CLASSICALLY CONDITIONED KEYPECKING TO SIMPLE AND COMPOUND STIMULI OF LONG DURATION

by

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Acknowledgements

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INTRODUCTION

There are two common methods for training pigeons to keypeck. The first, and most widely known, is the response-contingent reinforcement procedure (cf. Ferster and Skinner, 1957). The second method has only recently received much attention; food presentations in this procedure are stimulus, rather than response, contingent (Brown and Jenkins, 1968; Gamzu and Williams, 1971; Rachlin, 1969; Williams and Williams, 1969). In this latter procedure pigeons will peck at a stimulus intermittently presented on the response key in a well lighted box if the presentation of that key stimulus regularly preceeds access to food. This second type of procedure is an instance of forward classical conditioning. Presentation of the key stimulus, the conditioned stimulus (CS), is followed by availability of food, the unconditioned stimulus (US), and after a number of such CS-US pairings, a conditioned response occurs in the presence of the CS. In this case the conditioned response (CR) is keypecking.

Several other species have been conditioned in a similar fashion including quail (Gardner, 1969), monkeys (Sidman and Fletcher, 1968), and fish (Squier, 1969). It is even possible to establish a moderate amount of keypecking with pigeons if water or shock reduction is used as the US (Jenkins, personal communication, 1970; Rachlin, 1969).

This phenomenon has been designated autoshaping. Initial interest seemed to be in its use as a convenient method for establishing operant responses; a method which can be described with greater precision and

which is less tedious than the common "hand shaping" technique. Unfortunately the term "autoshaping" seems to imply operant control of these responses; i.e. that pecking occurs because of the accidental pairing of the response with food access. Below it will become evident that this implication is incorrect. It seems that the alternative designation, classically conditioned keypecking, adequately describes the procedure investigators used in obtaining the phenomenon, while at the same time, implies nothing about the processes taking place within the organism.

In their initial experiments Brown and Jenkins (1968) employed a partially instrumental, partially classical procedure. In Experiment I, an eight second key stimulus was followed by four seconds access to grain. If however, the pigeon pecked the key during the CS, this response was immediately followed by termination of the CS and the simultaneous delivery of the four second food presentation. Strictly speaking, then, only the first response in their procedure was entirely dependent upon classical conditioning. Food presentations before the first peck were always stimulus contingent, but after pecking had been established, "reinforcements" were more often than not, response contingent. This first experiment and its control procedures demonstrated that: 1) no pecking occurs to an intermittent key light not followed by food; 2) backward pairings are not effective in establishing the response; 3) very little pecking occurs with a constantly present key light and intermittent food presentation and 4) pecking during the CS will occur if the CS is light offset rather than light onset.

In their Experiment IV pecks had no programmed effects. The CS duration was always eight seconds and was always followed by the four second US, but pecking had no effect on the procedure. Under these conditions, a strict classical procedure, five out of their twelve subjects established and maintained substantial rates of pecking for 160 trials, while all but one of the remaining subjects made at least one peck during that same period.

Brown and Jenkins suggested that their findings might best be thought of as an instance of the instrumental conditioning of a "superstitious" behavior. Skinner (1948) defines superstitious behavior as an increase in the probability of a response on subsequent occasions due to an accidental (non-programmed) connection between the occurrence of that response and the appearance of a reinforcer. To Brown and Jenkins' way of thinking "autoshaping" begins as an accidental reinforcement of "looking at" the illuminated key which is then "superstitiously" repeated by the pigeon. The observed keypecking would be the natural outcome if it is assumed that pigeons have a species specific mechanism such that they tend to peck at things they look at.

Rachlin (1969) argued that if such a gradual process were occurring then the subject ought to be facing the key on the trial(s) just before the first peck. He found no such gradual process in either his positive (food reinforcement) or negative (shock reduction) procedures. The pigeon's first peck was not correlated with the pigeon's position in the chamber on the preceding trials. Rachlin's findings do not support the "superstitious" explanation of acquisition.

The Williams and Williams experiments (1969) provide even stronger evidence against the "superstitious" explanation of classically conditioned keypecking. In Experiment I of this study pecking was never followed by food presentation; rather a response during the six second CS would immediately turn off the stimulus and prevent the presentation of grain. Under these conditions the birds continued to peck on a large portion of the trials even though pecking was never followed by food and "not pecking" was always followed by food. Clearly adventitious reinforcement cannot explain the results of this study.

In Experiment III, an interesting variation of their original procedure, Williams and Williams provided their subjects with two differently colored key light stimuli presented simultaneously on different keys. One stimulus was identical in effect to the CS used in Experiment I; a response made to this stimulus would terminate the CS and prevent food presentation. Pecks made to the other stimulus had no programmed effect; responses to it would neither prevent food nor change the time of its scheduled arrival. In this experiment these two stimuli were presented simultaneously for six seconds prior to food presentations. With this procedure subjects pecked at the stimulus that had no programmed effect on virtually every trial and eventually made no pecks at all to the stimulus that prevented food presentation.

Experiment IV was similar to Experiment III in the use of the two stimuli which the subjects could peck at. However, in this variation the stimulus with no programmed effect was constantly present throughout the experimental sessions while the stimulus that prevented food presentation was presented six seconds before each US period. Under this set

of conditions the stimulus which prevented food presentation was pecked at regularly while the constantly preset stimulus with no programmed effects was pecked infrequently and only when the other stimulus was not present.

In a final variation of Experiment IV the stimulus which prevented food presentation was no longer presented but the continuous stimulus, with no programmed effects, remained. As in the first portion of Experiment IV this stimulus changed positions over the three possible keys six seconds before food presentations. Under these conditions most of the birds developed substantial rates of pecking during the six second period after stimulus position change when magazine presentation was imminent.

In their discussion of this study the Williamses pointed out difficulties with both the operant and respondent "explanations" of classically conditioned keypecking. Obviously an operant explanation is inadequate since in Experiment I there was never any positive contingency, accidental or otherwise, set up between pecking and reinforcement. While acknowledging the procedural similarities of their study with classical conditioning, they felt that a classical conditioning process would be an inadequate explanation for two reasons. First, they were doubtful that this type of directed responding (pecking at the key rather than, for example, pecking or preparing to peck at the magazine) is at all typical of classical conditioning. Second, they pointed out that pecking is a voluntary (skeletal) response rather than an involuntary (visceral, reflexive) response. Apparently they assumed (recalling Skinner, 1938) that these classes of responses should limit the domains

of operant and respondent conditioning.

It is the present point of view that voluntary-involuntary (operant-respondent) distinctions in response classes are for the most part unuseful. Miller (1969) has already demonstrated in a series of experiments that visceral responses, responses once considered the strict domain of classical conditioning, can be modified by instrumental conditioning. The present phenomenon might best be considered a case of the classical conditioning of a skeletal response that has formerly been obtained only with instrumental procedures.

To his credit, David Williams in a paper with Gamzu (1971) has changed his position on this point and now deals with the phenomenon entirely in the context of classical conditioning. In this latter study Gamzu and Williams successfully demonstrated that classically conditioned keypecking is not dependent upon the specific "pairing" relationship between the stimulus light and food; i.e. the precise signaling of the time of presentation of the unconditioned stimulus. If during the CS the probability of food presentation is greater than at any other time, pecking will occur, but if there is no difference in the probability of US occurrence, even if the same number of food presentations are forthcoming, pecking rates during the CS drop essentially to zero. They point out the similarity of these findings to Rescorla's results with a classically conditioned emotional response in dogs and rats (1968).

Jenkins (personal communication, 1970) has also subsequently suggested that the classical paradigm might be more useful in describing his data. In a study comparing classically conditioned keypecking in water- and food-deprived birds he maintained that the topography of the response is more

like "drinking" or more like "eating" in their respective cases. (Observers were correct 85% of the time in identifying whether the responses were made by food- or water-deprived animals). He points out that this evidence would be in line with a stimulus substitution analysis of classical conditioning; i.e. through temporal association the CS would take on properties of the US and the CR would be an imitation of the UR (unconditioned response), in this case eating or drinking.

The primary purpose of the present paper, which represents the beginning of an intensive research program into classically conditioned keypecking at Kansas State University, is to increase empirical knowledge, while at the same time developing the techniques and rationale of research into a relatively new area.

An important parameter that needs to be varied extensively is the duration of the CS. So far, stimulus durations of 3, 6, and 8 seconds have been reported in the delayed conditioning procedures, along with conditions of constant illumination of the key. The use of a much longer intermittent CS would be necessary to discover any differences in the rate or timing of responses by pigeons during the CS. Preliminary work had already indicated that the durations of 30 and 120 seconds used in this study yield substantial rates of pecking under some conditions.

Reliable conditioning with a CS of these durations would suggest the possibility of a program of research relating these present findings to results obtained with some operant procedures. Positive discriminative stimuli (S^D's) of comparable duration are regularly employed in operant procedures with incidental key-light-food correlations (such as successive discrimination and stimulus chaining procedures).

Another variable that is closely related to the duration parameter is the number of discrete stimulus components that make up the CS. Presumably if the CS were a fixed sequence of events instead of a single stimulus it might act as an external timing device for the subjects allowing a more accurate estimation of the time of US onset. Accordingly, groups were presented with either one stimulus for the entire CS period, or a sequence of four stimuli, each present during one quarter of the total CS.

METHOD

Subjects

Sixteen experimentally naive White King Pigeons, obtained from a local supplier, were maintained at 75% of their free feeding weight by daily sessions in the apparatus and when necessary, by supplementary feeding in their home cages. The colony room was kept under constant light conditions. One other subject died on the third day of the experiment and was replaced.

Apparatus

Two identical test chambers (Grason-Stadler, E6446CA) were each equipped with a transparent response key 12.5 cm above a solenoid actuated food magazine. Each had a 10-w lamp mounted above the magazine which illuminated the opening on every US presentation; and a 10-w lamp mounted on the far right of the panel, at approximately the same height as the response key, which provided general illumination at all times except during magazine presentation. Any of four colored stimuli (red, blue, green, or yellow) from a Multiple Stimulus projector (Grason-Stadler, #45801) could be presented on the key. A relay mounted inside the chamber provided auditory feedback whenever a response was made in the presence of the CS but not during the inter-trial intervals.

White noise, which ranged between 62 and 78 decibels inside the test chambers (as measured on the A scale of a General Radio Co. sound level meter), partially masked extraneous noise. In an adjacent room, relay operated switching circuits, steppers, and clocks controlled both boxes;

counters and print-out counters recorded responses from each box. With this arrangement two birds could be run simultaneously, presumably without cues from the adjacent box or control room.

Procedure

The subjects, after being randomly divided into four groups, were all given magazine training. The experimenter held the deprived bird over the raised and filled magazine until the animal began to eat. He then carefully released the bird while the subject was still eating and closed the experimental chamber. After the pigeon had eaten for about 30 sec, the experimenter lowered the magazine and then quickly raised it again. Then, by presenting successively shorter periods of grain access at successively longer intervals of time, the birds were trained to eat from the grain magazine within a four sec period. This entire process took between 5 and 15 presentations. Special care was taken to avoid shaping the birds to key peck. To further assure that the birds would continue to eat, the first five magazine presentations in the first conditioning session were of 10 sec duration and the next five of 8 sec duration. All subsequent magazine presentations were 4 sec long. Immediately after magazine training the birds were given the first 30 conditioning trials.

The conditioning trials consisted of two phases. The four treatment groups and the main features of the first phase are summarized in Table 1. This phase of the experiment was a simple 2x2 design. Two groups were run with a 120 sec total CS duration. Gr 120: 1-4 was presented a single 120 sec stimulus on each trial. Gr 120: 4-1 was presented four differently

TABLE 1

Summary of Procedure

Group Name	Procedure					
	Phase 1			Phase 2		
	CS Duration		# of	CS Duration		# of
	total	component	components	total	component	components
Gr30:4-1	30 sec	7.5 sec	4	30 sec	30 sec	1
Gr30:1-4	30	30	1	30	7.5	4
Gr120:4-1	120	30	4	120	120	1
Gr120:1-4	120	120	1	120	30	4

colored stimuli of 30 sec duration in sequence on every trial. Two other groups were run with a 30 sec total stimulus duration. Gr 30:1-4 had only one color presented for the entire 30 seconds; Gr 30:4-1 had four 7.5 sec colored stimuli presented in sequence on every trial. The orders of stimulus presentation used for the four stimulus groups were ABCD, DCBA, BDAC, and CADB (A=yellow, B=green, C=red, D=blue), with one subject in each group having one of the orders. One subject in each single stimulus group had each of the four colors.

All subjects were run 30 trials a day for 20 consecutive days with inter-trial intervals of four minutes. The magazine was always presented at the offset of the CS. Pecking in no way influenced either the duration of stimuli, or onset of magazine presentation. The only effect of pecking was to produce the relay click during the CS periods.

At the conclusion of the first phase, subjects were then run for an additional 16 days in a second phase. During this procedure the subjects received a CS of the same duration as in Phase 1 but were presented with the alternative number of stimulus components; i.e. the four component groups were now presented with a single stimulus for the entire CS duration and vice versa. Stimuli that had been used as the single stimulus in the first phase now became the lead off stimuli for the four component sequence in the second phase. Analogously the lead off stimulus in the first phase became the single stimulus used in the second phase; e.g. subjects that received single stimulus D in the first phase received the sequence DCBA in the second phase, and subjects that received the sequence BDAC in the first phase received the single stimulus B in the second phase.

All other details of the second phase were identical to the first phase. The first number in all group names refers to the Total CS duration, the second to the number of components in the first phase, and the third to the number of components in the second phase.

