SINGLE-ALTERNATION RESPONSE-INDEPENDENT LEARNING IN THE PIGEON

by

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TABLE OF CONTENTS

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LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

The concepts of stimulus aftereffects and perservative traces have been hypothesized to account for a variety of experimental findings in which differential responding occurs in the presence of nondifferential external stimuli. Differential responding under these conditions presumably occurs on the basis of the aftereffects of antecedent stimuli and responses. The existence of internal stimuli mediating temporal intervals has been used to explain the FI scallop effect (Skinner, 1938). Other examples of differential responding in the absence of differential external stimuli include temporal conditioning (Pavlov, 1928, p 41), delayed matching to sample (Smith, 1967; Berryman, Cumming, & Nevin, 1963; Blough, 1959), delayed reward in the absence of differential stimuli during the delay (Grice, 1948; Perkins, 1947), and sequence effects such as the single alternation effect (Capaldi, 1967). In temporal conditioning there is no external CS and the US is presented at regular temporal intervals. In a delayed matching to sample task the subjects must match the test stimulus to a sample stimulus which is no longer present. In a nondifferential delayed reward procedure, subjects are detained in a nondifferential delay compartment for various periods of time after making the response and before being permitted access to reward. The single alternation effect refers to the situation in which the single alternation

of rewarded and nonrewarded trials eventually results in lower responding on nonrewarded (N) trails than on rewarded (R) trials. This effect has been found in the straight alley runway (Capaldi, 1967), in a discrete trials lever pressing situation (Gonzalez, Bainbridge, & Bitterman, 1966), in a classically conditioned jaw movement in the rabbit (Poulos, Sheafor, & Gormezano, 1971), and in human eyelid conditioning (Prokasy, Carlton, & Higgins, 1967) and electrodermal conditioning (Longenecker, Krauskopf, & Bitterman, 1952).

In single alternation (SA) straight-alley runway studies with trials separated by an interval of 15 sec to 24 hrs, what is typically found is that rats run faster to the goal-box on R trails than on N trials. This effect is referred to as single alternation behavior (SAB) (eg, Capaldi, 1967) or patterned running in the case of response-dependent appetitive conditioning. Reward occurs regularly only on every other trial so that each N trial is followed by a R trial and vice-versa. The only differential stimulus is supposedly the aftereffects of the presence or absence of reward on the preceding trial.

As an explanation of SAB Capaldi (1967) offers the sequential hypothesis. Nonrewarded and rewarded trials are posited to produce specific and distinctive stimulus aftereffects which are salient stimuli on the following trial. These stimulus aftereffects of N and R trials are assumed to serve as the CS+ and CS-, respectively, and thus as cues for differential responding on the subsequent trial.

Single alternation behavior may be largely attributed to the presence of differential stimulus aftereffects; however, interpretation of sequence effects in the runway is complicated by the possible role of odor cues. Capaldi and Spivey (1964) obtained evidence for discrimination between rewarded and nonrewarded trials using the SA procedure with one trial per day and a 24-hr inter-trial interval (ITI). Surridge and Amsel (1965a) failed to replicate their results and suggested that differential odor cues may have been responsible for Capaldi and Spivey's results. On the other hand, Capaldi and Lynch (1966) controlled for odor cues and obtained SAB when N trials terminated with 120 sec, but not with 30 sec, of goalbox confinement. Amsel, Hug, and Surridge (1969) likewise controlled for odor cues and failed to replicate Capaldi and Lynch's results using 120 sec of nonrewarded goalbox confinement.

Evidence is accumulating to substantiate Surridge and Amsel's (1965a) claim that odor cues in the runway are an important contributor to SAB. Laboratory rats appear to produce odors which are perceptible to other rats in situations of differential reward-nonreward treatment. These odor cues presumably modify in both a conditioned and unconditioned manner the performance of animals run later in the maze (Morrison & Ludvigson, 1970; Collerain & Ludvigson, 1972; Sprott, 1969; Mellgren, Fouts & Martin, 1973; Wasserman & Jensen, 1969; Cheal & Sprott, 1971) and interfere with the acquisition and maintenance of differential responding based

on nonolfactory cues (eg., Katz, Woods & Carrithers, 1966; Amsel, Hug & Surridge, 1969).

Surridge and Amsel (1965a) made the daily order in which subjects were run within a squad unsystematic and did not obtain SAB with a 24-hr ITI. Amsel, Hug, and Surridge (1969) have since demonstrated the importance of odor cues in contributing to SAB in the runway situation. By manipulating the within-day order in which subjects were run, they were able to establish, disrupt, and reestablish SAB with a 24-hr ITI. Morrison and Ludvigson (1970) and Hardy, Gabiel, and Uphold (1971) clearly showed that odor cues left by donor rats exposed to reward and nonreward served as discriminative stimuli for rats subsequently run in the maze. If given a choice, rats avoided the arm of a T-maze in which other rats had previously been exposed to nonreward in the presence of reward-associated cues (Collerain & Ludvigson, 1972). Mellgren, Fouts, and Martin (1973) further demonstrated that rats approached a location more slowly in which another rat had previously been rewarded. There is another observation which provides evidence for an olfactory interpretation for much of the runway SAB. On any day SAB develops and becomes more marked only after several animals have been run consecutively on the same condition (Amsel, Hug, & Surridge, 1969).

