimulus generalization tests conducted during Phase 3 of Experiment 2 for subjects in Group RP(A).



WAVELENGTH (NM)

Figure Caption

Figure 12. Mean and individual stimulus generalization gradients for the stimulus generalization tests conducted during Phase 3 of Experiment 2 for subjects in Group RP(B).



WAVELENGTH (NM)

Upon comparison of the PDGs obtained in this experiment with those of Experiment 1, it is noted that the peaks of 10 of 14 pigeons shifted in this experiment although only one of six gradients peaked at a stimulus other than S+ in Experiment 1.

Every pigeon who displayed behavioral contrast also produced a peak and/or area shift. Four of these birds (55, 60, 75, and 76) had behavioral contrast during the five days immediately preceding the generalization test, whereas the response rates of the other two birds (65 and 79) had declined from the elevated rate prior to the day of the test. It is noteworthy that the only KP pigeon (58) who did not demonstrate behavioral contrast was also the only KP pigeon who had neither a peak shift nor an area shift.

There was no relationship between negative induction and a peak and/or area shift. Of the five RP birds who showed negative induction, four (52, 69, 81, and 89) had peak shifts and the other one (74) had an area shift. However, both RP birds (56 and 64) who did not show negative induction did demonstrate peak shifts.

Discussion

Behavioral Contrast

The most important findings in this experiment were the presence of behavioral contrast with a key-pecking

response and negative induction with a ring-pulling response. While these data appear to be consistent with the response additivity notion of behavioral contrast, a different interpretation emerges upon further scrutiny of the results.

According to the response additivity theory of Gamzu and Schwartz (1973), behavioral contrast will occur only in those situations which are conducive to autoshaping. Since autoshaping has previously been demonstrated to occur only with localized stimuli (Schwartz, 1973), additivity theory cannot explain the presence of behavioral contrast with nonlocalized stimuli.² Therefore, the demonstration of behavioral contrast in the present study by the KP birds runs counter to what would be predicted from additivity theory. On the other hand, these results are consistent with what would be predicted from the theories of Terrace, Amsel, and Premack. Since the theories of Terrace and Amsel are similar, it would be reasonable and economical to consolidate them and name the product the "emotional theory" of behavioral contrast. According to the emotional theory, behavioral contrast is caused by a change for the worse in one component of a multiple schedule. This theory makes no assumptions regarding the location of the stimuli.

The majority of the RP subjects, on the other hand, exhibited negative induction. It appears that the reduction in response rate is caused by a competing response. It

was observed that concurrent with the diminished rate of pulling the ring, there was an increased rate of pecking the ring.³ These ring-pecks competed with the ring-pulls and resulted in negative induction.

This negative induction can be interpreted as an example of the phenomenon of regression. When organisms are placed on extinction, their behavior frequently reverts to that which was displayed at an earlier time during their training. The majority of the birds had passed through a stage of pecking the ring during the shaping procedure. Upon placement on ID with the consequent introduction of periods of extinction, their behavior may have reverted to the earlier behavior of ring-pecking. This regression may be a consequence of the frustration caused by the omission of reinforcement during the extinction component. These ring-pecks then interfere with the ring-pulls and result in negative induction. Therefore, an emotional theory can be used to explain both the behavioral contrast with the KP birds and the negative induction with the RP birds.

The behavioral contrast for four of the six KP pigeons who showed contrast and for all five of the RP pigeons who showed negative induction lasted for only a short period of time. This is similar to the "peak behavioral contrast" described by Bloomfield (1966) and also obtained by Terrace (1966a). This temporary effect is further evidence in favor of an emotional theory. Excitatory behavior occurs

at the beginning of the discrimination and then dissipates with time. Although there is some evidence that autoshaping also diminishes with time (Wasserman, 1973), the decline is more gradual than in the peak behavioral contrast obtained here. Both Bloomfield (1966) and Terrace (1966a) found that a response-reset dependency in S- is necessary in order to obtain peak behavioral contrast. In those studies, however, after the peak effect, the response rate did remain at a level which was still above baseline, whereas here the response rate dropped all the way back down to the baseline level. The difference may be due to the fact that their procedures involved localized stimuli whereas in the present study diffuse stimuli were used. Perhaps the initial increase in responding with a key-pecking response is due to emotional factors and the prolonged contrast is caused by the stimulus-reinforcer relationship. If this is indeed the case, then with key-pecking one would expect only temporary (peak) behavioral contrast with diffuse stimuli but extended behavioral contrast with localized stimuli.

There is evidence to support the idea that there are two types of behavioral contrast. This may be inferred from the behavior of one of the KP pigeons (79). This bird initially exhibited an increase in rate of key-pecking upon placement on TD (peak behavioral contrast) which was followed by a decline in key-pecking to a level below that of

the baseline rate (negative induction). This decline in key-pecking was accompanied by rapid pecking at the wall to the left of the key. This odd behavior seems understandable when one considers that the diffuse discriminative stimulus was located on the wall. Thus, in the case of this pigeon, behavior at the beginning of TD was apparently affected by emotional factors, but later behavior was perhaps influenced by the stimulus-reinforcer relationship.

Based upon the results obtained here, one would expect extended behavioral contrast to occur only with key-pecking and the stimuli located on the key. The findings in this area are inconsistent. As elaborated upon previously, McSweeney (1975) and Bushnell and Weiss (1980) both found behavioral contrast with treadle-pressing but Hemmes (1973) and Westbrook (1973) did not. An obvious problem with these studies is that the experimenters measured only the response of treadle-pressing. They did not observe what else their pigeons were doing. The present study demonstrates the importance of observing one's subjects.

The response additivity theory can perhaps be modified to account for both the behavioral contrast exhibited by the KP pigeons and the negative induction shown by the RP pigeons. Since the response which increases in both cases is pecking, these added pecks may be elicited by the stimulus. Although diffuse stimuli were employed, Schwartz (1973) found that ongoing responding in the presence of

diffuse stimuli is affected by the stimulus-reinforcer relationship. If this were true, it would be expected that both behavioral contrast and negative induction would persist for the duration of discrimination training.

However, this was not the outcome obtained here; only two of the six KP birds who demonstrated behavioral contrast retained the increased rate of responding throughout TD.

While this version of the additivity theory could explain the behavior of these two subjects, it seems more parsimonious to hypothesize that once rate of responding has increased it may become conditioned to the schedule and, therefore, remain at the new level (Mackintosh, 1974, p. 374).

On the other hand, this modified additivity theory can account for the behavior of the RP subjects who pecked at the ring. These pecks may have been elicited by the discriminative stimulus and directed at the operant manipulandum (i.e., the ring). The temporary nature of this behavior may have been a result of the operant contingency predominating over behavior maintained by the stimulus-reinforcer relationship. The source of the discrepancy between Schwartz's (1973) results and those obtained here may also lie in the fact that while Schwartz used a tone, diffuse monochromatic stimuli were used in the present study. The reason for the disparate results obtained with the different modalities is unclear.

A test of behavioral contrast is the return of the response rates back to baseline level when the subjects are placed back on ND after discrimination training. However, this was difficult to measure in this experiment since most of the pigeons' response rates returned to baseline level while still on TD. The response rates of two KP birds did remain at the increased level throughout TD. When these two birds were returned to ND, their response rates did not systematically change from what they were on TD. This may also be an effect of the conditioning of the rate of responding to the schedule. Although Reynolds (1961a) did observe a return to baseline response rate when the birds were placed back on ND, few later researchers included the second ND phase in their experiments. Bloomfield (1967b) did not obtain a decrease in rate of responding in ND following TD; however, when the birds were again placed on TD their rates further increased. Therefore, a return to baseline may not be essential in order for one to conclude that behavioral contrast is present.

Peak Shift

Although a peak shift has been obtained with tones (Jenkins & Harrison, 1962), this is apparently the first demonstration of a peak shift with diffuse monochromatic stimuli. Similarly, while Bushnell and Weiss (1980) reported a peak shift with treadle-pressing, this is the first demonstration of a peak shift with a ring-pulling

response. It may be concluded from these results that the peak shift in pigeons is not restricted to the response of key-pecking nor to the localization of the discriminative stimuli.

With respect to the question of a relationship between behavioral contrast and the peak shift, if these two phenomena do have the same underlying cause as suggested by Terrace (1966b), they would be expected to occur in the same situations and with the same subjects. While every KP pigeon who displayed behavioral contrast also had a peak and/or area shift, and the one KP pigeon who had no behavioral contrast had no peak or area shift, there was no relationship between the display of negative induction for the RP pigeons and the appearance of a peak shift. Although all seven of these subjects did show peak and/or area shifts, two of them did not demonstrate negative induction. If negative induction in the RP pigeons is indeed analogous to the behavioral contrast demonstrated by the KP pigeons, then one would expect to find peak shifts in the same birds who show negative induction.

In addition to the requirement that behavioral contrast and the peak shift occur with the same pigeons, the notion that these two phenomena are related also necessitates that a peak shift occur only if the generalization test is given while behavioral contrast is present on the discrimination (Terrace 1966a). This prediction was

clearly not supported. A peak and/or area shift was demonstrated by every pigeon who displayed behavioral contrast regardless of whether the behavioral contrast was occurring at the time of the generalization test. On the other hand, if behavioral contrast is an emotional effect then it is possible that after the behavioral contrast has diminished these emotions are aroused again during the generalization test. The fact that this test is conducted in extinction and when many unfamiliar stimuli are presented may be sufficient to reinstate the emotional condition and the peak shift results. If this were the case, a peak shift should occur with errorless discrimination learning. Since Terrace (1964) did not obtain a peak shift with errorless learning, it is unlikely that behavioral contrast and the peak shift result from the same process.