Keypecking responses were recorded during each 1/4 of the CS and during the inter-trial intervals.

RESULTS

Figure 1 presents rates of responding during the CS on each day separately for each group. Each point represents mean responses per second plotted as a function of a day of training. All groups achieved rates of one response every three seconds or higher during the CS on several days in both phases.

Cursory inspection of this figure would seem to indicate that there were differences in mean rate between groups. The mean rate of pecking was greater for Gr 30:4-1 than any other group each day except for the first day of Phase 2. Although there are obvious differences in group rates for the first several days of Phase 1 (where Gr 120:1-4 had essentially a zero rate) these differences were not maintained throughout the entire experiment. Differences in the mean rates of pecking for the last five days of Phase 1 (presumably close to asymptotic performance) do not approach statistical significance ($F(3,12) = .69$).

Differences in rates of responding between groups during the initial portion of the experiment can be attributed to differences in the trial number on which responding was initiated. A two-tailed Mann-Whitney U-test (1947) was used to determine if differences between the trial number of the first, fifth, and tenth pecks of subjects receiving either the 30 or 120 second CS were statistically significant. Although differences in the trial number of the first peck were not, ($U(8,8) = 29$, $p < .40$), both differences in the trial number of the fifth peck ($U(8,8) = 11$, $p < .028$) and the trial number of the tenth peck ($U(8,8) = 5$, $p < .002$)

Figure Caption

Fig. 1. Mean rates of responding during the CS for each group.

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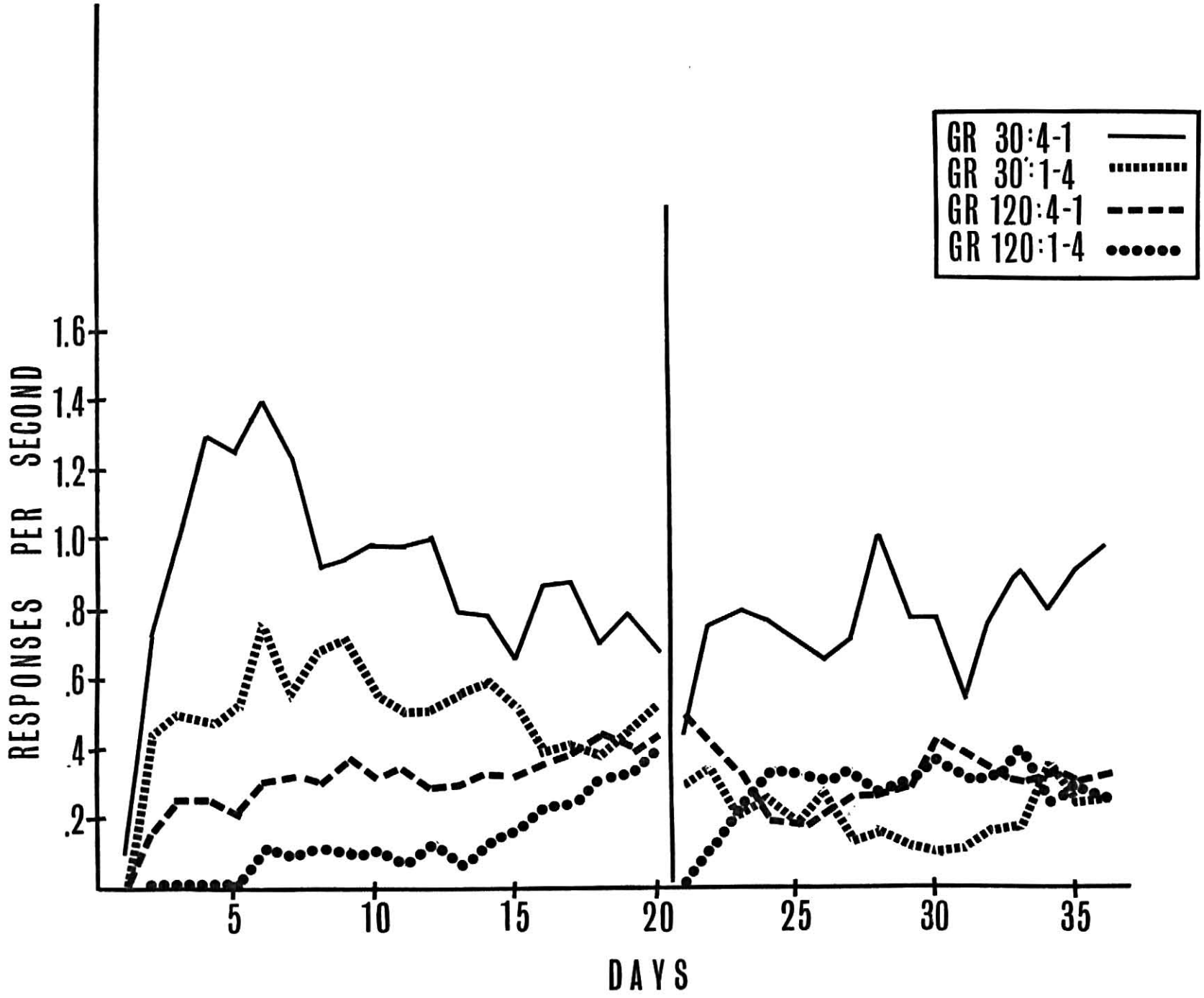

GR 30:4-1
GR 30:1-4
GR 120:4-1
GR 120:1-4
RESPONSES PER SECOND
1.6
1.4
1.2
1.0
.8
.6
.4
.2
5
10
15
20
25
30
35
DAYS

were statistically significant. The trial numbers of the fifth and tenth pecks were lower in the two 30 second CS conditions than in the two 120 second CS conditions.

There were no clear effects of number of components on the initiation of responding (first peck U (8,8) = 21, $p < .14$; fifth peck U (8,8) = 14.5, $p < .04$; tenth peck U (8,8) = 20, $p < .12$). In each case, however, the four-component mean trial number was numerically lower for both the 30 and 120 second CS conditions.

Response rates for individual subjects are presented in the next four figures. Figure 2 presents the rates in responses per second during the CS for individuals in Gr 30:4-1. Figures 3, 4, and 5 present these rates for individuals in Gr 30:1-4, Gr 120:4-1, and Gr 120:1-4, respectively. Inspection of these figures indicates that all subjects acquired the keypecking response to the CS. In addition it can be seen that there was considerable overlap in the response rates of individual subjects from one group to another. All but two subjects achieved a response rate of at least 0.10 responses per second during Phase 1. These two birds, both in Gr 120:1-4, had the lowest rates for all subjects in Phase 1, but both of these subjects increased their rates of responding during Phase 2. All subjects, except A-13, pecked during the CS at a rate of 0.30 responses per second or better on at least one day of the experiment. Unanalyzed data on individual subjects are presented in the Appendix.

Data on response rates during the inter-trial intervals are summarized in Figure 6. In this figure mean rate during the inter-trial intervals is plotted for each group in responses per second as a function of day of training. It should be noted that in Figure 6, the ordinate had

Figure Caption

Fig. 2 Rates of responding during the CS for the four subjects in Gr30:4-1.

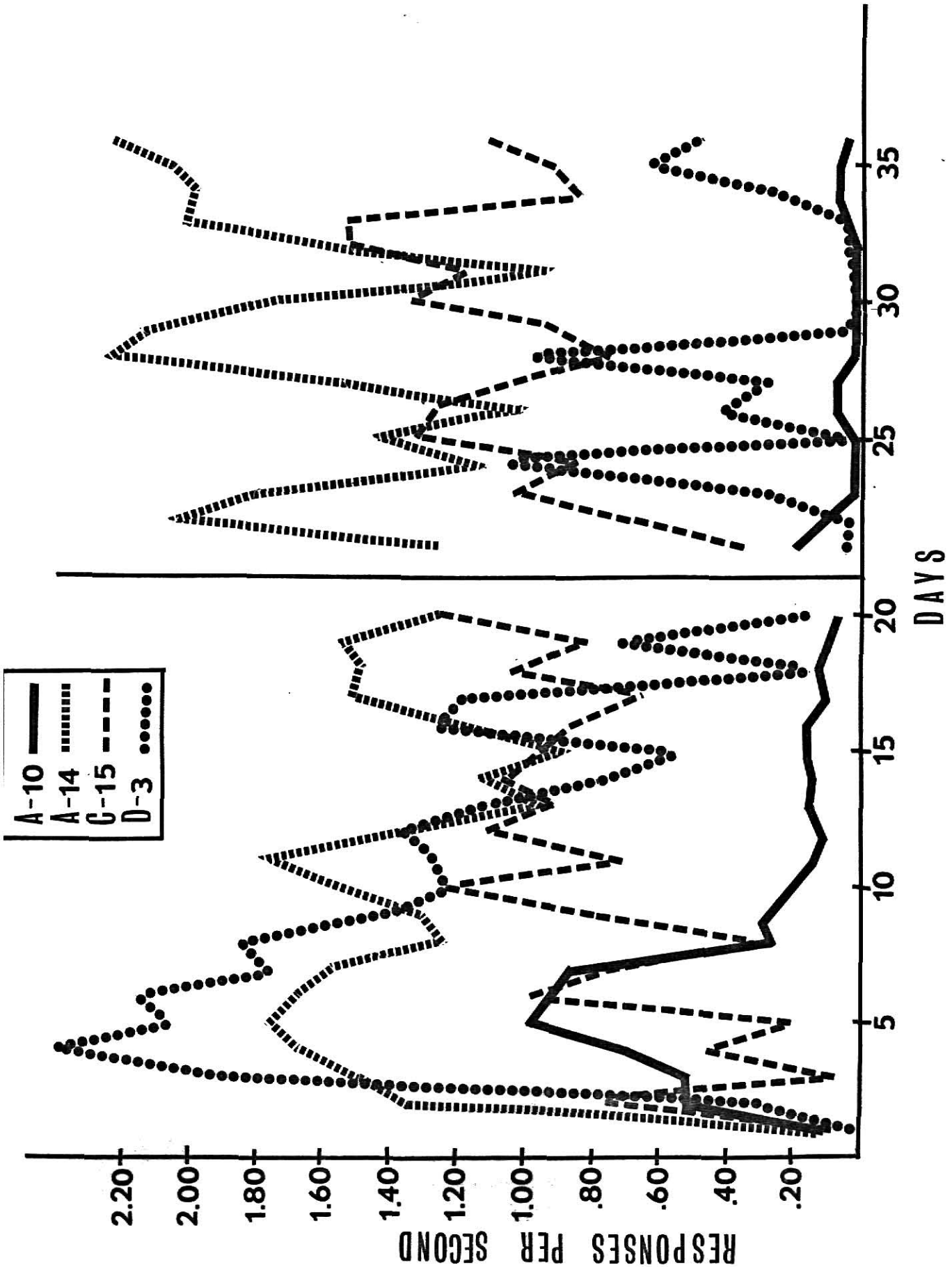

A-10
A-14
C-15
D-3
RESPONSES PER SECOND
2.20
2.00
1.80
1.60
1.40
1.20
1.00
.80
.60
.40
.20
5
10
15
20
25
30
35
DAYS

Figure Caption

Fig. 3. Rates of responding during the CS for the four subjects in Gr30:1-4.

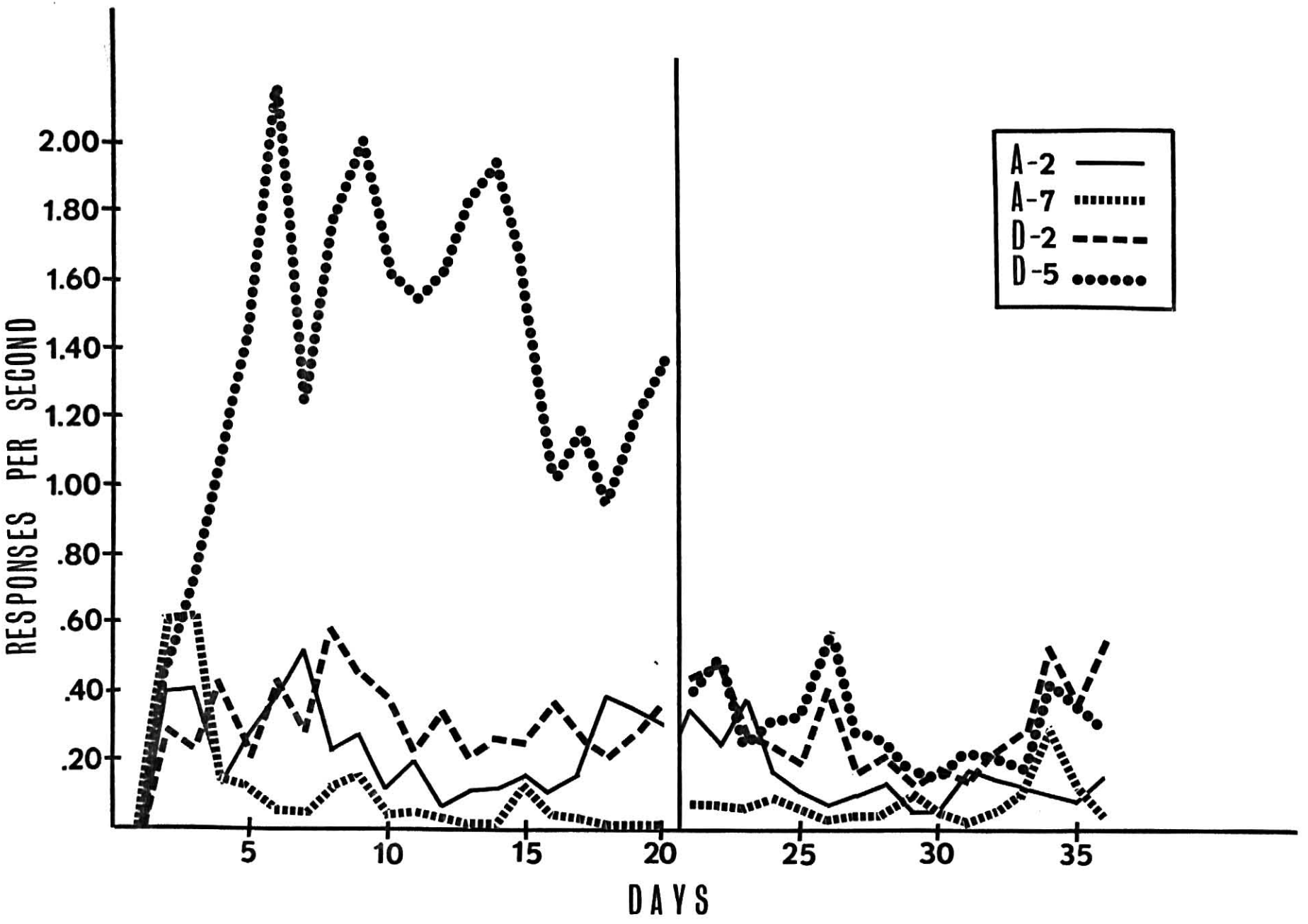

RESPONSES PER SECOND
2.00
1.80
1.60
1.40
1.20
1.00
.80
.60
.40
.20
5
10
15
20
25
30
35
DAYS
A-2
A-7
D-2
D-5

Figure Caption

Fig. 4. Rates of responding during the CS for the four subjects in Grl20:4-1.