Although the bulk of the evidence argues for the presence of odor cues laid down by frustrated or rewarded rats as one of the principal contributors to SAB in the runway, other variables are of importance in SAB. The magnitude of reward

(Ludvigson and Gay, 1966), the duration of nonrewarded and rewarded goalbox confinement (Surridge & Amsel, 1965b), and the massing of trials (Capaldi and Stanley, 1962; Katz, Woods, & Carrithers, 1966) have all been shown to influence SAB in the runway. When suitable controls for olfaction are not employed it is possible that these variables may influence the magnitude of odor trials produced by rats and thus SAB in the runway situation. Katz, Woods, and Carrithers (1966) used an SA procedure and controlled for odor effects by alternating two daily orders of R and N trials for each subject. Half of the subjects in each group began each day's trials with an R trial and the other half with an N trial. The daily order in which the subjects within a group were run was also varied. Katz and his associates obtained SAB with 15 sec and 2 min ITI's, but not with a 20 min ITI. Capaldi and Stanley (1962) did not employ similar controls for olfaction and obtained evidence for SAB with ITI's of 15 sec, 2 min, and 10 min when the order in which each group was run was fixed. By mixing the daily order in which subjects from each group were run, SAB was also obtained with a 20 min ITI. A subject from the 20-min ITI group was run alternately with a subject from the 15 sec ITI group, with a 15-sec subject running first. If a stronger odor trial is produced with a shorter ITI condition, the presence of odor cues from a 15 sec subject may provide discriminable cues for the 20 min subject. It is entirely possible that SAB under massed conditions such as Katz *et al* (1966)

used can be attributed more to learning where discriminative stimuli are not odor cues, although SAB under more spaced conditions may be largely dependent upon odor cues.

In one respect a response-independent procedure is better suited to demonstrate the sequential effect in the SA situation. In the response-dependent runway situation the sequential effects may be minimized due to the presence of secondary reinforcing properties that N trials may acquire. Since each N trial precedes an R trial, a chaining effect could develop in which the subject, loosely speaking, responds rapidly on an N trial in order to get to an R trial. Use of a response-independent procedure would minimize such chaining effects.

Recently Poulos, Sheafor, and Gormezano (1971) hypothesized that if a stimulus could control behavior established through a response-dependent SA procedure, it could also control responding in a response-independent SA procedure where trials are defined as presentation of the CS paired or unpaired with the US. Broadly speaking, in response-independent procedures the US corresponds to the reward and the SA procedure consists of paired CS-US presentations on alternate trials.

The effects of the SA procedure in a classical conditioning paradigm using jaw movement in the rabbit as the conditioned response were recently studied by Poulos, Sheafor, and Gormezano (1971). Holmes and Gormezano (1970) had earlier employed the same response and failed to obtain SAB with a small US magnitude. Using the same basic procedure, Poulos

et al varied the magnitude of the US, the amount of water squirted into the rabbit's mouth, and obtained clear evidence for SAB when the larger US magnitudes were employed. Two other factors may have contributed to Poulos et al's success: They ran their animals for 30 days for a total of 300 trials whereas Holmes and Gormezano only ran their subjects for 8 days for a total of 240 trials. Both studies employed a variable ITI but Poulos et al's mean ITI was somewhat shorter (105 sec) than was Holmes and Gormezano's (180 sec). Since it is probable that the salience of stimulus aftereffects decreases as a function of time, greater massing of trials would be expected to facilitate SAB in a response-independent procedure as it does in response-dependent training. In agreement with the data dealing with SAB in runway studies, Poulos et al obtained facilitation of SAB when the duration of the CS was increased on N trials. Conditioned stimulus duration on R trials had no effect on overall SAB.

The studies of Holmes and Gormezano (1970) and Poulos et al (1971) used jaw movement in the rabbit as the conditioned response; other studies using eyeblink in humans (Grant, Riopelle, and Hake, 1950), conditioning of the nicating membrane in the rabbit (Leonard and Theios, 1967), and eyeblink in the dog (Vardaris and Fitzgerald, 1969) have failed to find SAB even though in Grant et al's study the human subjects verbalized the reinforcement conditions. However, SAB was obtained in humans with a classically conditioned GSR (Longe-

necker, Krauskopf, and Bitterman, 1952) and eyeblink (Prokasy, Carleton, and Higgins, 1967). In contrast to Grant et al's (1951) study, subjects in these latter two experiments could not verbalize the reinforcement contingencies, suggesting the possibility that subjects' awareness may influence SAB. Using a human eyelid closure as their conditioned response, Hickok and Grant (1964) and Hartman and Grant (1962) demonstrated that prior knowledge of the trial sequence reduced the overall level of responding during acquisition in a double alternation of US procedure. Grant, Hake, and Riopelle's failure to obtain SAB with a classically conditioned eyeblink in humans may be attributed to a similar generalized inhibition of overall responding. Unfortunately, no studies have systematically manipulated the role of awareness of the trial sequence in any human response-independent SA procedure.

There is a second possible explanation for Grant et al's failure to find SA in humans. Due to large individual differences, Prokasy, Carleton, and Higgins (1967) did not obtain evidence for SAB using a human eyelid conditioned response when they examined group data. Analysis of the data in terms of individuals revealed that only seven of the 29 subjects did not show alternation behavior. These authors suggested that since it is conceivable that such individual differences arise from the subject's instructional set, conditionability of the subject, and other experimental constraints, analysis on an individual basis is more sensitive

to the detection of differential responding. Grant et al analyzed only group means.

The failure to find SAB with a nicatating membrane conditioned response in the rabbit (Leonard and Theios, 1967) and an eyeblink response in the dog (Vardaris and Fitzgerald, 1969) may be attributed to variations in procedural details. In addition to the different response topography, these latter two studies have fewer overall trials and/or they are run for a very short period of time with more trials occurring per day as compared with the runway studies or those using the jaw movement in the rabbit as the conditioned response.

A review of the literature revealed no studies to date that have examined SAB in the pigeon. One method of determining whether a similar effect to that of SAB in rats, rabbits, and humans occurs in pigeons is to employ an autoshaping procedure. Brown and Jenkins (1968) demonstrated that pigeons would peck at high rates to a stimulus localized on the key if the stimulus immediately preceded response-independent grain presentation. In an autoshaping procedure the US is grain presentation and the CS is response-key illumination; both stimulus presentations are controlled by the experimenter and are presented independently of the subject's behavior. Every other CS presentation is followed by US presentation. In a procedure in which nondifferential CS's are used on R and N trials, it is assumed that response-key illumination followed immediately by food presentation would result in stimulus

aftereffects distinct or at least different from those after-effects present following only response-key illumination. These differential stimulus aftereffects should in turn provide a basis for differential responding on R and N trials.

One possible method of manipulating differential stimulus aftereffects of R and N trials in an SA autoshaping procedure is to systematically vary the intervals between R to N and N to R trials using both equal and unequal ITI length conditions.