EXPERIMENT 3

This experiment was conducted to test the idea that there may be two types of behavioral contrast associated with discrimination training: peak behavioral contrast caused by emotional factors and extended behavioral contrast caused by the stimulus-reinforcer relationship. If this is indeed the case, then one would predict that with localized stimuli and a key-pecking response the increased rate of responding would persist throughout discrimination training. Here both components of behavioral contrast--emotional behavior and elicited pecks--would be present. The procedure used in this experiment is nearly identical to that of Experiment 2; it differs in that the discriminative stimuli are located on the key and only the key-pecking response is studied.

Method

Subjects

Four experimentally naive pigeons were maintained at 75% of their free-feeding weights throughout the experiment. Water and grit were available at all times in the home cages.

Apparatus

The operant chamber was identical to the one used in

Experiments 1 and 2, with the exception that all four walls were made of white painted plywood. Monochromatic stimuli with peak wavelengths of 555 and 576 nm were produced by Kodak wratten filters nos. 99 and 73 which were in the display cell located behind the key. A 7 W, 120 VAC house-light mounted in the upper corner of the chamber opposite the key and the door provided constant diffuse illumination in the chamber except during reinforcement periods when a magazine light operated.

Procedure

The operant response was key-pecking with the stimuli located on the key.

Preliminary training. A stimulus of wavelength of 555 nm was used throughout this stage. Preliminary training was nearly identical to the first four days of preliminary training of Experiment 1 with the only difference being the location of the discriminative stimulus on the key in this experiment.

Phase 1 (Nondifferential training (ND)). The pigeons were placed on a mult VI 30-sec VI 30-sec schedule. Each daily session consisted of 16 1-min stimulus periods separated by 10-sec blackouts. Two stimuli (555 and 576 nm) alternated in a quasi-random order with the restrictions that each stimulus be presented a total of eight times and no stimulus be presented more than twice in succession. Responses during both stimuli were reinforced

equally. This schedule remained in effect until the criterion of a stable rate of responding was maintained for five consecutive days for both stimuli. Average rate of responding on the last five days constituted the baseline.

Phase 2 (Discrimination training (TD)). This stage consisted of a mult VI 30-sec EXT schedule. Each daily session consisted of 30 1-min stimulus periods separated by 10-sec blackouts. The stimuli used in the VI 30-sec and EXT components were 555 nm (S+) and 576 nm (S-). These two stimuli were alternated in a quasi-random order with the restrictions that each stimulus be presented a total of 15 times and no stimulus be presented more than twice in succession. This schedule remained in effect until three criteria were met. First, the bird must have been on this schedule for at least 30 days.⁴ Second, a stable rate of responding must have been maintained for the last five days for both stimuli. Third, the average DI for those five days must have been at least .85.¹

Phase 3 (Nondifferential training (ND)). This is a repetition of Phase 1.

Results

Preliminary Training and Phase 1

All birds acquired the key-pecking response on the first day of training. Mean number of days on ND was 25.25 (range = 14 - 35). Table 1 shows the number of days spent

by each subject in every phase of the experiment.

Behavioral Contrast

Rates of responding for every subject for all phases of the experiment are presented in Figure 13. As can be seen from Figure 13, two out of four pigeons (62 and 67) demonstrated behavioral contrast. The rate of responding of Bird 62 increased initially upon placement on TD (Phase 2) and then decreased after a few days but continued to remain at a rate higher than that of baseline. Bird 67's response rate initially increased on TD, declined back to baseline level after a few days, and then again ascended to a level about twice that of baseline where it remained for the duration of TD.

The response rates of both of the pigeons who displayed behavioral contrast declined back to baseline level upon return to ND (Phase 3). A special procedure was required for Pigeon 62. During the first 20 days on ND (Phase 3), this subject had made few responses in the presence of 576 nm. It was, therefore, decided to place it on a mult VI 30-sec CRF schedule with 555 nm for the first component and 576 nm for the second component. This method was successful in inducing responding to 576 nm on the fifth day of the intervention. This schedule was in effect for Days 21-25 of Phase 3. The mult VI 30-sec VI 30-sec schedule was resumed on Day 26.

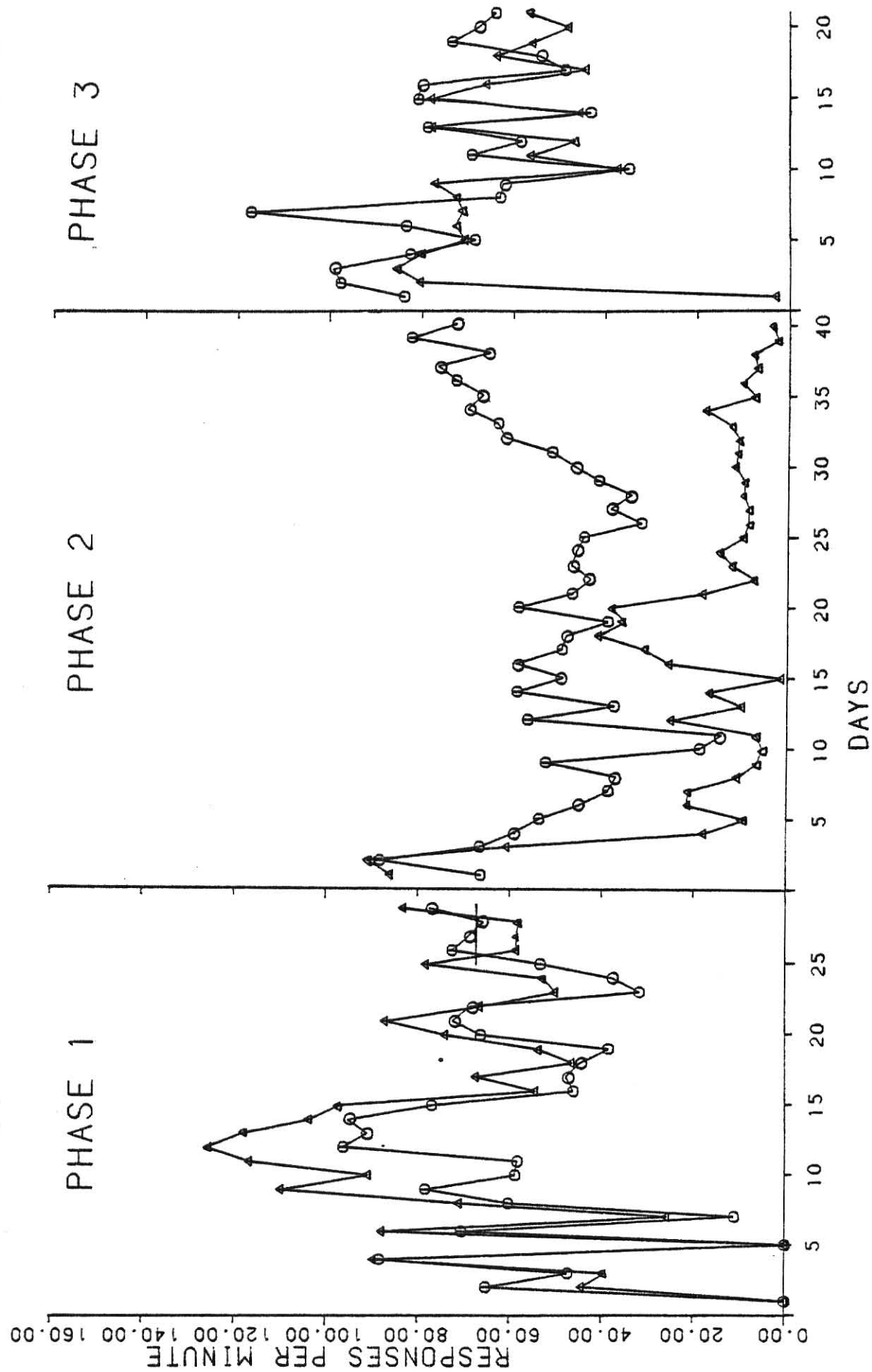
Both pigeons (59 and 66) who did not exhibit behavior-

Figure Caption

Figure 13. The rates of key-pecking during 555 and 576 nm for subjects in Experiment 3. Each graph is divided according to the three phases of the experiment. The horizontal line through the last five days of Phase 1 denotes the mean response rate for 555 nm and represents the baseline.