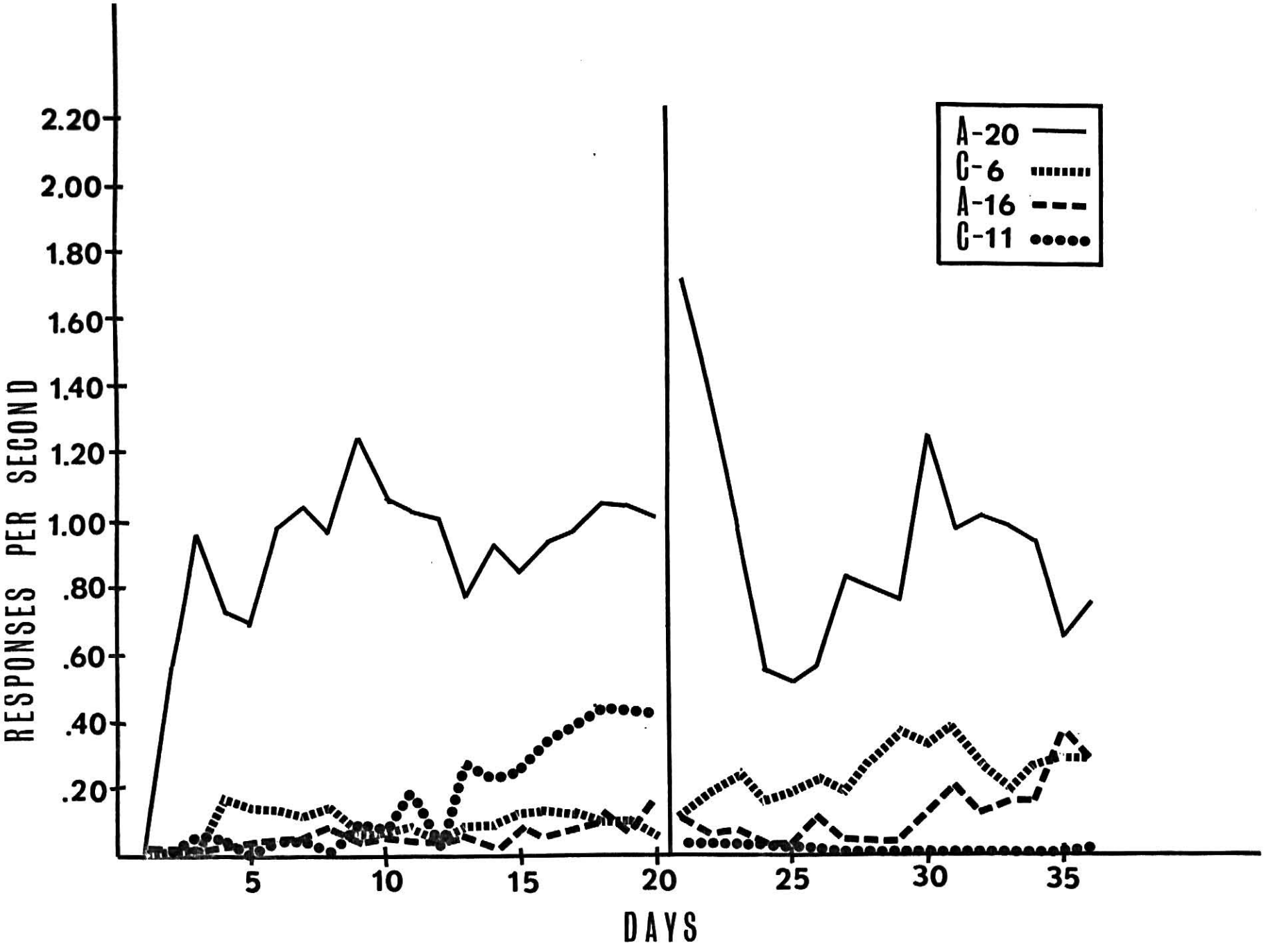

A-20
C-6
A-16
C-11
RESPONSES PER SECOND
2.20
2.00
1.80
1.60
1.40
1.20
1.00
.80
.60
.40
.20
5
10
15
20
25
30
35
DAYS

Figure Caption

Fig. 5. Rates of responding during the CS for the four subjects in Gr120:1-4.

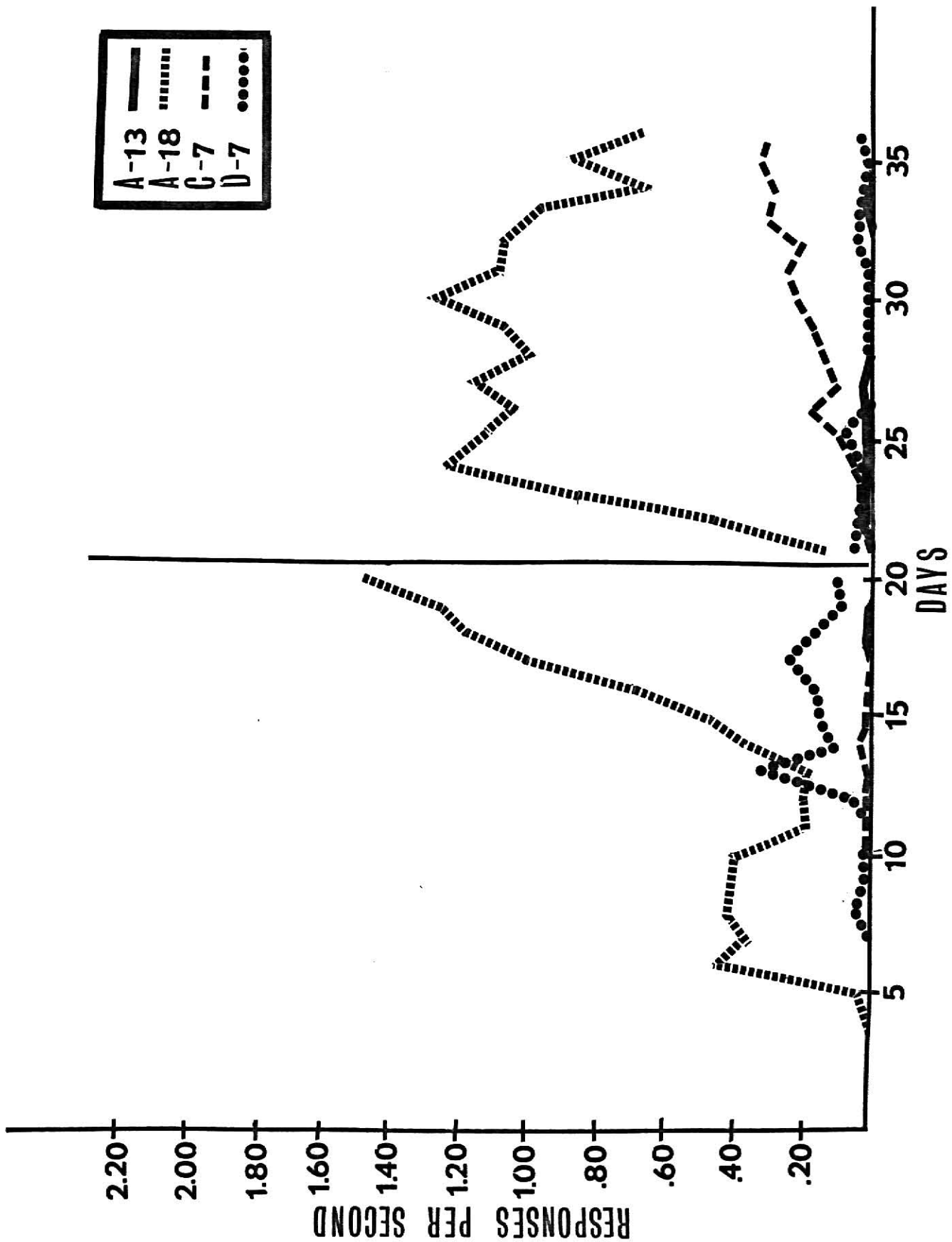
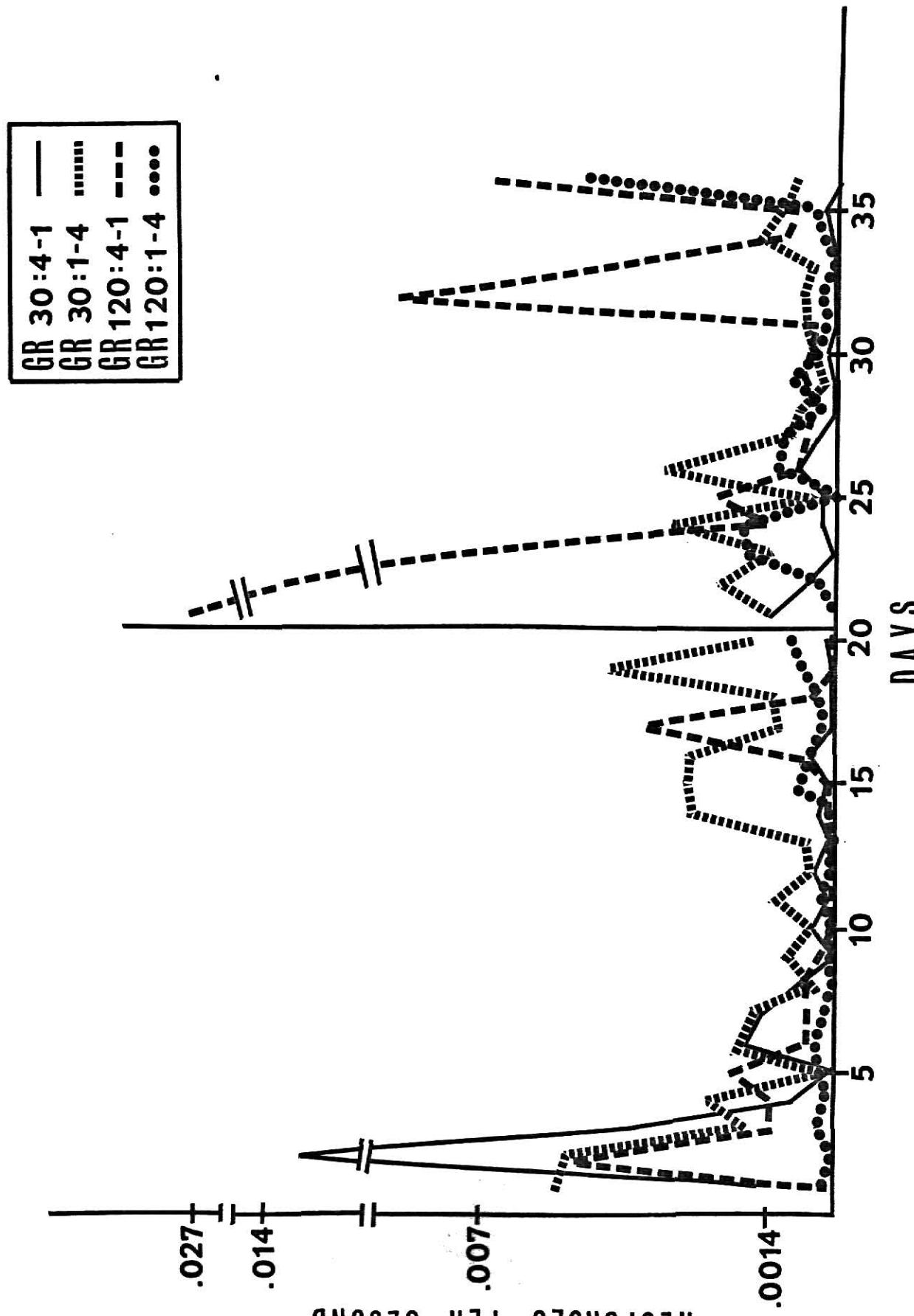

A-13
A-18
C-7
D-7
RESPONSES PER SECOND
2.20
2.00
1.80
1.60
1.40
1.20
1.00
.80
.60
.40
.20
5
10
15
20
25
30
35
DAYS

Figure Caption

Fig. 6. Mean rates of responding during the inter-trial interval for each group.