To the author's knowledge no such attempt has been made. Other manipulations of R and N trial aftereffects have been summarized above and include manipulation of CS duration and US magnitude using a classically conditioned jaw movement in the rabbit (Poulos, Sheafor, and Gormezano, 1971), manipulations such as goalbox confinement duration (Surridge & Amsel, 1965b) reward magnitude (Ludvigson & Gay, 1966) and equal ITI durations between R and N trials (eg, Capaldi and Stanley, 1962; Katz, Woods, and Carrithers, 1966) in the response-dependent runway studies. For the latter manipulation the ITI between R to N and N to R trials is always of the same length.

Pilot data suggested a failure to obtain differential responding when noncontingent 4-sec food presentations followed every other 8-sec CS presented every 120 sec. Failure to obtain SAB here may be related to the presence of nearly equal length ITI's and to the long interreinforcement interval (IRI) used. In order to determine whether SAB would be

obtained in the pigeon with equal and differential ITI lengths, the following two experiments were designed using response-independent presentation of stimuli. Experiment I consisted of one group in which food presentations followed every other CS presentation regardless of what the bird did. This group started with presentation of the CS- immediately following retraction of the feeder. A 64-sec IRI (measured from feeder reaction to onset of the subsequent grain presentation) was used. The interval between feeder retraction and onset of the CS- was increased in discrete steps until food presentations were 120 sec apart. When steady state performance was reached with an IRI of 120 sec, the original training condition was reintroduced (64 sec IRI). The interval between CS-(N trial) offset and CS+(R trial) onset was held constant.

Experiment II consisted of three groups and examined SAB with equal and unequal length ITI's. One group began with 8-sec ITI's between trials (8 sec group). These ITI's were simultaneously increased until CS responding was nondifferential. A second group, the 14 sec group, began with the equal ITI condition previous to the occurrence of nondifferential responding in the 8 sec group. Both of these groups were similar to Experiment I in that nondifferential CS presentations were used on R and N trials.

A third group served as a comparison condition for the 8 sec group. It is possible that with such a short IRI (24 sec) in the beginning of training that autopecking would occur throughout the entire period between grain presentations or

at least to CS presentations on both R and N trials. If this is the case, then differential responding to differential CS's on R and N trials should be minimized. The differential cue group examines this possibility. Procedurally this group is similar to the 8 sec group except that for the former differential stimuli were presented on R and N trials.

Experiment I

Methods

Subjects

Eight experimentally naive White King pigeons obtained from a local supplier served as subjects. After arrival all birds were fed *ad lib* for two weeks or more and then were reduced to and maintained at 75% of their free-feeding weights throughout the experiment. Birds were housed in a 24-hr artificially illuminated colony room in individual cages with free access to grit and water.

Apparatus

Four 34 x 38 x 32.5 cm (inside dimensions) plywood experimental chambers were used. Each contained a translucent Gerbrands response key located 4 cm directly above the upper part of the aperature of the Lehigh Valley grain feeder. The lower portion of the 4 x 4 cm opening to the grain feeder was 4.0 cm above the masonite floor. The interior of the chamber was painted flat gray throughout. A small plexiglass window covered with opaque material in the door of the experimental chamber permitted viewing of the subjects. A relay mounted

inside the chamber and behind the steel intelligence panel provided auditory feedback whenever the bird made a response by striking the key with a force of 7 N or more.

A 10w lamp mounted above the grain feeder and behind the intelligence panel illuminated the aperature of the grain feeder whenever grain was accessible. A 6w frosted Christmas tree light mounted above a round opening covered with translucent plastic and centered in the ceiling of the experimental chamber provided general illumination at all times except during grain presentation. The response key was transilluminated with a blue light.

Masking noise in the room and ventilating fans located in each individual box effectively masked extraneous sounds. Noise level inside experimental chambers ranged from 73 to 76 dB's (measured on the A scale of a General Radio Co sound level meter). An eight-channeled tape reader, relays, and other standard programming equipment scheduled grain presentation and other stimulus events. The total number of responses to the CS+, CS-, and to the ITI's preceeding R and N trials were recorded separately on Sodeco counters and Lehigh Valley printout counters. All programming and recording equipment were located in an adjacent room and simultaneously controlled programmed events in all four experimental chambers.

Design

After completion of feeder habituation the birds were given response-independent SA training with nondifferential

CS presentations on N and R trials. During the first phase of training the CS- onset was simultaneous with retraction of the feeder. A 56-sec key dark period (ITI) followed CS- offset and preceded the subsequent CS+ onset. During the following phases of training the ITI preceding the CS+ was held constant at 56 sec and the period between feeder retraction and CS- onset was increased in several steps until this ITI was 56 sec (56-56 sec ITI condition). At this point the original training condition (0-56 sec ITI condition) was reintroduced to determine if the original behavior could be recovered.

Training

Birds were feeder trained according to the following procedure: With the response key covered with gray tape and grain accessible, each deprived bird's head was held over the feeder until it had been eating the mixed grain for 30 sec, at which time the pigeon was released and the door of the experimental chamber closed. The interval between grain presentation was increased and the period of grain access decreased until the bird approached and ate from the tray within 4 sec. All birds successfully completed this phase in one day. The next stage of training began on the following day. With the response key still covered, grain presentations occurred at the same frequency as they would in the beginning of autopeck training (every 64 sec) for a total of 30 grain presentations. The first few grain presentations were extended beyond the usual 4 sec if the subject was not approach-

ing and eating within 4 sec. All birds successfully completed this stage of feeder habituation in one day by approaching and eating on three out of the last five 4-sec grain presentations.

The procedure employed in the beginning of autopeck training is shown in Table 1. For the various ITI conditions shown in Table 1 the number to the left of the hyphen denotes the ITI duration preceding CS- onset and the number to the right indicates the ITI duration preceding CS+ onset. The sequence of events was: 4-sec of the conditioned stimulus (CS), offset of the CS and simultaneous grain presentation for 4 sec, feeder retraction and onset of the next 4-sec CS. The CS preceding and following grain presentation was blue. The interreinforcement interval (IRI) was 64 sec. On the eleventh day of training the interval between feeder retraction and onset of the next CS was increased in one step from 0 to 4 sec (64 to 68 sec IRI). Subsequently the latter interval was successively increased in steps from 4 to 8 sec, from 8 to 16 sec, 16 to 32, and from 32 to 56 sec, increasing the IRI from 68 to 72, 80, 96, and 120 sec, respectively. There were ten consecutive daily sessions of each of the 0-56 through 56-56 sec ITI's. Pilot data obtained under similar conditions indicated that 10 days was long enough to obtain asymptotic performance. On Day 61 the 0-56 sec ITI condition was reintroduced for eight days to determine if the original behavior could be recovered.