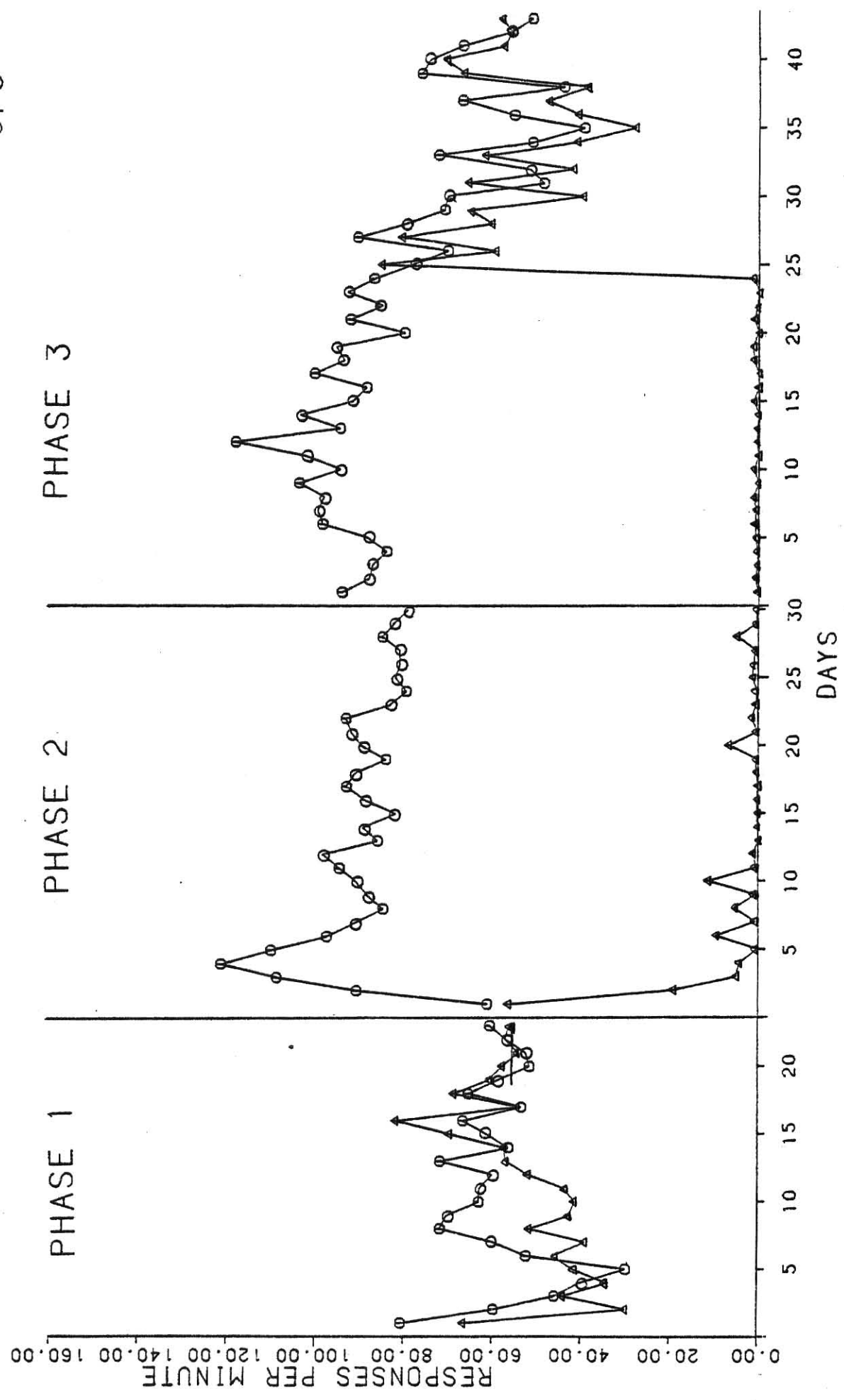
○ 555
▲ 576

59



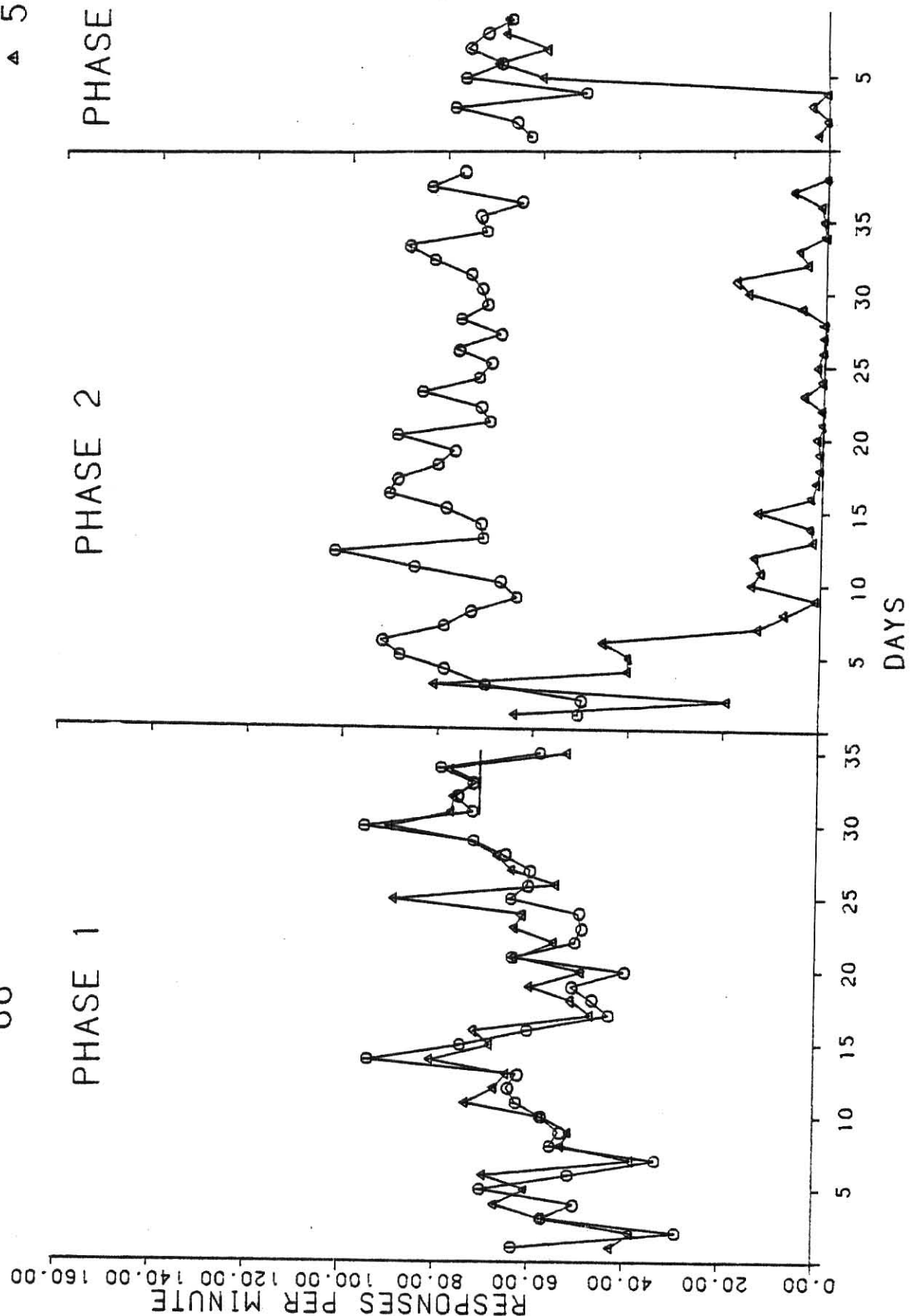
62

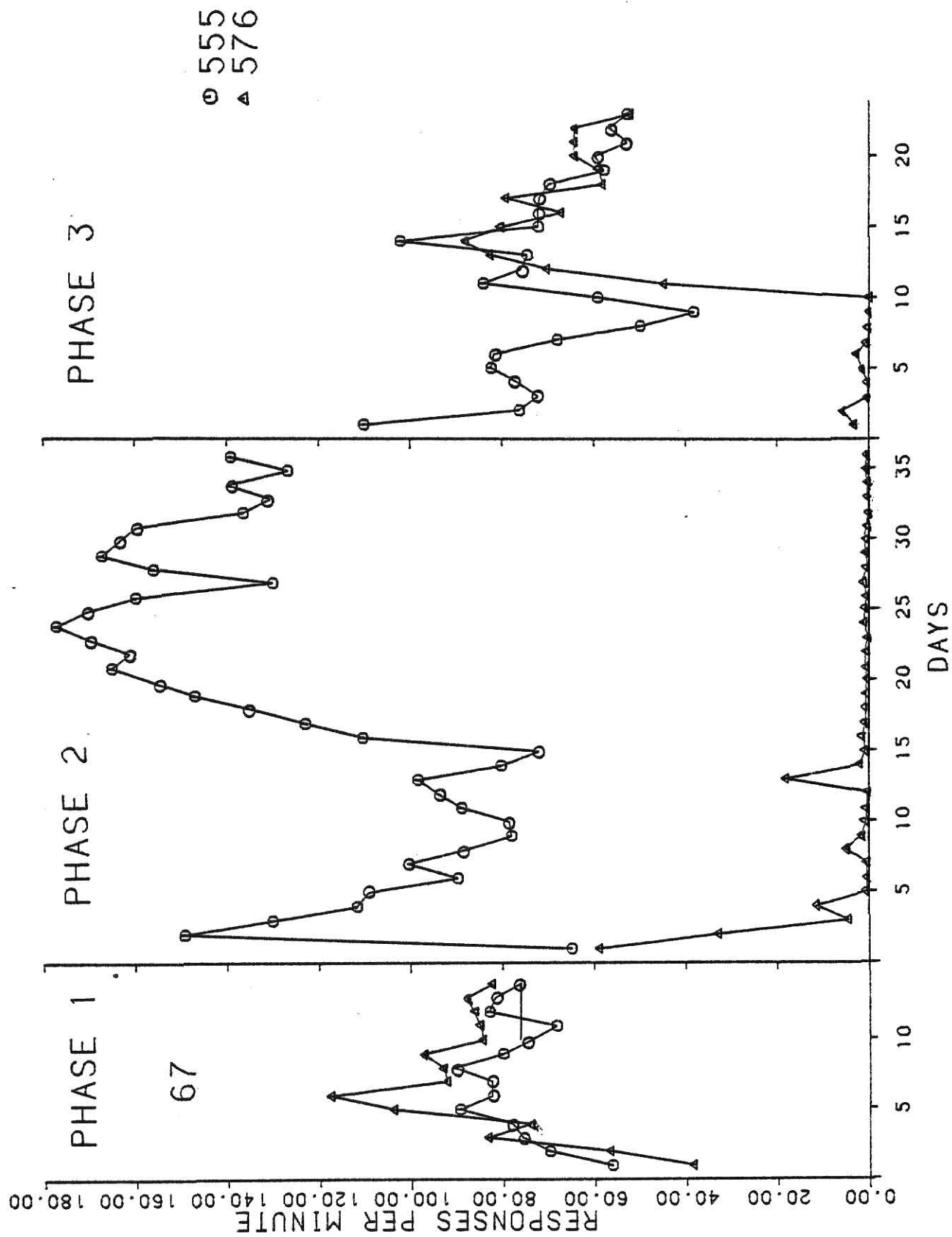
○ 555
▲ 576



○ 555
▲ 576

66





al contrast had erratic rates of responding throughout Phase 1. Bird 66's response rate became more stable during Phases 2 and 3, but Bird 59 remained unstable for the duration of the experiment.