GR 30:4-1
GR 30:1-4
GR120:4-1
GR120:1-4
RESPONSES PER SECOND
.027
.014
.007
.0014
5
10
15
20
25
30
35
DAYS

been expanded to a maximum of 0.027 responses per second rather than the maximum of 2.40 of Figures 1-5. Rates after the fourth day of training were nearly always below 0.0014 responses per second for all groups. Exceptions were for the most part due to individual subjects' temporary increases in responding on a small portion of inter-trial periods. Clearly responding during the inter-trial intervals was low in all groups.

A comparison of rate during the inter-trial intervals with rate during the CS is shown in Figure 7. In this figure the mean ratio of the rate of responding during the inter-trial intervals over the rate during the CS periods is plotted separately for each group on a log scale across days of training. Each point was obtained by calculating a ratio of rate for each subject and then determining the mean ratio for each group. There was no overlap in rate of pecking during the inter-trial intervals and rate during the CS periods for any subject on any day after the second day's training. After the sixth day of training the ratios of response rates are usually less than 1:100 and in only one case larger than 1:20.

Figure 8 presents separately for each group the mean number of CS presentations during which there was at least one peck on each day of the experiment. Number of trials up to a possible maximum of 30 per day are plotted as a function of days of training. During Phase 1 the two 30 sec groups approximated asymptotic performance on this measure after the first day, while Gr 120:4-1 took four days to reach a comparable level. These three groups pecked on more than two-thirds of the trials for the remainder of the experiment (excepting two days in Phase 2 for Gr 30:4-1). The lower means in Phase 1 for Gr 120:1-4 are due almost entirely to the

Figure Caption

Fig. 7. Mean ratios of rate of responding during the inter-trial intervals over the rate of responding during the CS for each group on a logarithmic scale.

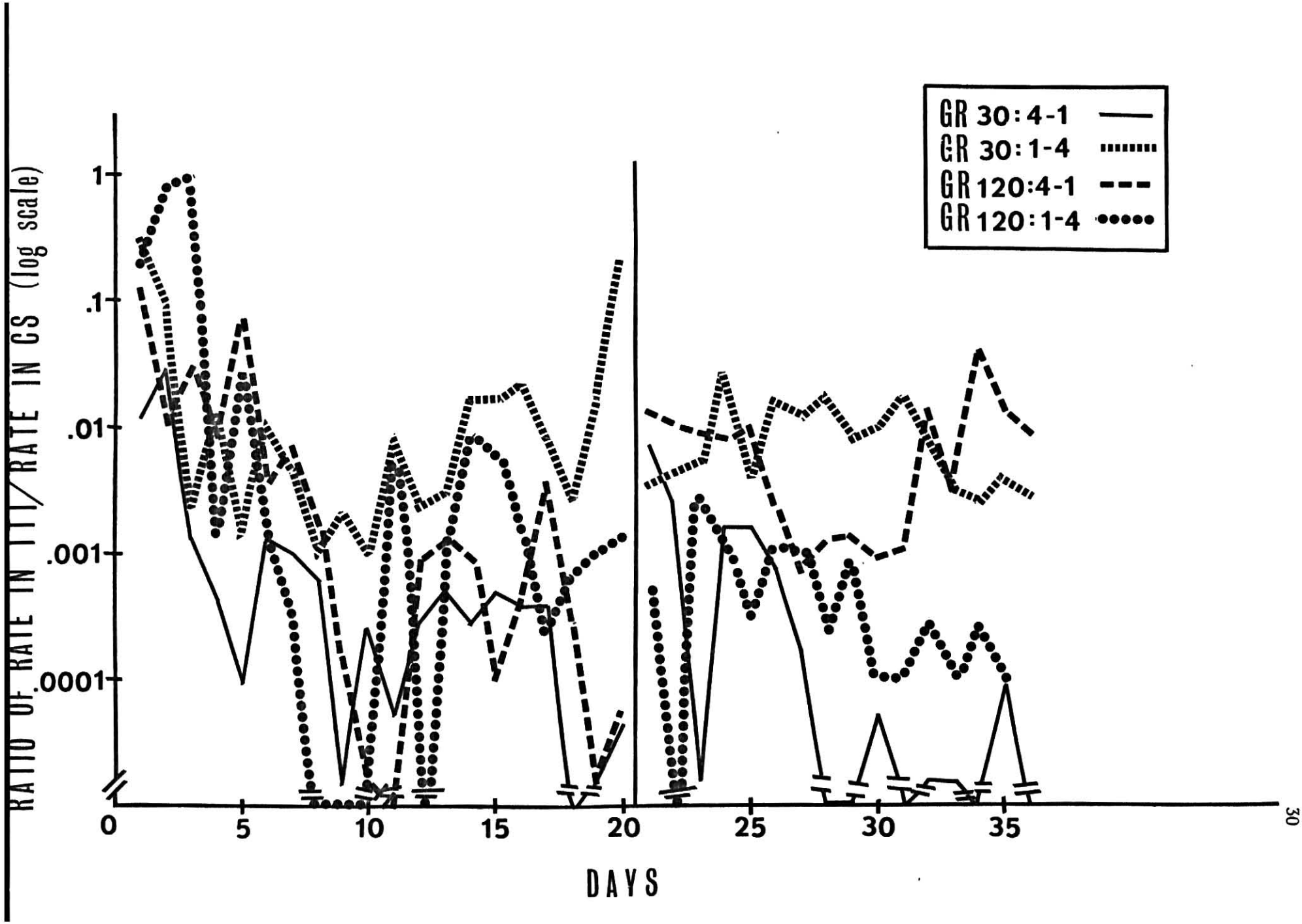
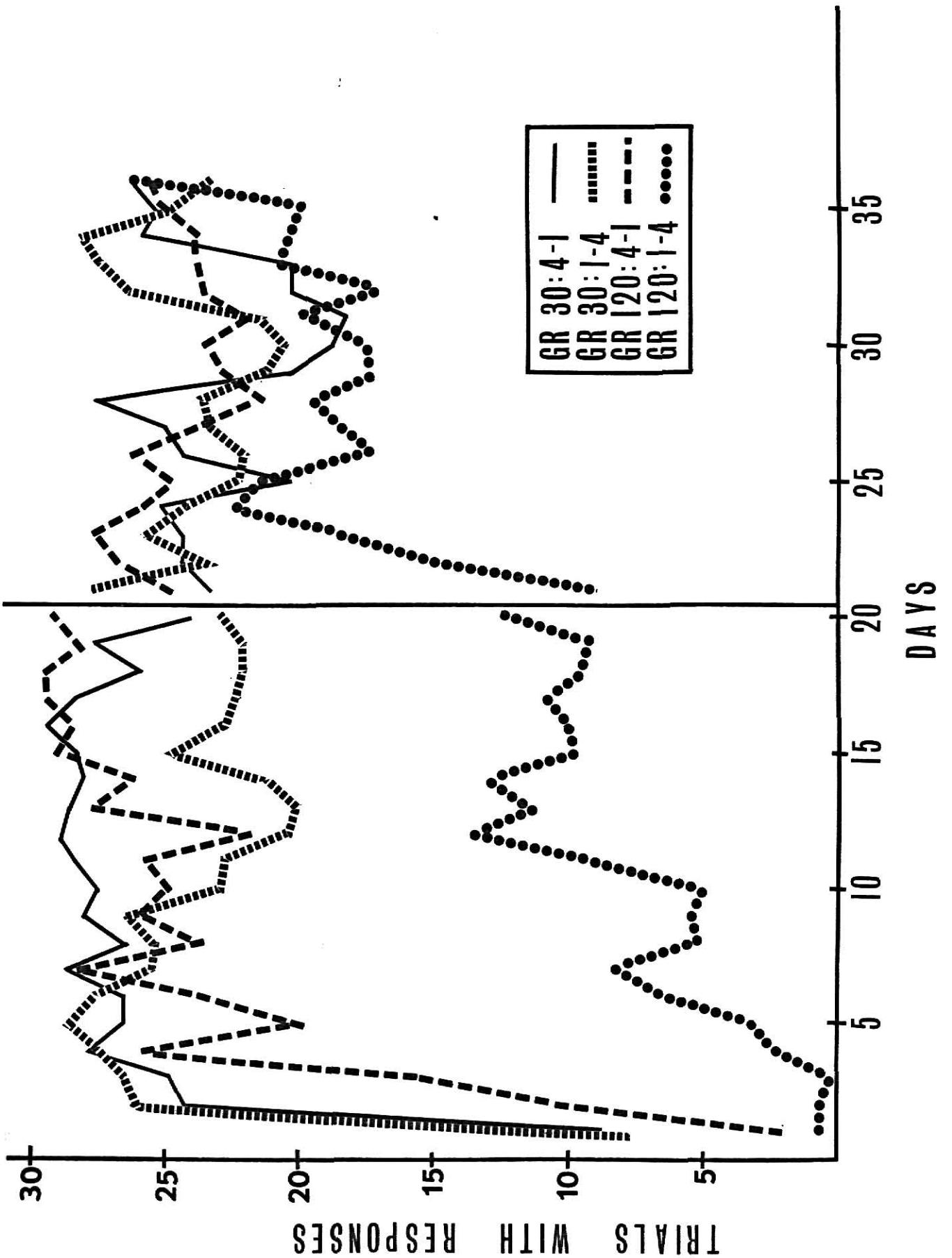

GR 30:4-1
GR 30:1-4
GR 120:4-1
GR 120:1-4
RATIO OF RATE IN ITI/RATE IN CS (log scale)
1
.1
.01
.001
.0001
0
5
10
15
20
25
30
35
DAYS

Figure Caption

Fig. 8. Mean number of CS presentations during which there was at least one peck for each group.


GR 30:4-1
GR 30:1-4
GR 120:4-1
GR 120:1-4
TRIALS WITH RESPONSES
DAYS
5
10
15
20
25
30
35

performance of two low responders in that group. During Phase 2 the performance of this latter group was more in line with the performance of the former three. The data presented in this figure clearly show the degree of consistency with which the subjects were pecking even though there were variations in individual rates of responding.

Figure 9 presents separately for each group the mean number of inter-trial intervals during which there was at least one peck. Although there were a total of 29 inter-trial intervals every day (excluding the 20 or so seconds the subjects were in the apparatus before the onset of the first CS period of the day) the ordinate of this figure has been expanded to a maximum of 10 inter-trial intervals, in contrast to the 30 CS periods shown in Figure 8. For every subject on every day after the second day of training, the number of inter-trial intervals during which there were pecks was always less than the number of CS periods with pecks even though the inter-trial intervals were two or eight times as long as the CS periods for the 120 and 30 second groups respectively.

The distributions of responses within the CS are presented in Figures 10 through 13. In these figures days are plotted along the abcissa and the ordinate represents the mean percent of total responding. Each subject's daily responses were counted separately during four equal time intervals each corresponding to one quarter of the CS. Percent responding in each quarter was calculated for each subject and then mean percent was calculated for the four subjects in each group. Each curve in these figures represents the mean percent of the responding during successive quarters of the CS and are labled from I to IV in order of distance from the CS. Under four-component conditions these intervals correspond to the

Figure Caption

Fig. 9. Mean number of inter-trial intervals during which there was at least one peck for each group.

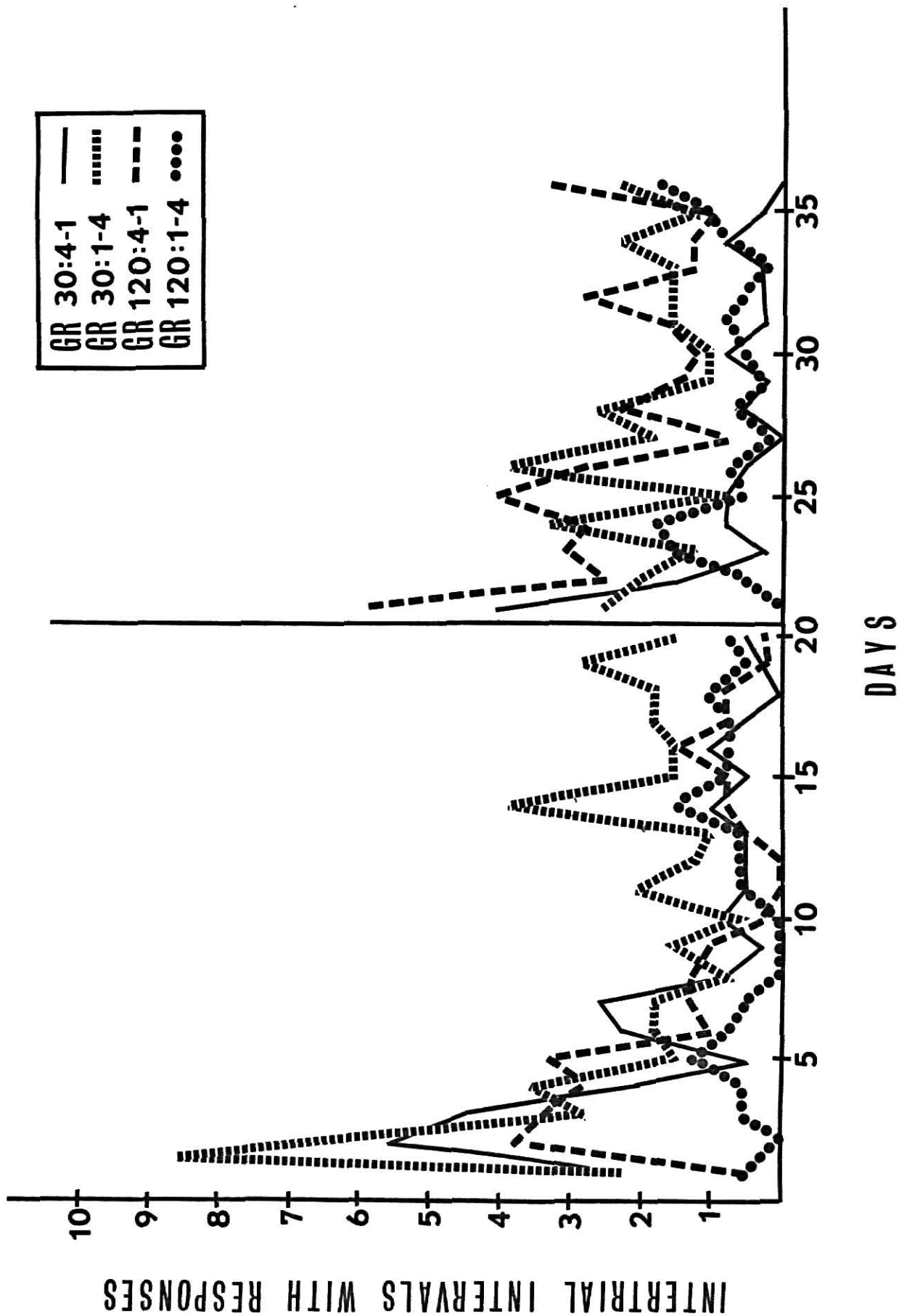

GR 30:4-1
GR 30:1-4
GR 120:4-1
GR 120:1-4
INTERTRIAL INTERVALS WITH RESPONSES
DAYS
1
2
3
4
5
6
7
8
9
10
5
10
15
20
25
30
35