The house light remained on except during grain presentation, and the response key was illuminated only during stimulus presentation. A daily session consisted of 30 presentations

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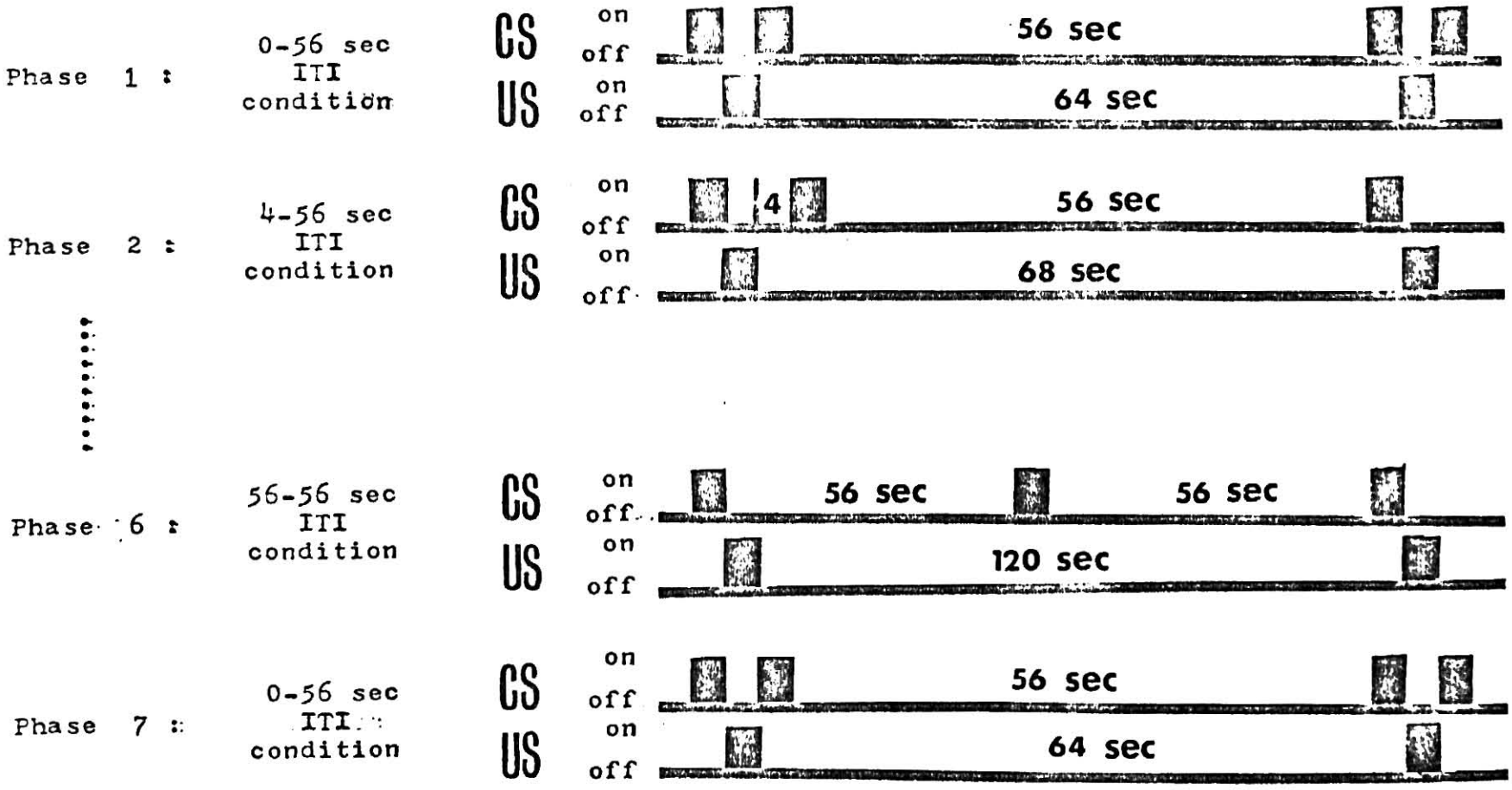
Table 1
Summary of the procedure for Experiment 1
(Not drawn to scale)



each of N trials (CS not followed by grain) and R trials (CS plus grain). The first trial of each session was always an R trial.