Discussion

This experiment was conducted in order to compare the duration of behavioral contrast with localized and diffuse stimuli. It was hypothesized that behavioral contrast in the presence of localized stimuli would be long-lasting whereas behavioral contrast in the presence of diffuse stimuli would be of short duration. Unfortunately, only two of four birds showed behavioral contrast in this experiment. Most previous research has also found that not every subject displays behavioral contrast. In addition, it should be noted that both of the birds who did not demonstrate behavioral contrast in this study had erratic rates of responding. This may be in part responsible for the failure to detect behavioral contrast.

Upon comparison of the patterns of response rate changes over the course of the experiment for those KP pigeons who showed behavioral contrast in both Experiments 2 and 3, it is clear that there are differences between the two groups. While four of six Experiment 2 (diffuse) pigeons showed peak behavioral contrast, both Experiment 3 (localized) pigeons maintained the increased rate of

responding throughout TD. Both Experiment 3 pigeons did have a peak immediately upon placement on TD. After Pigeon 62's initial peak, response rate declined slightly but remained at a level above that of baseline. On the other hand, after Pigeon 67's initial peak, the response rate fell back to baseline level and later increased again. It may be that the peaks for both of these localized subjects were caused by the emotional component of behavioral contrast and the lower stable level (for 62) and the second period of increased responding (for 67) were caused by the additive component of behavioral contrast.

Differences are also noted in the behavior of the subjects in the two groups when they were placed back on ND. While neither of the two Experiment 2 birds who had prolonged behavioral contrast decreased their response rates when placed on ND, both of the Experiment 3 birds with behavioral contrast decreased their response rates back to the baseline level. This may be taken as evidence for different sources of contrast for pigeons trained with diffuse and localized stimuli even when both groups exhibit prolonged contrast. It was suggested previously that those two Experiment 2 birds may have maintained the increased rates of responding throughout TD either because the response rate was conditioned to the schedule or due to the stimulus-reinforcer relationship. If the former explanation is correct, one would not expect response rate to

change when the schedule is reverted back to ND. However, if the increased rate of responding is being maintained by a stimulus-reinforcer relationship, when this relationship changes (i.e., when the schedule is changed from TD to ND) one would expect response rate to return to the baseline level. Since the response rates of these two Experiment 2 KP birds did not return to baseline level upon placement on ND, it appears likely that the stimulus-reinforcer relationship was not operating. On the other hand, the response rates of the Experiment 3 KP birds did return to the baseline level. The fact that these predictions regarding behavior in the second ND phase were supported empirically serves as further evidence on behalf of the idea that there are two types of behavioral contrast.

The concept that there are two components to behavioral contrast is not new. Bloomfield (1966) had suggested this idea. However, while Bloomfield was able to determine that the initial peak was caused by an emotional factor, he assumed that the extended increased rate of responding was also caused an emotional factor. This notion appears incorrect on the basis of the evidence obtained here where only peak behavioral contrast was observed with diffuse stimuli but prolonged behavioral contrast with localized stimuli. Rather, it appears likely that the peak contrast is indeed an emotional factor as Bloomfield had postulated but that the extended contrast is a result of the stimulus-

reinforcer relationship proposed by the response additivity theory of Gamzu and Schwartz (1973).

GENERAL DISCUSSION

These three experiments were conducted in order to test the response additivity theory of behavioral contrast and examine the relationship between behavioral contrast and the peak shift in pigeons. The responses of key-pecking and ring-pulling were used. According to the response additivity theory, behavioral contrast would be predicted only with responses which are conducive to autoshaping. Therefore, behavioral contrast would be expected to occur with the KP but not the RP pigeons, and only in Experiment 3 where the discriminative stimuli were localized on the response key. In Experiment 2, peak behavioral contrast was found with the KP pigeons using diffuse monochromatic stimuli. The response additivity theory is unable to account for the increase in response rate since the pecks were not directed at the stimulus. A theory based on emotional responses to non-reinforcement can explain these results.

The RP pigeons in Experiment 2 exhibited negative induction when placed on the discrimination. These pigeons were observed to peck at the ring concurrently with the decreased rate of ring-pulling. It appears likely that these pecks interfered with the operant response of ring-pulling and caused the negative induction. These pecks may

result from emotional factors similar to those which may produce behavioral contrast with the operant response of key-pecking or from the stimulus-reinforcer relationship. Based upon these results, it is expected that behavioral contrast would occur only with key-pecking. However, the findings of behavioral contrast with the response of treadle-pressing are inconsistent with these explanations.

Both behavioral contrast and negative induction occurred only at the beginning of discrimination training for the majority of the subjects in Experiment 2. This is evidence in favor of the idea that peak behavioral contrast and temporary negative induction are due to emotional factors. Other researchers (Terrace, 1966a; Bloomfield, 1966) also obtained peak behavioral contrast but only when a response-reset dependency was implemented in S-. Since this changed the duration of S- over the course of training and the S- periods lasted longer at the beginning of training, the emotional theory can explain the results. In these studies, localized stimuli were used and response rates remained at a level above baseline after the initial peak effect.

It is hypothesized that there are two types of behavioral contrast. Peak behavioral contrast occurs at the beginning of discrimination training when emotional factors are present and extended behavioral contrast occurs for the duration of training when localized stimuli are employed.

If the stimuli are diffuse, however, only peak behavioral contrast (as observed in the present study) occurs since the stimulus-reinforcer relationship does not maintain the increased level of responding.

In Experiment 3, where pigeons were trained under conditions identical to those of Experiment 2 with the exception that the stimuli were located on the key, the rate of responding remained at a level higher than that of baseline throughout TD training. This extended contrast appears to be the result of the stimulus-reinforcer relationship proposed by the response additivity theory.

Stimulus generalization tests were administered to all subjects in Experiment 2 in order to examine the relationship between behavioral contrast and the peak shift. Previous research has suggested that these two phenomena have the same underlying cause. If this were the case, they would be expected to occur together. Although it was found that all pigeons who exhibited behavioral contrast also had a peak and/or area shift, it was concluded that behavioral contrast and the peak shift have different causes since in some pigeons the peak shift occurred despite the fact that the test was given after the peak behavioral contrast had vanished. In addition, there did not appear to be a relationship between negative induction and the peak shift.

This experiment has not added any information which

helps to discern the theoretical basis of the peak shift. Any of the three theories outlined earlier (i.e., James, 1953; Spence, 1937; Terrace, 1966b) are able to explain the peak shift based upon our present level of knowledge. However, if there is indeed a relationship between behavioral contrast and the peak shift then the same theory should be able to explain both of them.

In conclusion, it was suggested that there are two types of behavioral contrast: peak behavioral contrast caused by emotional factors and extended behavioral contrast caused by the stimulus-reinforcer relationship. It also appears likely that the negative induction with ring-pulling pigeons is analogous to peak behavioral contrast with key-pecking pigeons and that both are due to the effects of frustration. It was concluded from the results obtained here that a relationship between behavioral contrast and the peak shift does not exist.

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Footnotes

¹The DI is obtained by the following formula: $S+ \text{ response rate} / (S+ \text{ response rate} + S- \text{ response rate})$.

²There are inconsistencies in the literature regarding the necessity of the localization of stimuli in order to obtain behavioral contrast. While Redford et al. (1974) and Schwartz (1975) did not observe behavioral contrast with diffuse stimuli, Farthing (1976) and Westbrook (1973) did obtain behavioral contrast. Other than the previously mentioned problem with the Redford et al. (1974) study (i.e., the birds did not discriminate), the reason for these discrepant results is not clear.

³These ring-pecks were noted by means of casual observation. They were not recorded because they had not been anticipated beforehand.

⁴This is important because the results of this experiment were compared with those of Experiment 2 and, therefore, the birds needed to be on TD long enough to observe whether or not peak behavioral contrast was present.

Appendices

Appendix A

Response rates (responses per minute) for the stimulus
generalization test in Phase 2 of Experiment 1

Group KP

Wavelength (nanometers)

Subject	519	531	542	555	563	573	581
82	2.00	12.50	26.75	93.75	78.75	69.50	19.50
85	8.50	1.50	10.75	61.75	33.50	12.25	4.25
90	1.25	15.25	11.50	113.75	99.75	96.50	19.00

Group RP

83	0.00	0.80	0.00	9.40	7.00	6.40	0.00
91	0.00	0.75	7.00	28.25	30.25	17.50	0.00
92	1.40	9.40	11.20	25.80	18.60	10.20	1.80

Appendix B

Response rates (responses per minute) for the stimulus
generalization test in Phase 3 of Experiment 2

Group KP(A)

Wavelength (nanometers)

55	28.60	62.20	116.00	53.20	25.20	1.40	0.20
58	0.80	7.60	24.60	40.40	19.80	0.60	0.20
60	36.40	48.00	100.60	123.60	5.40	0.00	0.00
65	40.40	51.40	59.00	45.80	0.80	0.00	0.00

Group KP(B)

75	0.20	1.20	3.20	58.00	72.60	42.20	21.60
76	2.80	2.20	7.20	58.00	73.40	35.20	5.80
79	7.40	2.60	4.20	31.00	25.40	9.20	3.00

Group RP(A)

52	5.80	1.60	48.60	36.60	11.60	0.20	0.00
56	10.20	11.00	19.20	2.60	8.40	1.40	4.60
69	0.00	3.80	23.20	22.20	8.80	5.60	0.00
74	1.20	1.00	5.40	9.60	1.20	0.00	0.00

Group RP(B)

64	0.60	0.00	10.80	18.80	31.80	23.40	0.00
81	0.20	0.40	9.40	11.00	17.60	9.60	0.00
89	0.00	0.00	2.60	23.60	29.00	16.60	0.40

Appendix C

S1 response rates (top), S2 response rates (middle),
and DI scores (bottom) in Phase 1 of Experiment 1.