Figure Caption

Fig. 10. Mean percent of responding in each quarter of the CS period for Gr30:4-1.

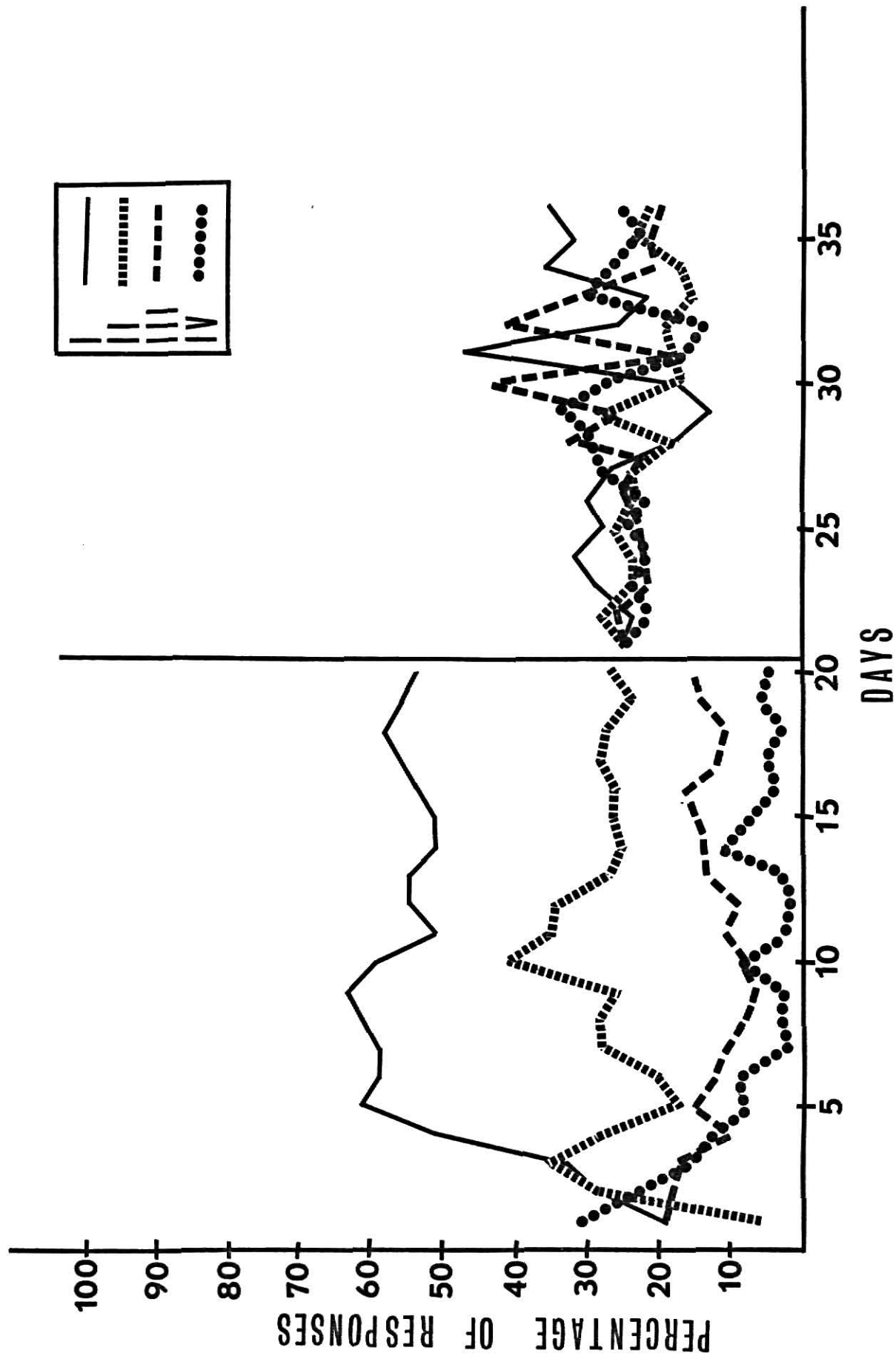

PERCENTAGE OF RESPONSES
100
90
80
70
60
50
40
30
20
10
5
10
15
20
25
30
35
DAYS
I
II
III
IV

Figure Caption

Fig. 11. Mean percent of responding in each quarter of the CS period for Gr30:1-4.

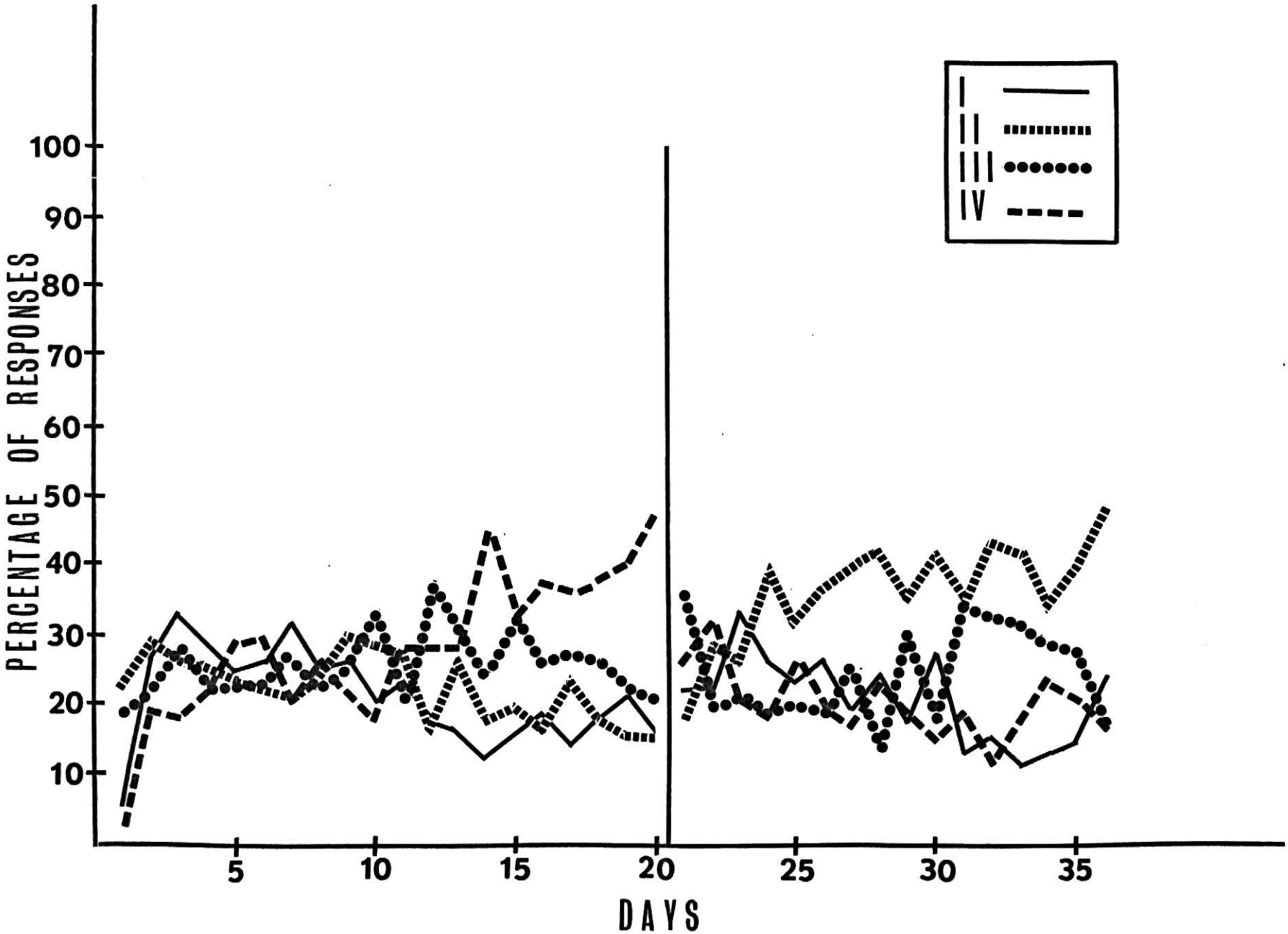

I
II
III
IV
100
90
80
70
60
50
40
30
20
10
PERCENTAGE OF RESPONSES
5
10
15
20
25
30
35
DAYS

Figure Caption

Fig. 12. Mean percent of responding in each quarter of the CS period for Grl20:4-1.