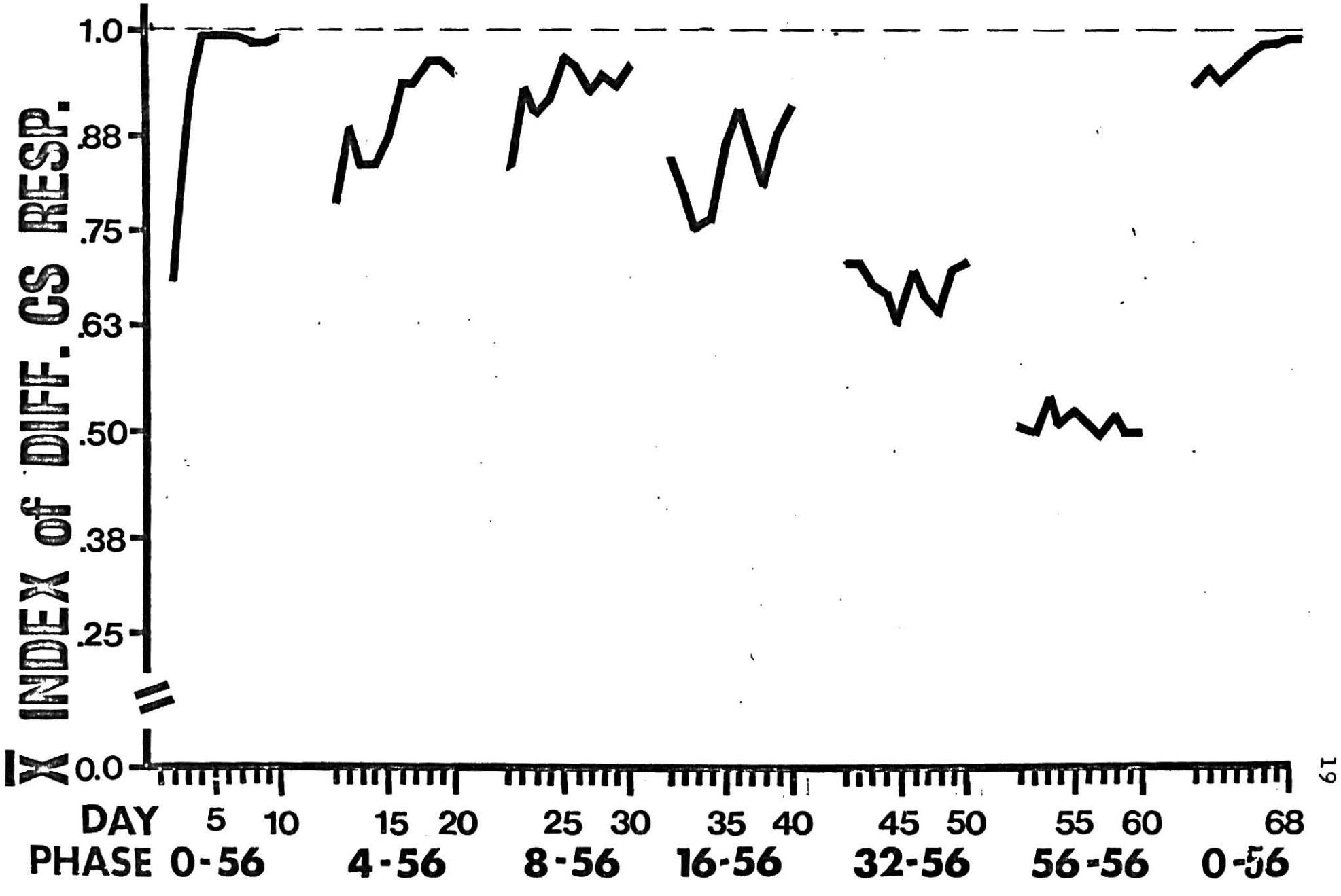
Results

With the exception of Bird 9 who began off-key responding to the CS+ after reintroduction of the 0-56 sec ITI condition, high daily rates of autopecking to the CS+ were obtained from each bird on the last four days for all ITI conditions. Rates ranged from 1.0 to 4.4 pecks per second. A daily index of differential CS responding for each subject was obtained by dividing the total number of responses to the positive CS by the total number of responses to the positive and negative CS's. Prior exploratory work indicated that this measure was less sensitive to day-to-day rate fluctuations than was a measure based on rate of responding to the CS-. Since for most birds the rate of pecking to the CS+ was stable, changes in the indices reflect primarily changes in the rate of pecking to the CS-. Using this index, nondifferential responding to the CS's yields a discrimination index of 0.5; more responding to the positive than negative CS results in a discrimination index between 0.5 and 1.0, and below 0.5 if there is more responding to the negative CS.

Figure 1 presents the mean index for all 8 birds on each day. Bird 9's data was not included from Day 65 through the end of training due to off-key pecking to the CS+. When the ITI follow-

Figure Caption

Figure 1. Mean index of differential CS responding for each day for Experiment 1. This index was obtained by averaging together the individual indices of differential CS responding (number of responses to CS+ divided by number of responses to the CS- and CS+ for each day).


1.0
.88
.75
.63
.50
.38
.25
0.0
IX INDEX of DIFF. CS RESP.
DAY 5 10 15 20 25 30 35 40 45 50 55 60 68
PHASE 0-56 4-56 8-56 16-56 32-56 56-56 0-56

ing feeder retraction (negative ITI) was increased from 0 to 4 sec and from 4 to 8 sec, the discrimination index dropped reflecting an increase in responding to the CS-. This downward trend continued as negative ITI increases were instituted from 16-56 through 56-56 sec, with nondifferential CS responding on the 56-56 sec ITI condition. The behavior of the first phase of training was recovered when the 0-56 sec ITI condition was reintroduced.

For the 0-56 through 56-56 sec ITI conditions analyses of variance and post-tests were performed on the indices of differential CS responding for the last four days of each condition. Due to mechanical failure data was not available for Birds 9 and 11 for Day 28 of the 8-56 sec ITI condition. For these subjects only the analyses were performed on the last four days on which data was available (Days 26, 27, 29, and 30). A 2 x 5 x 4 (squads x treatments x days) ANCVA with repeated measures on the last two factors indicated no significant main effects or interactions involving days or squads. Thus there was no evidence that asymptotic behavior had not been reached or that performance of squads differed. A significant treatments effect was obtained ($F = 74.1$, df 5,30, $p < .01$). Two-tailed Scheffe comparisons on the treatments factor revealed that with ITI conditions of 8-56 or less (0-56, 4-56, 8-56) the amount of differential responding to the CS's was not significantly different ($p > .05$). However, when the negative ITI exceeded 8 sec (16-56, 32-56, and 56-56 sec ITI conditions),

the index of differential responding decreased as the negative ITI was increased with statistically significant differences between each successive condition ($p < .01$). A mean index of CS responding for the last four days of the 56-56 sec ITI condition was obtained for each subject. A t-test performed on these mean indices revealed nondifferential responding ($p > .05$).

Figure 1 indicates that an abrupt increase in differential CS responding occurred when the 0-56 sec ITI condition was reintroduced. Asymptotic behavior on the latter condition was no different from that of the original 0-56 sec ITI condition.