Group KP

Training Day

Subject	1	2	3	4	5
82	25.15	36.43	43.99	57.73	68.36
	3.47	2.80	1.00	10.00	6.60
	87.88	92.86	97.78	85.24	91.20
85	85.87	101.44	125.28	132.87	121.24
	38.60	4.60	0.40	0.27	1.07
	68.99	95.66	99.68	99.80	99.13
90	83.66	85.16	84.79	97.62	89.77
	19.33	4.87	4.07	2.73	6.20
	81.23	94.59	95.42	97.28	93.54
	6	7	8	9	10
82	78.65	96.99	105.78	109.74	113.97
	2.73	0.13	4.07	0.40	5.33
	96.65	99.87	96.29	99.64	95.53
85	122.16	136.15	105.63	96.03	111.88
	0.13	2.20	5.93	5.80	2.53
	99.89	98.41	94.68	94.30	97.79
90	85.13	101.39	114.30	118.79	117.83
	5.13	3.40	2.93	2.09	0.50
	94.32	96.76	97.50	98.27	99.58
	11	12	13	14	15
82	87.99	90.93	85.75	97.96	93.42
	0.00	0.40	0.00	0.93	0.33
	100.00	99.56	100.00	99.06	99.65
85	105.23	103.53	114.40	101.81	115.76
	1.73	4.13	16.75	11.41	6.59
	98.38	96.16	87.23	89.92	94.62
90	126.06	129.64	136.55	131.72	135.89
	1.00	0.84	1.34	0.50	0.50
	99.21	99.36	99.03	99.62	99.63

Appendix C (continued)

Group RP

Training Day

	1	2	3	4	5
83	18.41	21.81	25.33	15.62	23.53
	7.20	2.80	0.13	0.67	0.66
	71.89	88.62	99.49	95.89	97.26
91	14.85	16.94	17.56	13.01	18.96
	7.07	3.67	1.87	0.53	2.13
	67.75	82.19	90.38	96.09	89.90
92	20.34	19.32	17.89	18.62	18.23
	10.00	5.87	4.07	1.73	0.33
	67.04	76.70	81.47	91.50	98.22
	6	7	8	9	10
83	21.44	9.33	12.63	19.88	18.39
	1.59	0.09	0.00	0.00	0.41
	93.11	99.07	100.00	100.00	97.81
91	12.74	18.83	19.38	26.59	22.07
	3.33	3.27	1.73	4.00	1.20
	79.28	85.20	91.80	86.92	94.84
92	25.59	25.63	25.04	26.16	29.34
	2.91	1.00	2.75	2.09	0.34
	89.78	96.24	90.10	92.61	98.86
	11	12	13	14	15
83	13.98	20.76	11.23	17.67	18.23
	0.50	0.73	0.87	4.20	1.13
	96.55	96.60	92.81	80.80	94.16
91	26.08	25.88	22.03	26.06	21.58
	0.80	0.16	0.34	0.75	1.41
	97.02	99.38	98.49	97.20	93.86
92	31.46	28.45	30.23	25.33	24.72
	0.59	0.13	0.33	0.00	0.00
	98.17	99.55	98.92	100.00	100.00

Appendix D

S1 response rates (top) and S2 response rates (middle)
in Phase 1 of Experiment 2

Group KP

Training Day

Subject	1	2	3	4	5	6
55	37.86 33.43	38.88 34.62	59.26 52.28	45.74 47.31	41.47 40.53	25.24 26.45
58	38.24 48.71	46.76 44.71	43.24 47.04	52.28 53.51	64.85 60.87	68.08 73.11
60	46.84 40.42	55.14 60.00	44.13 48.25	61.65 58.00	39.95 42.43	35.63 42.45
65	26.88 35.39	33.45 42.55	35.09 33.36	50.83 59.42	48.09 45.29	54.48 51.47
75	33.75 18.29	28.53 30.72	24.57 27.26	26.47 25.96	31.75 29.86	34.12 31.31
76	54.65 22.22	42.06 40.29	36.09 32.10	51.76 47.31	68.53 60.58	81.14 60.14
79	94.08 57.26	71.14 60.29	63.35 65.10	54.95 63.35	66.71 65.00	61.89 65.29
	7	8	9	10	11	12
55	43.86 42.40	39.41 40.74	22.78 33.22	18.68 25.79	55.24 50.68	61.27 58.85
58	51.06 41.97	67.79 61.15	48.17 55.78	47.31 58.86	61.20 59.12	55.34 54.86
60	43.29 52.57	3.03 0.38	44.85 54.43	45.58 43.86	54.85 49.95	54.21 44.00
65	56.07 51.35	51.35 47.77				
75	32.48 32.16	32.18 32.18	31.05 36.86	39.12 36.78	36.83 36.03	
76	90.00 70.99	80.88 80.15	91.73 70.63	66.84 69.57	56.83 41.43	76.86 62.79
79	76.03 60.87	80.39 64.76	82.35 70.53	85.82 61.31	95.53 72.69	86.76 80.97

Appendix D (continued)

Training Day						
	13	14	15	16	17	18
55	46.88 55.05	52.28 54.61	43.71 46.76	68.91 57.98	36.84 55.34	60.88 45.86
58	94.22 86.65	103.22 84.17	99.06 87.40	88.07 78.50	88.97 83.74	
60	49.39 40.92					
76	112.64 82.93	84.47 70.34	85.15 82.22	73.98 70.24	88.82 88.85	79.25 51.76
79	60.44 60.87	67.36 47.16	51.26 40.92	57.52 37.50	57.98 50.91	61.59 45.44
	19	20	21	22	23	24
55	46.67 60.58	41.83 44.71	45.44 57.12	51.12 54.38	38.02 46.89	56.36 58.38
76	67.50 68.71	80.63 69.81	60.00 57.52	42.12 43.71	49.35 71.39	56.62 63.17
	25	26	27	28	29	30
76	60.58 53.74	59.71 56.50	65.20 53.16	65.74 58.82	79.71 69.32	68.74 66.70
	31	32				
76	57.23 57.65	66.35 66.47				

Appendix D (continued)

Group RP

Training Day

	1	2	3	4	5	6
52	33.93 29.42	28.68 30.43	19.95 23.86	15.28 25.09	19.22 27.22	38.08 33.57
56	17.88 14.43	9.86 11.50	7.72 11.11	24.29 24.00	15.56 6.68	9.76 9.81
69	5.71 5.81	5.57 3.61	7.01 5.31	3.99 5.78	2.12 1.32	6.59 6.14
74	0.25 3.78	9.72 15.43	9.95 8.45	3.41 5.86	7.92 10.23	7.29 7.17
64	15.44 7.30	3.98 2.67	13.76 11.92	6.54 3.31	11.49 7.90	0.50 4.54
81	21.15 20.10	8.92 11.50	17.00 13.09	16.46 11.71	15.87 16.01	17.65 16.59
89	22.92 10.24	17.67 13.46	9.62 12.59	16.31 18.08	14.14 8.12	16.15 13.04

Appendix D (continued)

Training Day

	7	8	9	10	11	12
52	34.18 39.86	29.56 32.33	40.40 40.19	42.94 34.22	39.23 43.02	27.71 28.30
56	10.43 11.11	6.98 10.47	1.61 2.03	11.83 12.78	19.66 20.80	25.19 26.43
69	1.00 0.13	4.77 3.41	2.41 1.74	12.06 14.59	2.03 1.55	15.44 13.70
74	13.86 7.93	5.75 3.05	0.13 1.70	5.75 6.55	10.67 8.21	21.14 9.81
64	18.36 18.03	0.00 0.00	23.09 19.39	16.01 20.14	25.59 18.89	14.00 17.69
81	11.04 3.38	14.56 13.56	18.89 22.08	19.14 15.87	18.06 21.62	18.97 18.20
89	25.20 17.57	19.51 26.50	25.82 16.88	22.57 23.65	22.64 24.03	
	13	14	15	16	17	18
52	40.95 35.94	46.76 40.59	36.76 34.71	42.06 40.71	46.78 42.14	
56	24.61 26.14	19.90 28.83	26.91 22.07			
69	9.57 11.75	26.39 18.64	12.26 11.46	21.18 16.59	9.44 9.95	7.65 8.71
74	17.04 14.86	10.75 10.29	16.50 15.00	18.14 18.40	16.30 15.44	15.59 19.08
64	21.98 20.34	0.00 0.13	23.97 21.63	23.88 26.86	11.18 15.00	28.54 28.54
81	22.21 24.50	30.15 34.71	24.32 27.21	25.78 35.00	18.06 21.06	18.97 20.86

Appendix D (continued)

Training Day

	19	20	21	22	23	24
69	21.70 17.94	11.18 9.95	11.46 7.78	33.09 33.46	17.74 19.70	38.76 34.66
74	15.29 18.06					
64	21.62 23.68	24.90 21.98	10.04 15.28	22.78 16.62	27.67 34.85	23.02 23.88
81	26.80 26.94	24.65 27.21	24.29 26.89	5.43 11.39	1.02 1.14	21.68 22.78
	25	26	27	28	29	30
69	33.17 34.51	27.33 28.13	31.88 34.18	32.04 37.07	42.57 42.84	31.44 31.43
64	24.26 27.98	24.21 23.94				
81	21.79 25.18	28.91 28.13	41.61 45.14	40.60 44.29	34.75 29.71	35.55 39.25
	31	32	33	34		
69	28.41 29.14	37.79 40.00	37.06 31.88	26.44 29.13		

Appendix D (continued)

S1 response rates (top), S2 response rates (middle),
and DI scores (bottom) in Phase 2 of Experiment 2