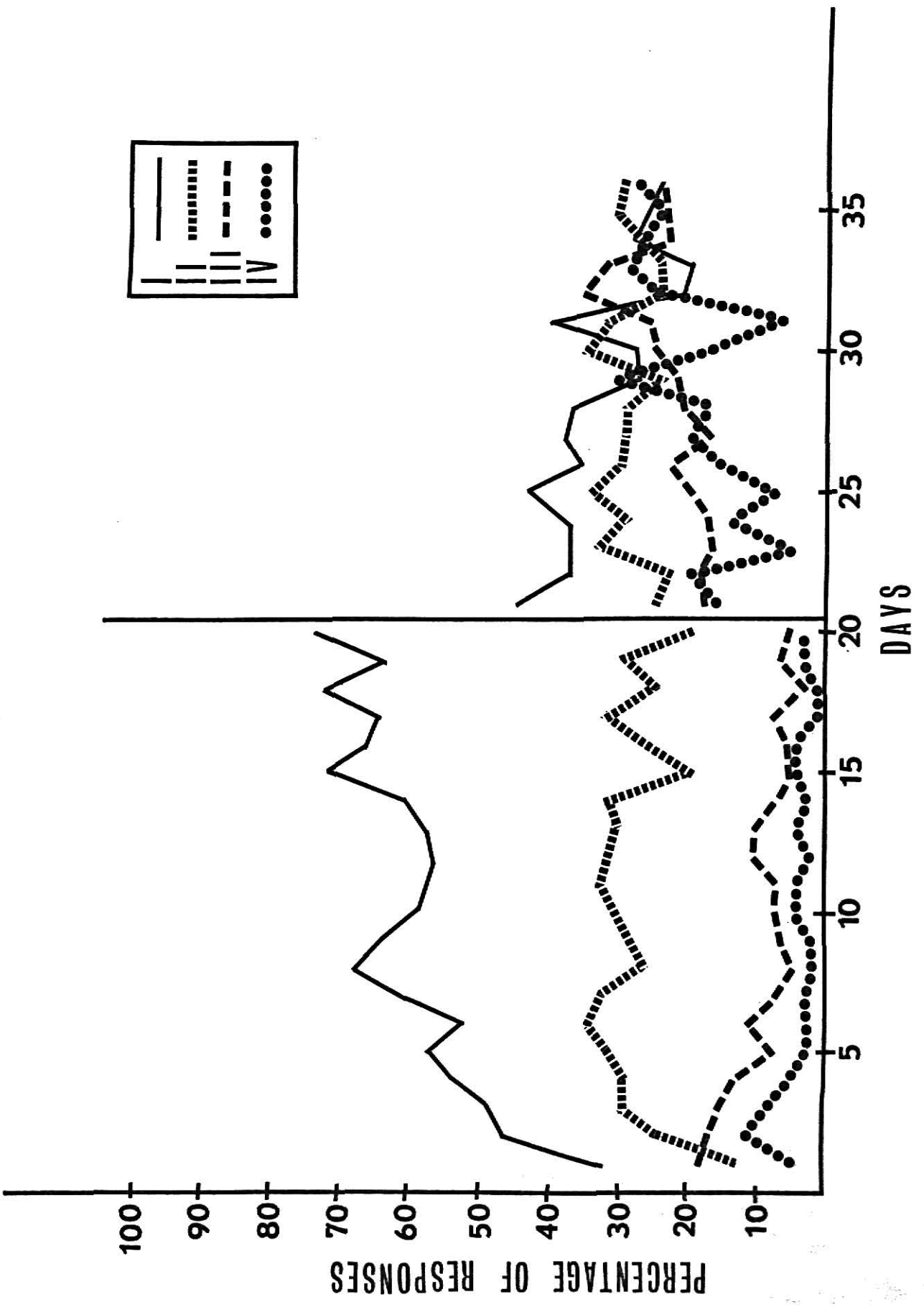
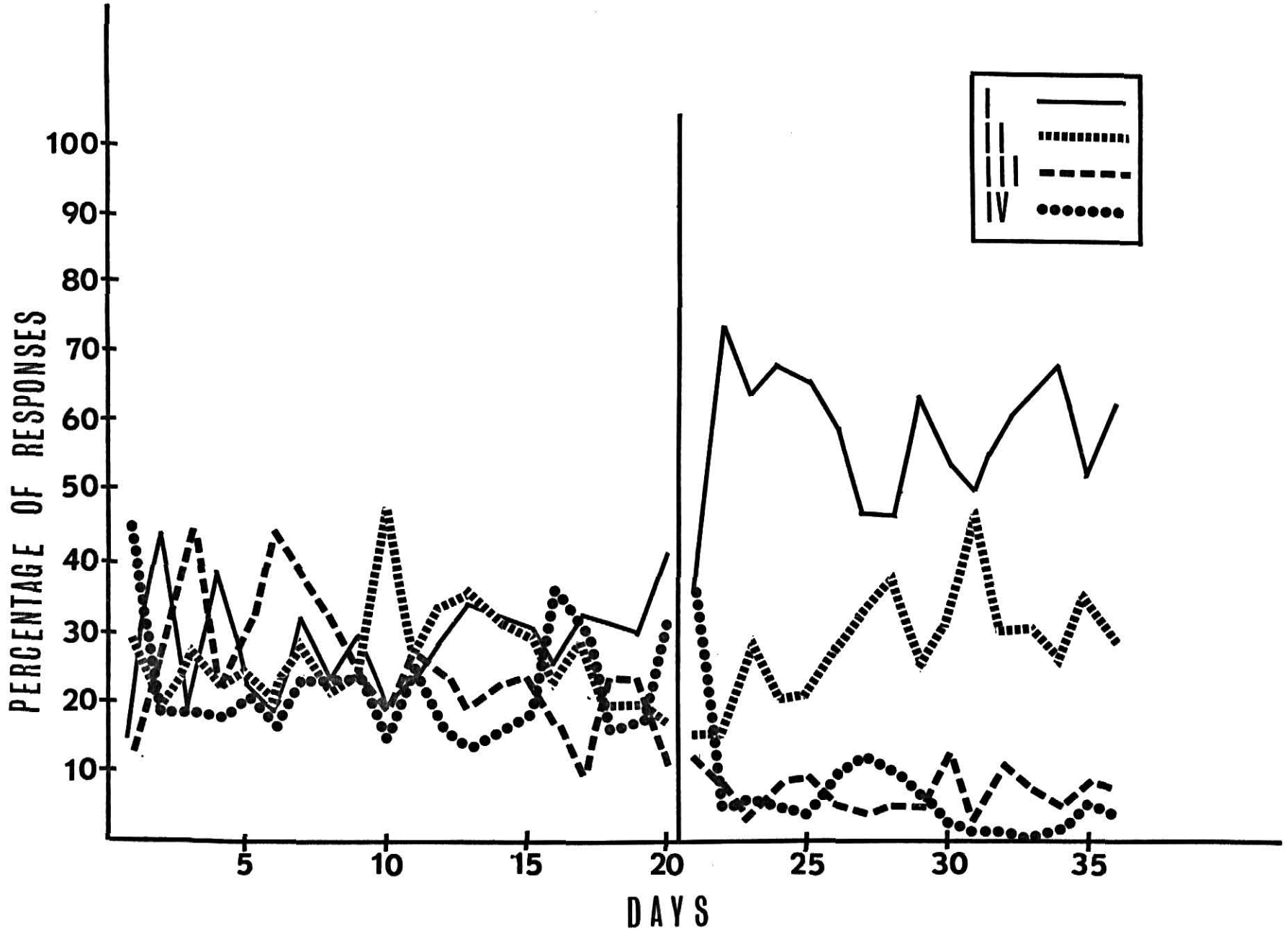

PERCENTAGE OF RESPONSES
100
90
80
70
60
50
40
30
20
10
5
10
15
20
25
30
35
DAYS
I
II
III
IV

Figure Caption

Fig. 13. Mean percent of responding in each quarter of the CS period for Gr120:1-4.


I
II
III
IV
100
90
80
70
60
50
40
30
20
10
PERCENTAGE OF RESPONSES
5
10
15
20
25
30
35
DAYS

length of time each colored component stimulus was present, and under the one-component conditions these intervals simply divide the CS into four equal parts. For example, in Figure 10 curve I represents the mean percent of responding in the 7.5 seconds just prior to magazine presentation for Gr 30:4-1. Curve IV in the same figure represents the mean percent of responding for the group in the first 7.5 seconds after CS onset.

Figures 11, 12, and 13 present the comparable data for Gr 30:1-4, Gr 120:4-1, and Gr 120:1-4 respectively. All points in Figures 10-12 are based on the four birds in each group. For Figure 13 the first phase results are based only on the performance of two birds, D-7 and A-18. The other two birds, C-7 and A-13, responded on only eight and two days respectively in the first phase. Both of these latter two birds responded on all days in the second phase and thus the second phase results plotted are for all four birds.

Figures 10 and 12 show response distributions for the groups with four-component CS's initially. In these figures the Phase 1 results are distributed in an ordered fashion with the greatest number of pecks occurring in the interval just prior to magazine onset (I) and the smallest number of pecks occurring in the interval furthest away from magazine onset (IV). Every subject in Gr 30:4-1 showed this exact order on at least 15 of the 20 days in Phase 1; that is to say this group effect is also obtained for each individual subject. In Gr 120:4-1 two birds, C-11 and A-20, showed this exact ordering on at least 17 of the 20 days, while another subject (A-16) showed this ordering on each of the last four days of the first phase and on four other days within that phase. The other bird in this group (C-6) showed a tendency to make more pecks as the time

of magazine onset approached during Phase 1 at least to the extent that only 10% of the last five days' responding was made in the component furthest from magazine presentation.

Figures 11 and 13 present the distribution data under conditions where a single component constituted the CS on the first phase. Although individual subjects were fairly consistent in the manner in which their pecks were distributed from day to day there were no clear group trends in response distributions.

The second phase results show once again responses distributed in an ordered fashion with the greatest amount of pecking occurring during the interval just prior to magazine onset (I) for Gr 120:1-4 (Figure 13). Two of the subjects in this group showed this exact order on at least 10 out of the 16 days in Phase 2. The other birds in this group (A-18 and D-7) showed a tendency towards increased rate as US presentation approached, at least to the extent that only 10% of each of the last five days responding was distributed in the two components furthest from magazine presentation.

Gr 30:1-4 (Figure 11) was the only group where the four-component condition failed to produce an ordering of response distributions over the CS period at any time in the experiment. No group trends were apparent for this group.

The second phase one-component conditions, Gr 30:4-1 and Gr 120:4-1 shown in Figures 10 and 12, yielded results similar to the initial one-component conditions. There were no apparent group trends in either group over the four quarters of CS duration during this second phase.

DISCUSSION

The results of this study show that stimuli which precede presentations of food by up to two minutes are effective in eliciting and maintaining classically conditioned keypecking.

Virtually all investigators of this phenomenon have indicated that classically conditioned keypecking has implications for operant research. The response of keypecking has long been used as a prime exemplar of an operant response. However, if keypecking can be produced by a classical conditioning procedure, its appropriateness as an operant is somewhat questionable.

Williams and Williams (1969) have suggested that classically conditioned keypecking might affect the "operant level" of instrumental keypecking. It seems rather unlikely, however, that the operant level would be raised by a constant number of pecks distributed evenly throughout the experimental session and that there would be no further interactions between operant and classically conditioned keypecking. In the present experiment, as in previous experiments, pecking occurred in substantial rates only during the CS and not during the inter-trial intervals. Changes in rate during the CS when four sequential stimuli were used imply at least a different operant level during different components of the CS. If the operant level of the instrumental keypeck is affected by the classical conditioning of the same response, then it is being differentially affected throughout the experimental session and is not simply an overall increase in rate.

Whenever there are incidental key light-food pairings in an operant procedure using pigeon subjects, there should also be some classically conditioned keypecking tendency. Gamzu and Williams (1971) have shown that this is true even if the extent of the "pairing" is simply differential probability of food presentation. The present experiment demonstrates that conditioned stimuli which precede food presentations by as much as two minutes produce classically conditioned keypecking. Considering these findings it seems probable that the results of such instrumental procedures as successive discrimination are contaminated by classically conditioned keypecking tendencies. Successive discrimination procedures regularly employ S^D's and S^Δ's of about the same duration as the CS's used in the present experiment. Behavioral contrast (see Reynolds, 1961) which is often observed in successive discrimination procedures might be due, to some extent, to the addition of a classically conditioned keypecking tendency during the S^D.

The chaining of fixed-interval (FI) schedules with terminal reinforcement is an example of another instrumental procedure in which stimuli are incidentally paired with food presentations (i.e. one stimulus always precedes "food presentation," the others always precede "no food presentations.") An effect often obtained with this procedure is that pigeons fail to maintain pecking on the initial components of longer chains (see Gollub, 1958). The procedure employed with the four-component groups in the present study (with the addition of an inter-trial interval) mimics FI chaining, and here, as in the operant procedure, few responses are emitted during the initial component of the sequence. It is conceivable that both effects are due to classically conditioned inhibition of

keypecking when a period free of food presentations is signaled by the stimuli present on the key, i.e. the initial components of the chain or sequential CS.

A third area of operant research that seems to be contaminated by classically conditioned keypecking is the differential reinforcement of low rates of responding (DRL). Hemmes (1970) has pointed out that pigeons on a DRL schedule perform rather poorly if keypecking is the response employed. On the other hand, with the treadle-press response performance is much better. Reynolds (1966) attributed the pigeons' poor performance on DRL to their "inability to inhibit keypecks." The Williams and Williams (1969) procedure yields results rather similar to DRL studies in that their subjects pecked even though pecking would prevent the presentation of food.

Because of the stimulus contingent nature of the present procedure it is obvious that these data have implications for various interpretations of the classical conditioning process. The term classical conditioning as it has been used here refers to a procedure (two stimuli presented in a temporal relationship) rather than to some neurophysiological processes or events. The results obtained when this procedure is used with pigeons in an operant chamber are not typical of the results obtained with other stimuli and other species.

It has already been pointed out that keypecking, unlike most classically conditionable responses, can easily come under the control of operant manipulations (Gamzu and Williams, 1971). The fact that keypecking is a skeletal rather than an autonomic response would also make it an unusual candidate for classical conditioning.

In the more typical case of classical conditioning the nature of the

conditioned response is not so noticeably affected by the particular conditioned stimulus employed. Since in this case responding is directed at the CS, a localized (i.e. "peckable") stimulus is presumably necessary for the effect.

Bitterman (1965) reported the classical conditioning of activity in pigeons with a procedure nearly identical to the present one in all respects except that the CS was termination of a houselight and the turning on of a buzzer. If the CS-US interval were long enough (10 sec) there was a reliable increase in the activity of the birds during the CS. This suggests that classically conditioned keypecking is tapping a more generalized response on the part of pigeons, just as salivation can be considered a measure of a general preparedness to receive food for dogs.

More recently Staddon and Simmelhag (1971) reported the results of an experiment in which food was presented to pigeons at 12-second intervals on a response-independent fixed-interval schedule. Their procedure can be thought of as classical conditioning with a temporal CS. The rather surprising result of their study was that the pigeons were very similar in their behavior. During the last few seconds of the 12-second interval their subjects were invariably pecking somewhere along the magazine wall (a response key was not available to peck). This particular type schedule has been employed in developing "superstitious" behavior (see Skinner, 1948). Its relationship to the present procedure is obvious. Although the development of superstition is a possible explanation of Staddon and Simmelhag's results the rather striking similarity of the "terminal response" in all their subjects is suggestive of a process other than

superstition. These results seem to fit more closely into the classical conditioning frame of reference used in this paper and by Bitterman (1965).

There are several ways of measuring the strength of a conditioned response; these are more or less related to the particular response being measured. Classically conditioned keypecking is generally described in terms of number of pecks; this measure is quite comparable to Pavlov's use of number of saliva drops. Percent CR is often employed in studies where the CR is a discrete response (e.g. eyelid conditioning); in this paper the number of CS periods during which there was a response was given. A third type of measure employed here gave the ratio of rate during the inter-trial interval to rate during the CS; this could be described as an "excitation ratio" making clear the relationship to the measure generally employed in studies of conditioned suppression (e.g. Hoffman, 1969).

Classically conditioned keypecking is easily obtained under stimulus conditions where most conditioned responses would not occur. It seems rather inappropriate to speak of an optimal CS-US interval (usually given at .5 sec) if reliable conditioning occurs with stimuli that are minutes in duration.