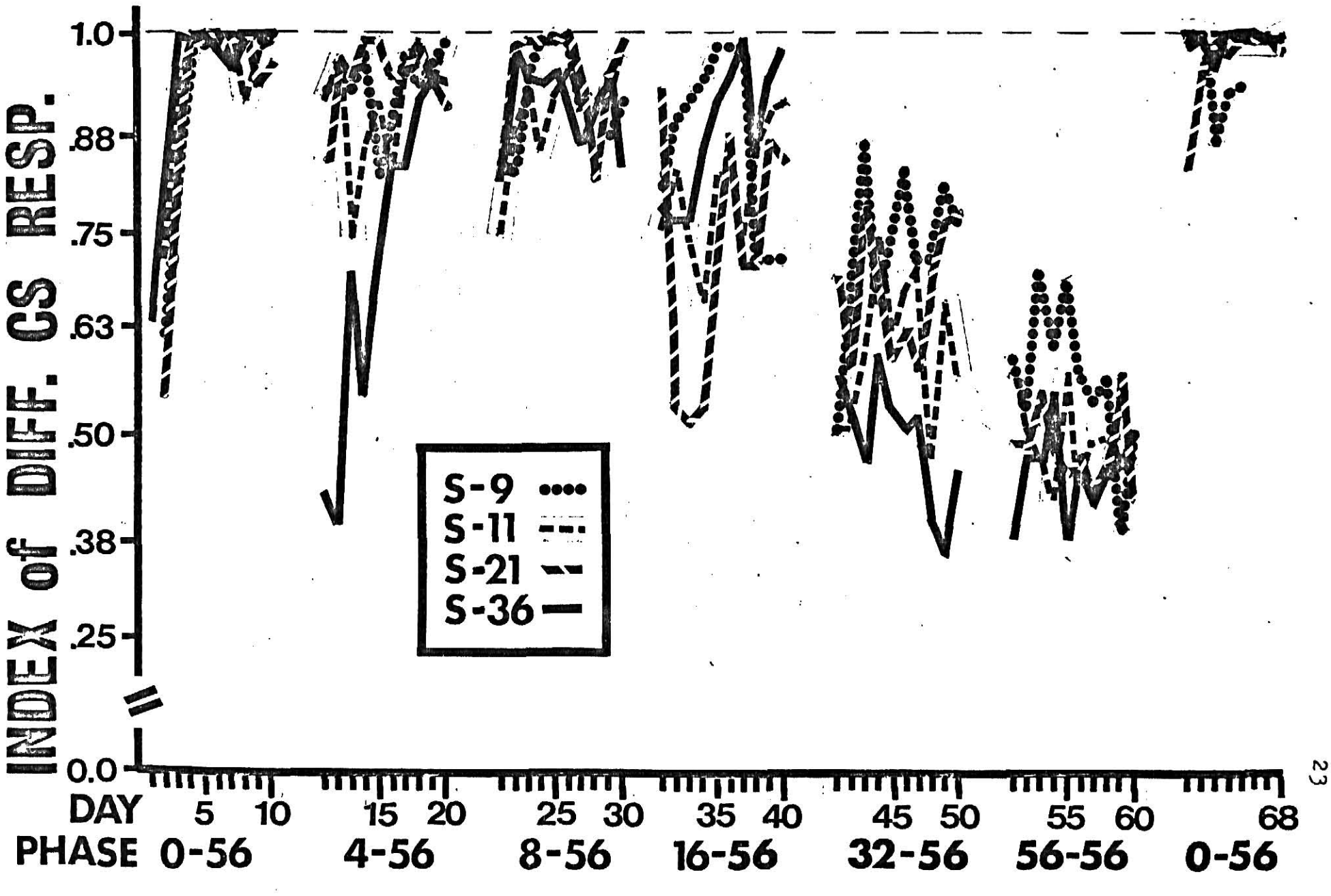
The daily indices of differential CS responding for each bird are presented in Figures 2a and 2b. The presence of individual differences indicates that subjects were not equally sensitive to increases in negative ITI duration.

Upon reintroduction of the 0-56 sec ITI condition, Bird 9 increased the amount of off-key pecking such that most of his pecking during the CS+ struck the intelligence panel near the perimeter of the key and was not recorded. For this reason, this subject was not included in either Figure 1 or Figure 2a from Day 65 through the end of training. Except for Bird 9's off-key pecking to the CS+, his observed behavior was very similar to the other subjects' in that almost all pecking during the stimulus for the reintroduced 0-56 sec condition was confined to the CS+.

Table 2 presents for each bird a mean rate of responding per minute during the ITI preceding onset of the CS- (negative ITI) and CS+ (positive ITI) for the last four days of each ITI

Figure Caption

Figure 2a. Daily individual indices of differential CS responding for Squad 1 of Experiment 1. These indices were obtained for each subject by dividing the number of responses to the CS+ by the total number of responses to the CS- and CS+ for each day.