Subject	Group KP					
	Training Day					
	1	2	3	4	5	6
55	55.67	55.15	76.15	77.74	80.36	76.95
	79.60	52.00	47.73	48.40	32.20	18.07
	41.15	51.47	61.47	61.63	71.39	80.98
58	80.54	85.90	91.54	88.62	100.39	90.78
	113.47	70.33	65.93	42.07	27.47	17.60
	41.51	54.98	58.13	67.81	78.52	83.76
60	42.94	50.20	71.00	58.14	90.23	100.75
	63.20	53.13	62.67	51.47	56.40	22.20
	40.46	48.58	53.12	53.04	61.54	81.94
65	58.69	89.06	75.00	88.69	89.08	79.02
	59.07	63.73	29.13	18.93	4.07	14.73
	49.84	58.29	72.03	82.41	95.63	84.29
75	26.27	36.30	57.14	50.64	52.69	72.45
	37.47	33.00	27.93	34.93	18.73	16.87
	41.21	52.38	67.17	59.18	73.77	81.12
76	53.08	62.31	85.00	73.12	85.25	88.83
	78.13	82.33	83.33	68.13	69.75	80.34
	40.45	43.08	50.50	51.77	55.00	52.51
79	50.31	50.62	53.61	48.11	70.84	83.16
	58.73	53.67	52.09	44.91	27.00	18.66
	46.14	48.54	50.72	51.72	72.40	81.67

Appendix D (continued)

Training Day						
	7	8	9	10	11	12
55	90.63	80.69	88.31	81.77	87.36	88.08
	11.60	12.13	25.07	6.87	8.67	2.13
	88.65	86.93	77.89	92.25	90.97	97.64
58	99.05	94.67	91.86	96.72	97.77	96.85
	6.60	11.13	6.47	23.13	4.93	11.07
	93.75	89.48	93.42	80.70	95.20	89.74
60	86.85	98.07	112.27	109.54	104.30	105.31
	27.33	26.73	17.13	10.13	5.20	8.53
	76.06	78.58	86.76	91.54	95.25	92.51
65	75.78	75.08	71.15	65.63	60.46	74.77
	16.00	12.07	2.53	14.40	2.00	1.67
	82.57	86.15	96.57	82.01	96.80	97.82
75	83.89	62.41	69.95	72.05	68.31	61.78
	14.00	4.20	2.93	4.27	3.20	1.60
	85.70	93.69	95.98	94.41	95.53	97.48
76	113.25	107.01	138.30	131.16	125.23	121.08
	44.50	26.59	69.25	67.84	39.00	24.34
	71.79	80.10	66.63	65.91	76.25	83.26
79	88.26	62.60	59.43	43.31	38.76	39.44
	22.66	33.00	18.41	16.34	12.80	8.87
	79.57	65.48	76.34	72.61	75.17	81.64

Appendix D (continued)

Training Day

	13	14	15	16	17	18
55	85.13 8.00 91.41	84.62 2.40 97.24				
58	93.19 7.47 92.58	77.94 11.00 87.63	94.33 1.73 98.20	72.38 0.60 99.18	90.78 1.73 98.13	78.32 0.53 99.33
60	81.81 6.87 92.25	81.31 11.07 88.02	98.89 11.00 89.99	117.92 2.87 97.62	116.65 9.73 92.30	105.31 3.60 96.69
65	68.24 1.87 97.33	73.13 5.27 93.28	65.00 1.13 98.29	49.48 0.67 98.66	48.36 6.07 88.85	46.46 3.00 93.93
76	107.38 21.20 83.51	108.00 23.87 81.90	107.80 16.40 86.80	108.54 11.13 90.70	115.65 12.27 90.41	136.07 8.47 94.14
79	32.77 9.80 76.98	22.39 6.27 78.12	18.52 18.07 50.61	22.61 25.13 47.36	18.58 20.00 48.16	28.86 19.27 59.96
	19	20	21	22	23	24
58	78.44 0.53 99.33	69.08 0.40 99.42	71.74 1.67 97.73	70.52 0.20 99.72	70.00 1.13 98.41	56.00 1.00 98.25
60	110.34 8.27 93.03					
65	37.19 2.87 92.84	38.65 3.67 91.33	27.00 3.73 87.86	36.06 4.27 89.41	35.15 0.67 98.13	27.93 0.00 100.00
76	123.43 10.53 92.14	120.70 5.27 95.82	135.54 4.53 96.77	121.77 5.53 95.66	131.71 7.60 94.54	124.95 7.87 94.07
79	25.89 16.27 61.41	17.28 9.27 65.08	24.82 13.13 65.40	22.85 5.20 81.86	25.20 8.07 75.74	32.44 3.07 91.35

Appendix D (continued)

Training Day						
	25	26	27	28	29	30
58	66.30	58.13	62.94	56.40	51.83	56.54
	1.00	8.53	1.87	0.33	1.33	5.00
	98.51	87.20	97.11	99.42	97.50	91.88
65	29.84					
	0.07					
	99.77					
79	25.67	26.52	22.77	23.26		
	4.13	2.67	7.07	5.07		
	86.14	90.85	76.31	82.10		
	31	32	33			
58	60.39	71.95	58.66			
	0.33	0.40	4.33			
	99.46	99.45	93.13			

Appendix D (continued)

		Group RP					
		Training Day					
		1	2	3	4	5	6
52		37.31	38.66	46.62	43.86	47.53	32.32
		46.87	50.87	43.60	40.67	24.73	16.47
		44.32	43.18	51.67	51.89	65.78	66.24
56		19.62	16.14	24.92	29.77	32.04	26.57
		33.20	14.80	15.80	16.33	7.13	11.07
		37.15	52.17	61.20	64.58	81.80	70.59
69		24.90	21.28	26.23	7.69	10.88	14.24
		33.53	18.07	20.80	7.00	8.60	7.80
		42.62	54.08	55.77	52.35	55.84	64.61
74		10.43	17.36	16.32	18.35	21.08	17.45
		15.33	8.40	16.87	10.00	5.67	2.87
		40.49	67.39	49.17	64.73	78.80	85.88
64		21.66	19.57	20.20	27.60	25.67	16.31
		37.13	23.47	20.60	22.27	19.40	6.47
		36.84	45.47	49.51	55.34	56.96	71.60
81		21.79	7.81	8.76	17.14	21.03	14.54
		35.34	7.34	11.80	14.89	4.47	2.93
		38.14	51.57	42.61	53.55	82.47	83.23
89		8.91	11.35	14.84	11.33	5.49	15.07
		10.73	6.27	3.53	1.47	2.07	4.00
		45.37	64.42	80.79	88.51	72.62	79.02

Appendix D (continued)

Training Day

	7	8	9	10	11	12
52	12.68	33.94	52.15	48.67	55.00	50.57
	3.20	8.53	18.27	13.40	7.07	5.27
	79.84	79.92	74.06	78.41	88.61	90.56
56	29.31	21.53	25.69	24.51	29.16	25.53
	6.73	3.00	2.20	1.07	3.33	0.67
	81.33	87.77	92.11	95.82	89.75	97.44
69	7.13	20.15	22.54	36.48	16.61	29.34
	1.93	4.53	5.33	1.91	2.09	1.84
	78.80	81.65	80.88	95.02	88.84	94.11
74	13.03	8.21	13.16	15.85	22.65	15.00
	1.20	0.27	1.13	1.87	1.47	3.53
	91.57	96.82	92.09	89.45	93.91	80.95
64	25.36	31.56	28.45	17.45	18.28	29.41
	8.93	4.75	7.50	5.16	8.84	8.91
	73.96	86.92	79.14	77.17	67.40	76.74
81	13.47	21.67	18.94	20.62	20.05	20.71
	1.07	0.80	0.93	1.80	1.47	4.13
	92.64	96.44	95.32	91.97	93.17	83.37
89	18.99	15.50	26.79	26.62	32.83	28.69
	1.87	13.13	0.33	0.40	2.33	2.73
	91.04	54.14	98.78	98.52	93.37	91.31

Appendix D (continued)

Training Day						
	13	14	15	16	17	18
52	59.16	48.58	49.22	49.19	47.95	42.60
	6.20	1.13	2.53	4.33	10.67	12.13
	90.51	97.73	95.11	91.91	81.80	77.84
56	32.07	20.48	20.71	22.23	21.40	22.58
	2.80	3.93	9.40	12.20	7.53	2.93
	91.97	83.90	68.78	64.57	73.97	88.52
69	26.88	33.19	32.73	36.66	32.50	29.62
	1.59	2.50	4.84	2.34	2.73	0.93
	94.42	92.99	87.12	94.01	92.25	96.96
74	24.51	12.40	19.92	18.32	17.21	20.05
	0.67	1.40	0.60	1.87	2.13	1.40
	97.34	89.86	97.08	90.74	88.99	93.47
64	25.38	28.03	18.29	20.60	23.43	22.35
	6.66	3.50	5.13	1.47	1.47	4.07
	79.20	88.90	78.10	93.34	94.10	84.60
89	31.55					
	0.00					
	100.00					
	19	20	21	22	23	24
52	38.27	42.92	39.18	43.84	35.88	34.77
	15.80	10.00	7.80	3.93	4.87	4.33
	70.78	81.10	83.40	91.77	88.05	88.93
56	21.58	23.15	18.87	23.89	28.78	20.51
	6.93	2.00	4.53	3.07	2.27	3.67
	75.69	92.05	80.64	88.61	92.69	84.82
74	14.11	20.74	21.23	23.28	22.16	21.76
	1.59	1.66	0.66	0.59	0.25	1.16
	89.89	92.58	96.97	97.54	98.88	94.93
64	26.52	25.58				
	2.67	1.87				
	90.85	93.19				

Appendix D (continued)

		Training Day					
		25	26	27	28	29	30
52		29.01	39.82	42.23	48.54	43.00	44.54
		10.73	7.40	6.07	11.67	3.20	2.13
		73.00	84.33	87.43	80.62	93.07	95.44
56		22.81	25.69	22.61	26.73	23.95	
		4.27	0.07	3.13	3.53	2.73	
		84.23	99.73	87.84	88.33	89.77	

Appendix D (continued)

S1 response rates (top), S2 response rates (middle),
and DI scores (bottom) in Phase 4 of Experiment 2