Consider also the fact that classically conditioned keypecking occurs throughout the CS-US interval (if a single color is used). In eyelid conditioning (which can also be described in terms of rate) the typical finding in delay conditioning procedures is for the blink to occur at the end of the interval, just prior to the onset of the US (Boneau, 1958). In salivary conditioning the CR often occurs simultaneously with the onset of

the US (Sheffield, 1965). Conditioned suppression (Estes and Skinner, 1941) is perhaps the only other classically conditioned response that occurs throughout the CS period, as does classically conditioned key-pecking. It would be interesting to see if sequential stimuli used as the CS would affect conditioned suppression in the same way as they affect classically conditioned keypecking, but to the writer's knowledge the use of sequential stimuli in conditioned suppression has not been reported.

APPENDIX

Subject A-10 Gr 30:4-1

Day	IV	Pecks During CS Quarter III	II	I	# of Trials with Pecks	Pecks during ITI	# of ITI's with Pecks
1	4	37	31	41	10	0	0
2	67	85	67	248	27	4	2
3	72	81	138	185	28	3	2
4	26	50	167	380	30	1	1
5	34	26	204	618	29	0	0
6	30	44	219	549	29	4	2
7	10	6	138	612	30	0	0
8	3	3	43	182	30	0	0
9	8	11	38	196	30	0	0
10	13	12	23	152	30	0	0
11	10	8	30	95	29	0	0
12	7	16	23	66	30	0	0
13	12	26	32	76	30	2	1
14	9	18	39	77	30	0	0
15	20	18	16	102	30	2	1
16	14	18	7	114	28	0	0
17	11	5	18	64	28	1	1
18	2	15	20	82	30	0	0
19	2	5	18	66	29	0	0
20	8	9	8	45	25	0	0
21	28	24	15	9	28	0	0
22	100	22	21	31	30	10	4
23	0	48	38	25	21	0	0
24	9	3	2	6	13	1	1
25	5	9	7	3	15	1	1
26	10	6	4	0	14	0	0
27	47	12	6	3	22	0	0
28	32	12	9	15	28	0	0
29	16	7	3	0	15	0	0
30	10	15	3	1	11	0	0
31	2	8	1	2	9	0	0
32	5	4	1	0	8	0	0
33	4	1	1	0	6	0	0
34	63	11	0	1	20	0	0
35	45	10	6	2	19	0	0
36	41	5	0	1	18	0	0

Subject A-14 Gr 30:4-1

Day	Pecks During CS Quarter IV	III	II	I	# of Trials with Pecks	Pecks during ITI	# of ITI's with Pecks
1	12	26	41	49	12	25	5
2	92	171	388	555	30	46	6
3	62	158	468	643	30	21	6
4	51	169	570	703	29	14	4
5	39	138	624	776	30	3	1
6	23	150	619	704	30	9	3
7	24	94	558	773	30	37	8
8	13	40	306	756	30	20	3
9	10	46	406	698	30	1	1
10	43	36	369	694	30	1	1
11	77	84	629	801	30	3	2
12	7	72	433	753	30	2	1
13	20	52	247	537	30	0	0
14	9	53	358	588	30	5	2
15	5	16	165	563	30	3	1
16	12	38	227	759	30	3	3
17	12	49	494	795	30	0	0
18	6	26	533	775	30	0	0
19	3	29	497	852	30	1	1
20	8	27	365	737	30	2	2
21	40	158	398	537	30	38	12
22	87	390	657	700	30	5	1
23	60	365	568	624	30	1	1
24	20	170	408	427	30	8	2
25	31	240	456	553	30	7	2
26	9	100	290	505	30	19	2
27	38	234	495	614	30	10	1
28	77	433	719	783	29	0	0
29	189	393	605	720	30	0	0
30	31	209	556	746	30	3	1
31	50	149	301	359	30	0	0
32	158	291	443	496	30	1	1
33	114	376	629	684	30	1	1
34	101	363	593	725	30	0	0
35	67	369	667	692	30	4	1
36	130	443	734	755	30	0	0

Subject C-15 Gr 30:4-1

Day	Pecks During CS Quarter IV	III	II	I	# of Trials with Pecks	Pecks during ITI	# of ITI's with Pecks
1	8	20	18	53	13	19	5
2	50	91	157	373	28	100	7
3	0	3	16	43	12	0	0
4	3	25	65	295	22	0	0
5	2	1	49	143	18	0	0
6	15	53	242	479	29	37	4
7	17	34	199	435	27	3	2
8	0	2	61	217	15	0	0
9	15	22	144	509	29	0	0
10	14	56	372	659	30	10	2
11	13	55	162	421	29	0	0
12	18	76	292	608	30	0	0
13	31	77	271	458	30	1	1
14	21	62	334	525	30	1	1
15	5	51	260	531	30	0	0
16	3	44	194	544	29	8	1
17	9	36	132	429	29	1	1
18	23	49	315	537	30	0	0
19	3	52	252	434	30	0	0
20	7	83	343	680	30	0	0
21	55	53	103	118	29	1	1
22	69	161	198	296	30	0	0
23	60	201	293	367	29	0	0
24	14	152	273	333	29	0	0
25	32	236	392	537	30	0	0
26	7	158	440	534	30	0	0
27	10	135	313	448	30	0	0
28	6	68	256	365	30	0	0
29	24	129	290	392	30	0	0
30	37	194	443	531	30	0	0
31	19	206	421	430	30	0	0
32	70	319	502	486	30	0	0
33	30	311	520	521	30	0	0
34	1	70	305	387	29	0	0
35	17	144	294	374	30	0	0
36	30	251	355	359	30	0	0

Subject D-3 Gr 30:4-1

Day	IV	Pecks During CS Quarter III	II	I	# of trials with Pecks	Pecks during ITI	# of ITI's with Pecks
1	0	0	0	0	0	0	0
2	48	59	83	71	12	226	7
3	171	449	486	628	29	87	10
4	205	590	729	628	30	8	3
5	130	381	648	684	29	1	1
6	113	417	728	684	28	0	0
7	85	230	618	662	27	0	0
8	59	193	639	773	30	0	0
9	41	146	527	555	23	0	0
10	36	156	447	457	20	0	0
11	22	90	479	540	25	0	0
12	26	133	490	566	25	4	1
13	21	56	360	549	24	0	0
14	8	27	168	508	22	2	1
15	3	1	109	397	23	0	0
16	29	69	372	658	30	0	0
17	13	44	401	608	26	0	0
18	0	0	1	137	13	0	0
19	13	20	186	419	21	0	0
20	0	0	15	151	11	0	0
21	2	3	4	33	6	8	3
22	2	6	11	20	7	2	1
23	22	44	67	105	17	0	0
24	72	273	293	290	28	0	0
25	0	0	9	19	6	0	0
26	27	111	83	138	24	0	0
27	8	37	82	122	18	0	0
28	133	256	235	241	23	0	0
29	10	5	3	5	6	0	0
30	1	5	6	1	4	0	0
31	0	0	7	10	4	0	0
32	12	20	5	3	13	0	0
33	15	26	1	0	15	0	0
34	27	101	71	33	24	0	0
35	76	221	191	72	22	0	0
36	27	141	176	87	26	0	0

Subject A-2 Gr 30:1-4

Day	Pecks During CS Quarter IV	III	II	I	# of Trials with Pecks	Pecks during ITI	# of ITI's with Pecks
1	0	1	1	0	26	157	9
2	44	78	116	121	29	8	5
3	59	100	79	133	21	0	0
4	19	19	31	47	26	0	0
5	62	52	54	72	27	0	0
6	63	65	82	129	27	0	0
7	59	77	150	184	28	0	0
8	26	28	60	92	23	0	0
9	59	86	54	55	20	0	0
10	29	58	14	9	24	0	0
11	55	33	30	49	12	0	0
12	11	33	3	9	18	0	0
13	23	62	16	2	15	5	1
14	56	37	18	0	21	72	7
15	50	70	14	3	25	73	3
16	48	50	5	0	25	66	2
17	88	35	8	0	22	13	2
18	155	139	43	2	25	29	3
19	133	145	33	2	28	73	2
20	93	115	41	23	28	19	1
21	96	94	40	27	30	3	2
22	118	48	104	36	28	3	1
23	40	45	89	50	27	3	1
24	36	50	227	28	27	0	0
25	19	30	66	27	23	0	0
26	9	10	51	36	23	0	0
27	2	1	38	19	25	0	0
28	1	9	67	14	29	7	5
29	13	20	57	24	13	0	0
30	0	16	24	8	17	2	1
31	3	8	25	13	18	0	0
32	12	28	113	11	30	0	0
33	3	18	72	39	29	0	0
34	4	17	72	20	29	0	0
35	3	7	54	25	22	0	0
36	2	10	51	18	22	0	0

Subject A-7 Gr 30:1-4

Day	IV	Pecks During CS Quarter III	II	I	# of Trials with Pecks	Pecks during ITI	# of ITI's with Pecks
1	3	6	10	6	5	0	0
2	108	119	172	152	29	1595	24
3	141	143	140	137	30	51	9
4	40	29	29	35	27	70	14
5	50	17	21	20	28	5	5
6	23	7	6	11	21	11	5
7	12	14	1	19	18	0	0
8	53	26	11	9	22	1	1
9	45	25	48	13	25	4	3
10	5	9	13	6	9	0	0
11	11	8	17	12	19	3	2
12	6	9	3	2	11	1	1
13	7	1	3	1	7	0	0
14	6	2	1	0	6	0	0
15	48	47	13	1	20	0	0
16	18	8	5	2	10	1	1
17	6	8	6	0	9	1	1
18	4	4	1	1	4	0	0
19	6	0	0	3	5	3	3
20	4	0	0	0	4	13	3
21	13	34	13	3	22	3	1
22	27	20	14	2	9	0	0
23	23	20	6	1	18	1	1
24	28	14	6	7	16	12	9
25	4	6	6	2	8	6	1
26	10	14	3	2	5	5	1
27	16	4	9	2	12	8	2
28	21	12	3	2	10	7	2
29	11	10	7	2	14	3	3
30	4	12	1	2	10	4	2
31	6	20	8	0	11	4	1
32	20	52	13	5	16	10	3
33	77	126	48	6	25	11	5
34	22	30	18	11	25	11	4
35	21	51	38	0	18	7	1
36	6	1	13	7	11	2	2

Subject D-2 Gr 30:1-4

Day	Pecks During CS Quarter IV	III	II	I	# of Trials with Pecks	Pecks during ITI	# of ITI's with Pecks
1	0	0	0	0	0	0	0
2	86	67	57	46	27	5	3
3	53	63	40	61	30	2	2
4	127	114	85	65	30	0	0
5	73	66	32	26	30	2	1
6	151	124	73	34	30	38	2
7	94	106	39	19	30	43	7
8	180	130	138	81	30	12	2
9	89	106	127	89	30	21	3
10	71	98	88	84	30	11	2
11	94	48	39	13	30	32	6
12	172	71	38	25	27	10	3
13	46	56	53	35	28	10	3
14	144	38	29	26	28	8	2
15	99	41	43	40	26	9	3
16	155	67	43	58	30	13	3
17	105	56	46	32	30	18	4
18	117	22	32	23	30	5	4
19	114	49	44	33	28	46	6
20	158	61	47	56	30	17	2
21	139	80	10	154	30	23	6
22	155	76	18	180	28	62	7
23	29	47	18	142	29	32	3
24	46	31	36	99	28	21	4
25	41	27	38	79	29	6	2
26	128	35	89	106	30	90	14
27	30	16	51	46	26	14	3
28	43	25	49	68	25	3	2
29	22	17	42	40	30	1	1
30	14	16	46	73	30	3	1
31	31	17	37	36	28	12	5
32	39	35	72	51	29	4	3
33	103	70	44	36	28	2	1
34	291	82	36	71	29	28	5
35	174	41	59	52	30	22	4
36	169	92	138	68	30	16	7

Subject D-5 Gr 30:1-4

Day	IV	Pecks During CS Quarter III	II	I	# of Trials with Pecks	Pecks during ITI	# of ITI's with Pecks
1	0	0	0	0	0	0	0
2	54	92	130	143	19	2	2
3	62	212	266	299	25	0	0
4	91	271	351	340	27	0	0
5	43	287	463	499	28	0	0
6	212	557	677	700	30	0	0
7	74	252	386	448	26	0	0
8	101	377	572	540	26	0	0
9	107	494	616	584	30	0	0
10	104	376	510	464	28	0	0
11	108	339	511	428	30	0	0
12	119	337	484	513	25	2	1
13	106	406	553	592	30	0	0
14	72	436	613	640	29	0	0
15	55	280	500	554	28	0	0
16	25	131	310	472	26	0	0
17	37	182	395	451	28	0	0
18	9	112	306	432	29	0	0
19	63	228	359	416	30	0	0
20	53	306	391	481	29	0	0
21	27	112	113	106	28	6	1
22	37	49	223	137	27	0	0
23	9	10	100	103	29	0	0
24	28	15	144	95	26	0	0
25	48	59	140	50	30	0	0
26	68	116	185	149	30	0	0
27	10	109	118	11	30	0	0
28	4	15	136	73	30	1	1
29	5	67	73	19	27	0	0
30	10	15	80	36	25	0	0
31	31	90	75	9	28	0	0
32	16	68	103	3	30	0	0
33	1	38	114	12	29	0	0
34	38	142	134	68	29	0	0
35	27	130	136	31	29	0	0
36	13	89	140	27	30	0	0