INDEX of DIFF. CS RESP.
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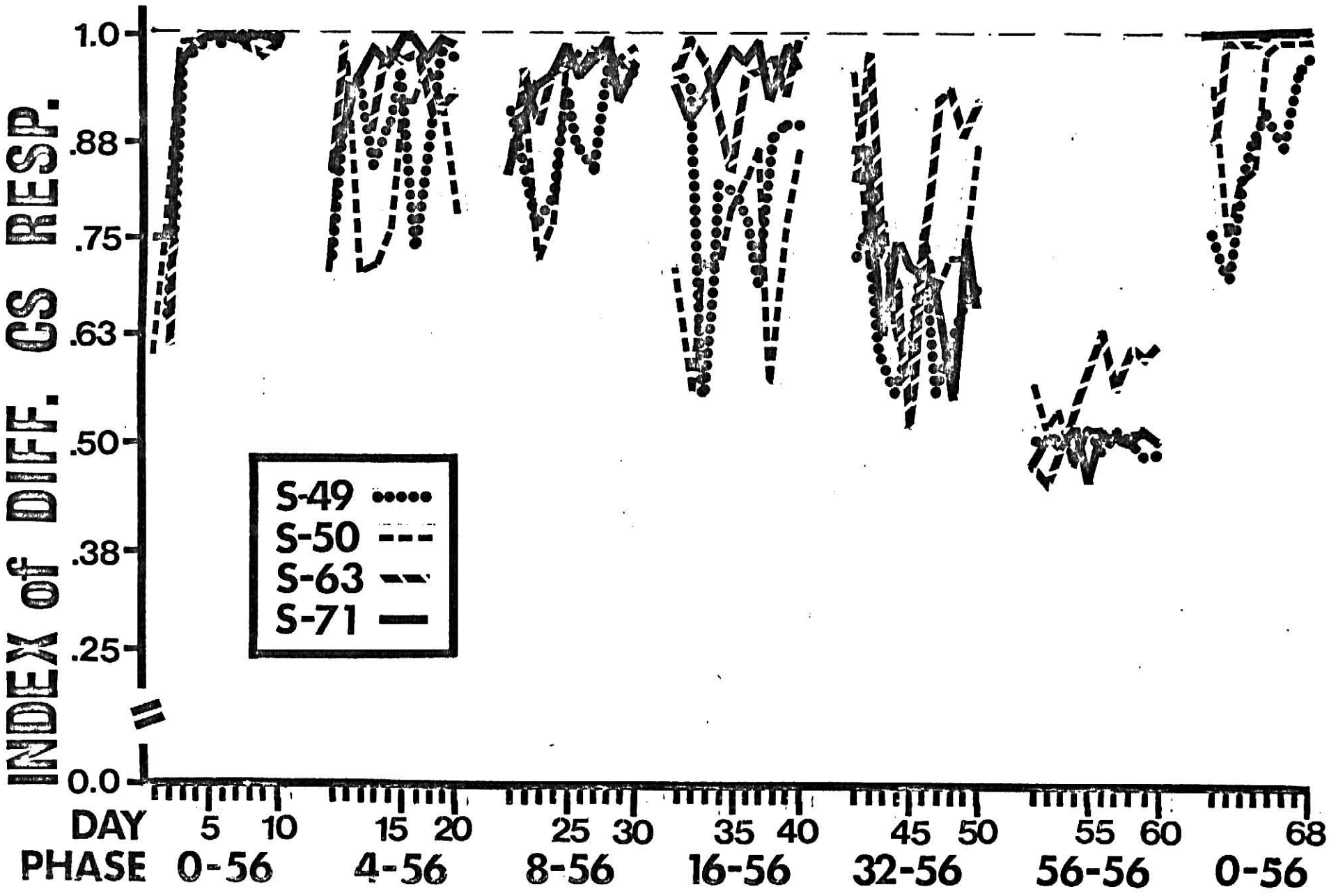
S-9
S-11
S-21
S-36
DAY 5 10 15 20 25 30 35 40 45 50 55 60 68
PHASE 0-56 4-56 8-56 16-56 32-56 56-56 0-56

Figure Caption

Figure 2b. Daily individual indices of differential CS responding in Squad 2 of Experiment 1. These indices were obtained for each subject by dividing the number of responses to the CS+ by the total number of responses to the CS- and CS+ for each day.


INDEX of DIFF. CS RESP.
1.0
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.25
0.0
S-49
S-50
S-63
S-71
DAY 5 10 15 20 25 30 35 40 45 50 55 60 68
PHASE 0-56 4-56 8-56 16-56 32-56 56-56 0-56

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TABLE 2

Mean responses per min for the last 4 days of each ITI condition to positive ITI and negative ITI for each subject of Experiment I

	0-56		4-56		8-56		16-56		32-56		56-56		0-56	
	neg. -	pos. +	neg. -	pos. +	neg. -	pos. +	neg. -	pos. +	neg. -	pos. +	neg. -	pos. +	neg. -	pos +
S-9	.109		0.0	.009	0.0	.054	0.0	.073	0.0	.099	0.0	.45	-	.027
S-11	.127		0.0	.082	0.0	.064	0.0	.073	.219	4.44	4.2	5.64	-	5.23
S-21	.916		0.0	79.375	.032	7.02	.53	11.29	.84	3.46	1.69	3.6	-	4.27
S-36	.154		0.0	5.759	.656	.054	0.0	.018	0.0	.254	0.0	.472	-	.209
S-49	1.134		1.375	13.88	6.375	47.367	6.125	58.458	13.172	40.039	31.275	29.963	-	59.438
S-50	.426		.375	2.06	0.0	3.375	1.03	.979	.219	.453	.028	1.16	-	.063
S-63	.544		0.0	.227	0.0	.027	0.0	.063	0.0	.045	0.0	8.375	-	0.0
S-71	5.05		0.0	11.96	.625	33.718	.187	20.713	.531	7.418	10.76	15.299	-125.75	

condition. It also presents daily individual rates of responding to the positive and negative ITI's for each of the last four days of each condition. It should be noted that except on the 56-56 sec condition the negative ITI was always of a shorter duration than the positive ITI. Since no separate measure was taken for the first period of the positive ITI equal in duration to the negative ITI, no statistical analyses were performed. As Table 2 depicts, little positive ITI responding occurred to the 0-56 sec ITI condition, and informal analysis of the data and observation of the birds revealed that when it occurred, over two thirds of it was confined to the last half of the positive ITI. This same patterning of positive ITI responding was present across conditions for all birds. The birds seemed to mediate time since CS- offset with typical behavior including avoidance of the key by walking or turning away from it after CS- offset and increased head bobbing and key orientation as the ITI progressed. Approximately 15 sec before onset of the R trial, the birds would generally move in closer to the key and head bob and/or peck on or near the key.

As the length of the negative ITI increased, the rate of negative ITI responding increased for four of the birds, but until the introduction of the 56-56 sec ITI condition, little negative ITI responding occurred in comparison to positive ITI responding. Examination of Table 2 also reveals that three subjects never responded to the negative ITI, three showed increased negative ITI responding as the negative ITI was increased, and two others showed no trend. In addition, ITI behavior did not correlate with CS responding.

Even though nondifferential responding to the CS's occurred on the 56-56 sec ITI condition for all except Bird 63 (see Figures 2a and 2b), a two-tailed t-test performed on the mean negative and positive ITI rates for each subject revealed a higher rate of responding to the positive ITI ($p < .01$). Only Bird 49 failed to respond more to the positive than negative ITI's on the 56-56 sec ITI condition.