Group KP						
Training Day						
Subject	1	2	3	4	5	6
55	93.05	87.44	82.77	98.92	96.66	
	1.87	2.67	1.80	2.53	1.13	
	98.03	97.04	97.87	97.51	98.84	
58	66.06	59.53	61.00	60.16	68.08	
	1.53	0.80	1.53	0.13	1.07	
	97.74	98.67	97.55	99.78	98.45	
60	104.30	109.12	96.19	55.03	52.27	61.53
	1.20	0.53	4.40	1.33	6.07	0.87
	98.86	99.52	95.63	97.64	89.60	98.61
65	37.31	34.90	32.28	31.30	30.99	30.85
	0.00	0.00	0.67	0.07	0.20	0.00
	100.00	100.00	97.97	99.78	99.36	100.00
75	50.66	49.92	43.52	43.52	33.94	41.75
	0.13	0.07	1.33	0.33	0.13	1.80
	99.74	99.86	97.03	99.25	99.62	99.87
76	120.39	145.08	138.09	134.69	131.85	135.85
	13.73	9.60	6.53	10.67	4.80	7.20
	89.76	93.79	95.48	92.66	96.49	94.97
79	22.27	21.97	33.65	24.72	26.40	37.46
	13.33	27.40	21.73	22.00	12.53	9.13
	62.56	44.50	60.76	52.91	67.81	80.40

Appendix D (continued)

Training Day

	7	8	9	10	11	12
60	88.46 2.20 97.57	80.83 1.20 98.54	78.40 1.47 98.16	63.96 0.20 99.69	74.14 0.73 99.02	77.72 0.27 99.65
65	33.46 0.00 100.00					
75	36.76 0.20 99.46	35.86 0.00 100.00	35.92 1.27 96.59			
79	43.16 6.60 86.74	48.65 5.27 90.23	59.38 5.53 91.48	62.37 4.67 93.03	61.54 0.67 98.92	44.31 6.13 87.85
	13	14	15	16	17	18
60	65.57 4.87 93.09	59.54 2.33 96.23	56.83 1.60 97.26	62.94 0.87 98.64	55.21 0.27 99.51	67.35 0.20 99.70
79	34.05 4.13 89.18	32.91 0.53 98.42	40.56 3.13 92.84	43.83 1.47 96.75		
	19					
60	63.85 0.00 100.00					

Appendix D (continued)

Group RP

Training Day

	1	2	3	4	5	6
52	36.70 1.27 96.66	5.34 0.73 87.97	12.93 3.27 79.81	16.30 2.93 84.76	21.23 9.87 68.26	38.05 10.13 78.97
56	23.30 0.87 96.40	19.72 3.60 84.56	29.38 0.13 99.56	22.35 2.53 89.83	20.82 0.27 98.72	
69	30.93 1.73 94.70	36.66 4.27 89.57	32.24 3.33 90.64	33.40 2.67 92.60	34.69 1.67 95.41	
74	16.82 4.93 77.33	14.93 1.93 88.55	19.26 0.87 95.68	13.73 1.00 93.21	14.31 0.00 100.00	14.33 3.67 79.61
64	22.16 2.27 90.71	22.38 3.53 86.38	25.96 3.27 88.81	25.39 5.00 83.55	23.88 6.93 77.51	25.28 5.33 82.59
81	18.08 1.47 92.48	24.28 0.40 98.38	26.11 3.40 88.48	23.68 1.53 93.93	22.27 1.60 93.30	28.34 1.60 94.66
89	21.40 0.00 100.00	27.85 0.73 97.45	26.57 0.80 97.08	30.31 0.13 99.57	22.35 0.40 98.24	
	7	8	9	10	11	12
52	28.25 5.40 83.95	32.92 9.40 77.79	47.63 5.53 89.60	49.31 2.60 94.99	48.69 4.20 92.06	43.55 6.80 86.49
	13	14				
52	40.18 3.07 92.90	40.20 2.73 93.64				

Appendix D (continued)

S1 response rates (top) and S2 response rates (bottom)
in Phase 5 of Experiment 2

Group KP

Training Day

Subject	1	2	3	4	5	6
55	106.15 45.70	103.85 78.57	109.56 103.09	92.31 95.50	90.29 90.87	83.14 86.11
58	72.65 0.25	76.60 36.20	83.47 81.70	83.45 79.18	95.44 95.68	79.31 79.66
60	62.45 0.00	70.19 0.38	81.30 54.25	80.20 102.86	103.41 117.65	79.56 86.54
65	37.36 0.25	41.94 0.00	50.00 0.13	49.29 3.25	60.43 0.13	66.51 0.13
75	39.57 3.91	39.43 0.00	37.21 3.56	43.11 0.00	41.65 4.58	50.53 34.68
76	125.91 25.28	137.45 84.43	119.85 77.43	160.71 139.22	123.93 115.10	116.76 113.08
79	37.21 24.81	35.39 56.18	42.50 47.08	45.59 57.98	35.43 39.71	39.86 40.38

Appendix D (continued)

Training Day

	7	8	9	10	11	12
55	83.16 82.72	84.32 85.38	93.27 87.55	72.94 84.76	80.97 84.90	99.71 96.14
58	85.25 82.64					
60	84.79 78.43	73.83 70.90	93.90 87.09	94.41 108.17	94.41 95.35	81.55 89.71
65	89.57 0.13	75.73 32.12	58.95 51.26	54.81 79.33	81.84 106.31	69.09 90.00
75	45.18 47.31	46.09 49.38	49.76 46.79	50.18 45.29	49.71 41.75	
76	113.17 105.58	118.25 101.04	127.06 95.29	127.57 114.66		
79	30.15 32.55	36.47 27.38	41.03 35.88			
	13	14	15	16	17	18
55	79.85 76.43	81.41 83.65	89.42 94.76			
60	82.05 79.71	88.25 83.59	86.44 96.84			
65	86.07 83.59	92.88 86.50	77.48 82.79	76.76 80.48	76.47 64.95	64.22 66.79
	19	20	21	22	23	24
65	69.56 59.71	60.74 55.78	53.16 58.71	54.03 51.78	60.87 60.00	58.25 59.42

Appendix D (continued)

Group RP

Training Day

	1	2	3	4	5	6
52	58.82 25.28	45.15 33.43	48.38 51.49	46.03 44.86	64.60 66.41	66.91 59.42
56	38.51 5.47	34.76 0.00	32.04 5.47	25.14 0.00	31.89 4.96	42.84 0.00
69	26.14 20.80	36.63 19.62	32.77 24.66	27.40 18.24	25.45 23.13	29.02 16.40
74	22.43 7.07	17.43 15.56	15.00 13.62	16.29 15.00	19.26 21.00	26.18 20.91
64	19.14 11.32	14.29 4.47	17.43 12.90	21.29 13.57	18.40 16.27	19.26 20.00
81	18.29 2.54	15.72 15.98	35.43 42.26	28.82 41.57	22.64 35.94	34.57 32.86
89	28.25 0.00	25.43 0.00	26.57 0.00	34.51 0.00	18.68 0.00	33.25 0.00

Appendix D (continued)

Training Day

	7	8	9	10	11	12
52	47.94 44.26	52.35 41.03	29.42 26.14	1.83 4.70	12.74 9.86	18.03 16.31
56	34.76 6.48	31.43 0.00	30.57 6.43	29.14 0.00	18.50 15.96	16.04 29.28
69	30.74 20.09					
74	22.86 19.35	19.91 21.12	21.99 18.17			
64	20.19 19.67	18.50 19.47	21.32 20.86	21.63 21.00		
81	37.29 33.11	26.80 25.86	25.78 19.81	24.23 29.57	9.14 13.19	22.06 21.70
89	30.72 0.00	31.00 0.00	22.13 0.00	24.14 0.00	17.92 10.14	16.98 14.43
	13	14	15	16	17	18
52	21.37 20.09	25.74 27.43	35.43 32.00	27.82 39.32	32.88 40.78	34.26 37.28
56	20.29 20.09	14.85 25.61	35.88 31.73	22.57 26.76	27.52 25.24	18.93 25.53
81	21.65 17.91	23.57 22.14	21.55 24.67	16.15 20.56	17.14 16.46	
89	21.00 20.43	20.39 29.72	31.02 29.57	22.08 26.89	8.77 11.92	11.89 15.57
	19	20	21	22	23	
52	27.82 30.00	33.06 32.79				
89	15.58 13.54	18.50 18.46	19.26 29.86	7.57 21.43	7.79 10.63	

Appendix E

S1 response rates (top) and S2 response rates (bottom)
in Phase 1 of Experiment 3.