Subject A-16 Gr 120:4-1

Day	Pecks During CS Quarter IV	III	II	I	# of Trials with Pecks	Pecks during ITI	# of ITI's with Pecks
1	0	0	0	0	0	0	0
2	18	4	2	5	4	0	0
3	3	4	8	2	5	0	0
4	13	8	17	27	17	4	3
5	0	3	11	89	16	11	4
6	10	4	12	92	21	1	1
7	0	27	41	120	27	4	2
8	19	47	118	149	22	1	1
9	7	18	70	68	16	0	0
10	7	12	108	98	25	0	0
11	0	22	71	49	15	0	0
12	0	7	42	46	18	0	0
13	5	25	70	76	21	2	2
14	24	11	45	24	22	0	0
15	40	43	147	62	29	0	0
16	10	26	108	79	26	1	1
17	22	29	116	134	27	0	0
18	29	63	157	158	28	0	0
19	34	47	78	89	23	0	0
20	67	151	199	225	29	1	1
21	167	111	98	70	29	1	1
22	78	79	49	42	29	2	2
23	71	90	56	24	28	0	0
24	38	26	38	26	28	0	0
25	13	28	46	38	24	1	1
26	92	111	93	109	29	2	1
27	52	34	37	48	27	0	0
28	36	48	15	23	22	0	0
29	77	52	34	17	27	1	1
30	176	89	106	118	30	0	0
31	77	119	240	280	28	1	1
32	41	57	95	269	30	0	0
33	85	128	115	206	28	0	0
34	62	100	113	323	28	0	0
35	227	91	312	651	29	0	0
36	133	150	293	569	29	0	0

Subject A-20 Gr 120:4-1

Day	IV	Pecks During CS Quarter III	II	I	# of Trials with Pecks	Pecks during ITI	# of ITI's with Pecks
1	4	3	0	5	3	0	0
2	319	394	420	894	29	184	15
3	352	599	1424	1053	30	13	4
4	179	407	1149	899	30	6	1
5	138	299	898	1135	29	14	3
6	137	620	1122	1651	29	0	0
7	151	420	1192	1934	30	0	0
8	61	322	1313	1744	30	11	3
9	267	596	1525	2040	30	7	4
10	111	330	1427	1941	30	1	1
11	48	261	1395	1956	30	0	0
12	66	217	1322	1986	28	0	0
13	18	134	834	1784	30	0	0
14	53	184	902	2140	30	2	2
15	11	125	785	2116	30	3	3
16	70	326	815	2140	29	5	5
17	131	262	944	2117	30	101	2
18	108	301	1288	2042	30	8	2
19	59	193	1245	2247	30	1	1
20	32	350	1200	2018	30	0	0
21	1368	1748	1568	1473	30	753	17
22	1244	1458	1263	912	30	383	7
23	1183	1073	793	490	30	217	8
24	630	524	412	407	29	7	5
25	776	510	379	210	26	30	5
26	552	718	515	284	30	8	4
27	1050	1024	641	252	30	15	3
28	923	1033	597	298	30	6	5
29	840	1201	550	168	28	8	2
30	1368	1576	1042	472	30	5	3
31	1150	1255	705	366	30	2	2
32	1160	1257	890	374	30	288	10
33	1314	1543	542	144	30	101	4
34	1075	1356	687	226	30	16	2
35	664	1047	487	96	30	16	1
36	752	1101	522	282	30	187	8

Subject C-6 Gr 120:4-1

Day	IV	Pecks During CS Quarter III	II	I	# of Trials with Pecks	Pecks during ITI	# of ITI's with Pecks
1	1	2	1	0	3	1	1
2	0	0	4	3	3	0	0
3	21	10	25	33	7	18	5
4	132	55	160	278	30	26	7
5	139	112	99	160	27	28	5
6	108	89	106	184	25	13	3
7	10	53	116	204	28	10	3
8	22	49	164	269	29	5	1
9	7	6	45	169	29	0	0
10	60	46	171	114	29	0	0
11	25	61	111	78	28	0	0
12	7	41	71	42	29	1	1
13	26	100	88	65	29	0	0
14	52	105	79	49	29	3	1
15	68	174	119	57	30	0	0
16	39	192	135	82	30	0	0
17	43	129	191	84	30	3	1
18	12	76	119	150	29	0	0
19	30	111	111	120	29	0	0
20	21	50	75	64	30	0	0
21	146	138	65	59	30	6	5
22	176	170	144	140	30	1	1
23	252	154	158	270	30	3	3
24	163	105	95	199	30	32	6
25	222	148	91	173	30	32	10
26	257	187	154	192	30	8	6
27	186	134	128	210	30	0	0
28	301	291	182	237	30	7	4
29	243	364	366	359	30	5	3
30	219	250	280	434	30	8	2
31	271	289	291	504	29	9	3
32	132	169	278	381	30	6	1
33	101	101	147	301	30	6	1
34	88	122	253	456	27	8	1
35	100	160	265	508	29	0	0
36	101	164	260	491	29	5	5

Subject C-11 Gr 120:4-1

Day	Pecks During CS Quarter IV	III	II	I	# of Trials with Pecks	Pecks during ITI	# of ITI's with Pecks
1	4	0	0	2	3	1	1
2	2	5	5	1	5	0	0
3	11	23	30	75	20	5	4
4	0	3	22	119	26	0	0
5	0	3	0	11	3	1	1
6	0	12	23	105	19	0	0
7	0	4	34	82	28	0	0
8	0	0	3	68	13	0	0
9	0	0	29	305	29	0	0
10	0	2	20	263	16	0	0
11	0	2	74	644	29	0	0
12	0	1	14	140	12	0	0
13	1	5	75	857	30	0	0
14	1	0	11	804	24	0	0
15	0	0	9	904	27	0	0
16	0	0	34	1177	29	0	0
17	0	0	20	1378	30	0	0
18	0	2	69	1486	30	1	1
19	0	0	33	1498	30	0	0
20	0	0	52	1451	27	0	0
21	5	16	42	50	10	0	0
22	3	14	46	41	16	0	0
23	4	8	45	84	22	1	1
24	0	21	31	54	16	0	0
25	9	22	37	50	19	0	0
26	5	13	25	53	15	0	0
27	8	8	15	13	8	0	0
28	4	4	3	3	3	0	0
29	4	0	4	1	6	0	0
30	0	2	0	0	3	0	0
31	0	0	0	1	1	0	0
32	0	3	0	0	2	0	0
33	5	4	0	0	5	0	0
34	10	2	0	6	8	3	2
35	10	6	6	7	12	5	3
36	18	4	4	11	14	0	0

Subject A-13 Gr 120:1-4

Day	Pecks During CS Quarter IV	III	II	I	# of Trials with Pecks	Pecks during ITI	# of ITI's with Pecks
1	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0
4	0	0	0	0	0	1	1
5	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0
17	22	0	0	0	2	0	0
18	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0
20	13	0	0	0	4	0	0
21	4	3	1	0	1	0	0
22	0	0	0	23	4	0	0
23	4	0	13	40	19	2	1
24	0	0	3	22	9	0	0
25	0	0	4	15	8	0	0
26	11	0	15	17	0	0	0
27	14	1	7	11	8	0	0
28	9	0	6	21	5	0	0
29	0	0	2	23	6	0	0
30	0	0	9	17	11	0	0
31	0	0	1	1	1	0	0
32	0	2	0	4	2	0	0
33	0	0	4	31	3	0	0
34	0	0	0	9	11	0	0
35	7	4	1	27	10	0	0
36	6	4	2	33	22	0	0

Subject A-18 Gr 120:1-4

Day	Pecks During CS Quarter IV	III	II	I	# of Trials with Pecks	Pecks during ITI	# of ITI's with Pecks
1	1	0	0	0	1	1	1
2	0	1	0	2	3	0	0
3	0	0	0	0	0	7	2
4	1	2	1	11	7	1	1
5	19	73	32	32	13	9	5
6	235	436	498	427	27	10	3
7	127	318	409	441	23	2	2
8	94	325	496	565	20	0	0
9	116	376	462	524	19	0	0
10	96	348	497	458	19	0	0
11	22	135	254	278	15	0	0
12	37	123	259	257	24	0	0
13	33	134	234	248	28	2	1
14	74	201	461	524	28	0	0
15	125	261	278	775	29	1	1
16	167	482	841	965	29	3	1
17	241	750	1162	1356	27	6	3
18	356	766	1386	1631	30	14	4
19	504	909	1434	1615	27	22	2
20	651	1216	1634	1792	28	1	1
21	384	29	70	10	14	0	0
22	187	353	814	236	29	6	2
23	211	143	1463	1232	28	37	5
24	159	430	1851	1980	30	43	7
25	171	595	1540	1719	28	2	1
26	87	360	1472	1831	30	33	3
27	99	377	1854	1833	30	28	1
28	58	382	1768	1352	30	8	2
29	120	464	1561	1687	29	20	1
30	27	530	2358	1843	30	4	2
31	41	271	1969	1575	30	4	3
32	31	342	1840	1610	29	8	2
33	39	374	1595	1495	30	0	0
34	11	234	690	1417	30	3	2
35	22	328	1240	1506	28	6	3
36	1	144	954	1305	30	122	5

Subject C-7 Gr 120:1-4

Day	Pecks During CS Quarter IV	III	II	I	# of Trials with Pecks	Pecks during ITI	# of ITI's with Pecks
1	1	0	2	0	2	1	1
2	0	0	0	0	0	0	0
3	0	2	1	0	1	0	0
4	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0
10	0	0	2	0	1	0	0
11	9	7	1	3	11	1	1
12	1	5	11	7	11	0	0
13	0	1	11	9	8	0	0
14	4	10	20	18	11	0	0
15	0	0	0	0	0	0	0
16	2	0	0	0	1	0	0
17	0	0	1	1	1	0	0
18	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0
20	0	0	0	2	2	0	0
21	0	0	0	1	1	0	0
22	0	0	0	34	12	0	0
23	0	0	0	49	13	0	0
24	4	2	12	211	29	0	0
25	0	7	13	338	25	1	1
26	0	4	12	599	28	0	0
27	3	1	19	383	27	0	0
28	23	2	33	461	27	0	0
29	10	0	8	597	29	0	0
30	0	3	27	769	29	0	0
31	3	1	17	873	30	0	0
32	0	0	2	778	29	0	0
33	0	6	38	1026	30	1	1
34	21	21	23	952	29	1	1
35	0	49	32	1106	28	6	1
36	0	9	76	1024	29	14	2

Subject D-7 Gr 120:1-4

Day	Pecks During CS Quarter IV	III	II	I	# of Trials with Pecks	Pecks during ITI	# of ITI's with Pecks
1	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0
4	1	2	2	2	3	0	0
5	0	0	0	0	0	0	0
6	0	0	2	0	1	0	0
7	31	6	25	38	10	0	0
8	8	12	0	2	1	0	0
9	3	2	1	3	3	0	0
10	0	0	0	0	0	0	0
11	51	49	56	18	11	2	1
12	275	392	262	215	19	0	0
13	95	108	126	120	9	2	1
14	98	154	150	126	13	24	6
15	73	156	163	184	10	12	2
16	94	194	248	301	10	6	2
17	65	125	173	240	13	0	0
18	16	81	114	120	8	0	0
19	31	77	110	112	10	0	0
20	35	84	136	111	15	5	2
21	25	6	52	87	21	0	0
22	4	9	10	75	16	0	0
23	7	5	33	35	14	0	0
24	17	23	26	55	21	0	0
25	40	62	59	144	25	0	0
26	5	6	22	40	12	0	0
27	3	2	52	11	9	0	0
28	5	5	44	15	16	0	0
29	4	1	9	3	5	0	0
30	4	12	11	6	5	0	0
31	5	7	114	16	18	0	0
32	2	0	32	11	8	0	0
33	0	14	52	25	20	0	0
34	0	3	26	6	11	0	0
35	0	2	25	0	13	0	0
36	1	10	62	28	23	0	0

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CLASSICALLY CONDITIONED KEYPECKING TO SIMPLE AND COMPOUND STIMULI OF LONG DURATION

by

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ABSTRACT

Sixteen experimentally naive pigeons were conditioned to keypeck using a classical conditioning procedure. The conditioned stimulus (CS) was the illumination of a pigeon response key with one of four colored lights. The unconditioned stimulus (US) was a four second presentation of a grain magazine which immediately followed the end of the CS. A four minute inter-trial interval between the offset of US and onset of CS followed each US presentation. The subjects were divided into four groups. In Phase 1 of the experiment these groups were arranged in a 2x2 matrix. Two levels of CS duration were employed: 30 or 120 sec. Two numbers of sequential components within the CS were employed: one component for the entire CS period, or four components in sequence, each present during 1/4 of the stimulus period. In Phase 2 subjects were continued at their previous level of CS duration but were shifted to the alternative number of sequential CS components. Subjects were run for 20 days in Phase 1 and 16 days in Phase 2, 30 trials a day.

All subjects in all groups keypecked. Subjects in the two 30 sec groups responded significantly sooner than subjects in the two 120 sec groups. There were no significant differences in rate of pecking between groups by the last five days of Phase 1. Rates of pecking during the inter-trial intervals for all birds never exceeded rates during the CS. In Phase 1 the subjects run under the four component conditions showed an increase in rate of pecking over the four components as the time of CS onset approached. The subjects in the one component groups did not

exhibit this regularity. During Phase 2 when subjects were shifted from four to one components in the CS there were again no group tendencies to increase in rate of pecking as the time of CS presentation approached. Of the two one component groups that were shifted to four components in Phase 2, one group, the 120 sec duration group, showed a tendency to increase in rate of pecking as the time of CS onset approached during Phase 2. The other group, the 30 sec duration group, did not show a tendency to increase in rate in either the first or second phase of the experiment.

The implications of these findings for instrumental and classical conditioning were discussed.