Subject	Training Day					
	1	2	3	4	5	6
59	0.00	65.05	47.26	88.11	0.00	70.38
	0.00	44.15	39.17	89.41	0.00	87.67
62	80.50	59.56	45.87	40.24	29.85	52.21
	66.29	29.86	43.98	34.22	41.65	46.30
66	63.24	28.86	57.06	50.24	70.00	51.53
	42.50	38.00	57.26	67.14	60.29	69.38
67	56.18	69.85	75.88	77.97	89.42	82.43
	38.43	56.65	83.16	73.98	103.71	117.50
	7	8	9	10	11	12
59	10.99	60.15	78.20	58.68	58.11	96.03
	25.62	70.82	109.56	90.58	116.50	125.83
62	59.71	71.65	70.10	62.85	62.62	59.86
	39.00	51.51	42.57	41.36	43.69	51.84
66	33.27	55.40	53.57	57.35	62.62	64.56
	38.29	53.01	51.43	57.09	73.27	67.43
67	82.43	90.74	80.00	73.83	68.30	82.94
	92.18	93.09	97.36	84.38	84.95	86.39
	13	14	15	16	17	18
59	90.89	94.95	76.75	46.01	47.65	44.57
	118.25	103.43	96.92	54.17	67.14	46.29
62	71.65	56.25	61.15	66.47	53.32	65.25
	56.86	57.23	69.52	81.55	54.17	68.53
66	62.62	94.04	74.56	60.43	43.40	47.06
	64.76	80.83	68.22	71.71	47.16	51.06
67	81.78	76.32				
	88.00	82.36				

Appendix E (continued)

Training Day						
	19	20	21	22	23	24
59	38.45	66.20	72.21	68.60	31.75	37.57
	53.86	73.86	86.91	66.32	49.95	52.57
62	58.71	51.47	52.28	56.91	60.45	
	60.87	57.55	54.09	57.00	56.03	
66	51.35	40.19	63.71	50.53	49.14	49.95
	60.00	48.93	62.91	54.91	63.35	61.32
	25	26	27	28	29	30
59	53.22	72.38	68.88	65.68	77.25	
	78.03	58.41	58.43	57.98	83.00	
66	64.05	60.59	60.15	65.74	72.06	95.10
	88.73	54.56	64.18	67.07	72.71	89.85
	31	32	33	34	35	
66	72.35	76.02	72.33	79.08	58.22	
	76.86	76.31	71.44	77.43	52.50	

Appendix E (continued)

S1 response rates (top), S2 response rates (middle),
and DI scores (bottom) in Phase 2 of Experiment 3

Subject	Training Day					
	1	2	3	4	5	6
59	66.35	88.28	66.58	59.38	53.68	45.24
	85.93	90.91	60.66	17.91	9.00	21.66
	43.57	49.26	52.32	76.82	85.64	67.62
62	61.15	90.62	108.63	121.17	109.87	97.27
	56.33	19.13	4.93	4.27	0.27	9.53
	52.05	82.57	95.66	96.60	99.76	91.08
66	50.64	49.80	70.26	78.01	88.29	92.36
	63.87	19.33	80.91	40.25	40.41	45.91
	44.22	72.04	46.48	65.97	68.60	66.80
67	64.90	149.15	130.03	111.56	109.00	89.61
	58.80	32.93	4.53	11.40	0.33	0.33
	52.47	81.91	96.63	90.73	99.70	99.63
	7	8	9	10	11	12
59	38.80	37.04	52.31	18.88	14.18	56.27
	21.16	10.66	6.41	5.33	6.53	25.13
	64.71	77.65	89.08	77.98	68.47	69.13
62	90.70	84.59	88.14	90.62	94.41	98.13
	0.73	5.47	0.80	11.27	0.67	1.13
	99.20	93.93	99.10	88.94	99.30	98.86
66	79.13	73.84	63.93	67.35	85.54	102.27
	13.09	6.91	1.00	14.47	12.67	14.27
	85.81	91.44	98.46	82.31	87.10	87.76
67	100.51	88.14	77.94	78.38	88.77	94.06
	0.47	5.13	1.47	0.67	0.40	0.27
	99.53	94.50	98.15	99.15	99.55	99.71

Appendix E (continued)

Training Day

	13	14	15	16	17	18
59	37.61 9.80 79.33	58.62 17.40 77.11	48.71 1.27 97.46	58.86 25.67 69.63	48.96 31.40 60.93	47.95 41.00 53.91
62	85.80 0.00 100.00	89.07 0.27 99.70	81.79 0.41 99.50	88.64 0.50 99.44	92.81 0.00 100.00	90.88 0.66 99.28
66	71.17 1.60 97.80	71.91 2.40 96.77	78.94 13.33 85.55	90.99 2.13 97.71	89.69 1.27 98.60	80.97 0.53 99.35
67	98.27 18.13 84.42	80.18 2.00 97.57	71.95 0.73 99.00	110.31 1.40 98.75	122.86 0.80 99.35	134.06 0.67 99.50
	19	20	21	22	23	24
59	39.06 35.33 52.51	58.37 38.33 60.36	46.79 18.40 71.77	42.77 7.20 85.59	47.00 12.13 79.49	45.93 14.80 75.63
62	83.91 0.41 99.51	89.44 6.59 93.14	91.69 0.41 99.55	92.88 1.53 98.38	82.99 0.47 99.44	79.29 0.27 99.66
66	77.64 0.53 99.32	89.55 1.13 98.75	70.18 0.00 100.00	72.49 0.27 99.63	84.49 4.20 95.26	72.59 0.20 99.73
67	146.95 0.59 99.60	156.29 0.50 99.36	164.98 0.91 99.45	161.14 0.91 99.44	169.99 0.25 99.85	177.14 1.09 99.39

Appendix E (continued)

		Training Day					
		25	26	27	28	29	30
59		44.31	31.88	38.55	34.11	41.21	46.54
		9.53	8.53	8.53	9.60	9.60	11.33
		82.30	78.89	81.88	78.04	81.11	80.42
62		81.61	80.72	80.72	84.62	82.07	78.92
		1.33	1.00	0.67	4.67	0.40	0.27
		98.40	98.78	99.18	94.77	99.51	99.66
66		70.23	77.74	68.34	76.62	71.15	72.38
		1.53	0.47	0.13	0.00	4.87	16.13
		97.87	99.40	99.81	100.00	93.59	81.78
67		170.53	159.72	129.95	155.89	167.16	163.38
		0.91	0.53	1.47	0.27	0.80	1.00
		99.47	99.67	98.88	99.83	99.53	99.39
		31	32	33	34	35	36
59		51.34	61.78	63.20	69.95	66.47	72.38
		10.93	10.67	12.73	17.87	7.13	10.07
		82.45	85.27	83.23	79.65	90.31	87.79
66		74.77	82.42	88.37	71.63	73.02	64.15
		19.07	3.80	6.07	0.27	0.73	1.13
		79.68	95.59	93.57	99.62	99.01	98.27
67		159.74	136.39	130.52	139.87	126.66	139.13
		0.47	0.00	0.20	0.33	0.73	0.20
		99.71	100.00	99.85	99.76	99.43	99.86
		37	38	39	40		
59		76.30	65.08	82.19	72.45		
		6.67	7.80	2.40	3.67		
		91.96	89.30	97.16	95.18		
66		83.23	76.68				
		7.33	0.00				
		91.91	100.00				

Appendix E (continued)

S1 response rates (top) and S2 response rates (bottom)
in Phase 3 of Experiment 3

Subject	Training Day					
	1	2	3	4	5	6
59	83.88	97.72	99.26	82.57	68.51	83.47
	3.00	80.34	85.63	80.39	70.67	72.78
62	93.86	87.69	87.00	83.86	88.25	98.29
	0.25	0.78	0.25	0.38	0.76	0.76
66	62.60	66.06	78.53	51.00	76.30	68.59
	2.14	0.00	3.46	0.00	60.00	69.66
67	110.00	76.17	72.09	76.60	82.28	81.70
	3.18	5.69	0.13	0.25	1.55	2.69
	7	8	9	10	11	12
59	117.21	63.03	62.43	35.00	69.23	58.13
	71.14	72.57	77.16	37.43	56.21	46.68
62	99.38	97.94	103.57	94.29	102.29	117.96
	0.67	1.14	0.00	1.15	0.00	0.53
66	75.88	72.38	66.57			
	58.98	67.64	67.64			
67	67.93	49.86	38.22	59.13	84.03	75.86
	0.13	0.00	0.00	0.00	44.72	70.19
	13	14	15	16	17	18
59	78.82	43.29	80.88	80.34	48.75	54.26
	77.74	45.58	78.00	65.91	44.27	63.68
62	94.33	103.30	91.44	88.40	100.10	93.46
	0.38	0.00	1.17	0.00	0.13	1.15
67	74.42	102.03	71.94	72.06	71.76	69.85
	82.43	88.41	79.53	67.06	79.04	57.96

Appendix E (continued)

Training Day

	19	20	21	22	23	24
59	73.53 55.78	67.79 48.03	64.04 56.65			
62	95.19 1.41	79.86 0.13	92.06 0.93	84.84 0.38	92.74 0.00	86.75 1.07
67	57.69 58.82	59.57 64.16	52.65 64.18	56.47 64.10	52.57 51.86	
	25	26	27	28	29	30
62	78.21 85.00	70.19 59.27	90.44 80.43	79.71 60.15	70.92 65.29	70.10 39.50
	31	32	33	34	35	36
62	48.50 65.43	51.55 41.76	72.21 61.60	50.97 40.92	39.38 27.78	55.10 40.61
	37	38	39	40	41	42
62	66.91 47.71	43.85 38.07	76.03 66.43	74.13 71.03	66.78 57.33	55.71 55.57
	43					
62	50.97 58.02					

BEHAVIORAL CONTRAST AND PEAK SHIFT IN PIGEONS:
A RE-EVALUATION OF THE RESPONSE ADDITIVITY THEORY
OF BEHAVIORAL CONTRAST

By

BONNIE LYNN GROSSFLAM

B.A., University of Rochester, 1978

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Department of Psychology

KANSAS STATE UNIVERSITY

Manhattan, Kansas

1981

Abstract

This study tested the response additivity theory of behavioral contrast and examined the relationship between behavioral contrast and the peak shift in pigeons using diffuse monochromatic stimuli with key-pecking and ring-pulling as the response classes. In Experiment 1, it was found that diffuse monochromatic stimuli do exert control over responding with both response classes. In Experiment 2, when the birds were transferred from a mult VI VI to a mult VI EXT schedule, the key-pecking pigeons exhibited peak behavioral contrast and the ring-pulling pigeons displayed negative induction when diffuse monochromatic stimuli were employed. An increased rate of pecking at the ring was observed along with the negative induction in the RP subjects. Peak shifts were obtained with both key-pecking and ring-pulling birds. Experiment 3 was conducted with localized stimuli and a key-pecking response in order to compare behavioral contrast with that of Experiment 2. The subjects who did show behavioral contrast in this experiment exhibited the phenomenon for the duration of discrimination training. It was concluded that behavioral contrast has two components: peak behavioral contrast at the beginning of discrimination training caused by emotional factors and extended behavioral contrast maintained by the stimulus-reinforcer relationship.