Experiment II

Experiment I examined R and N trial stimulus aftereffects by increasing the negative ITI and holding the positive ITI constant until both ITI's were of equal duration. In contrast the 8 sec group of Experiment II began with equal ITI's between R-N and N-R trials, and these ITI's were successively increased until grain presentations were 60 sec apart (26-26 sec ITI condition) at which time nondifferential responding to the CS's occurred. Like Experiment I this group also received nondifferential CS presentations on R and N trials. Another nondifferential CS group the 14 sec group began with the equal ITI condition (14-14 sec) previous to the development of nondifferential R and N trial responding in the 8 sec group. The 14 sec group was changed from an equal (14-14) to an unequal ITI condition (14-56) to determine if the increase in the positive ITI would improve asymptotic performance. A third group, the differential cue group, in contrast to the other groups of Experiments I and II, received differential stimuli on R and N trials. This group served as a comparison condi-

tion for the 8 sec group to determine whether differential R and N trial responding would occur with a 24 sec IRI in the beginning of training and be maintained as the IRI and ITI's were lengthened. Failure to obtain marked differential responding with short IRI's would suggest that pigeons cannot discriminate between stimuli with response-independent food presentations occurring in close temporal proximity. Procedurally this group was otherwise similar to the 8 sec group, except that the differential cue group received additional training on a 56-56 sec ITI condition (120 sec IRI).

Method

Subjects

Twenty experimentally naive White King pigeons served as subjects. There were eight subjects each in the 8 sec and the 14 sec groups, and four subjects in the differential cue group. Maintenance of the subjects throughout Experiment II was identical to that of Experiment I.

Apparatus

Four plywood experimental chambers similar to those used in Experiment I were enclosed in separate sound-attenuating chambers. Masking noise ranged from 73 to 77 dB's in the individual chambers. Data was recorded on a Gerbrands six-channel event recorder, and the number of responses to the CS+, CS-, and total ITI responses were recorded separately on Sodeco counters. With the exception of response key transillumination, to be discussed below, all other apparatus details

were similar to Experiment I.

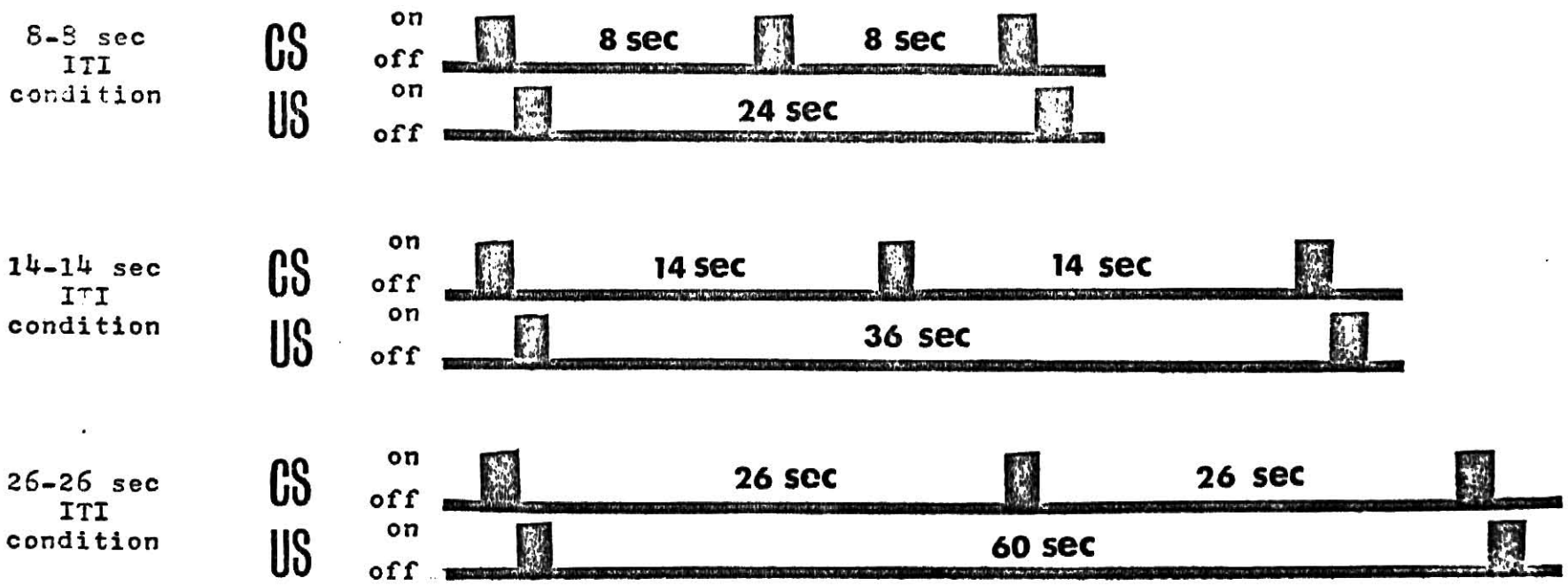
Training

The procedure used for feeder habituation in Experiment II was identical to that of Experiment I. No subjects were eliminated for failing to meet feeder habituation criteria and each phase of feeder training was successfully completed in one day by every bird.

Table 3a presents the training conditions for the 8 sec group. The procedure for this group differed from Experiment I in that the former started with 8-sec ITI's between feeder retraction and onset of the following stimulus on the key and between offset of the latter stimulus and onset of the next 4-sec CS. On Day 37 both of these 8-sec ITI's were simultaneously increased to 14 sec, lengthening the IRI from 24 to 36 sec. On Day 58 the ITI's were again simultaneously increased from 14 to 26 sec, increasing the IRI from 36 to 60 sec. Training continued for a total of 72 consecutive days. The number and order of daily CS presentations for all groups of Experiment II were identical to those of Experiment I. A procedural irregularity on Day 57 for Subject 737 consisted of intermittant feeder malfunction.

Experiment II differed from Experiment I in terms of the color of response-key transillumination. For Experiment I response-key illumination was blue for all subjects. However, for each subject in the 8 and 14 sec groups of Experiment II the response key was transilluminated either blue, red, yellow, or green with each subject receiving only one of these four

Table 3a
Summary of the procedure for the 8 sec group
(Not drawn to scale)

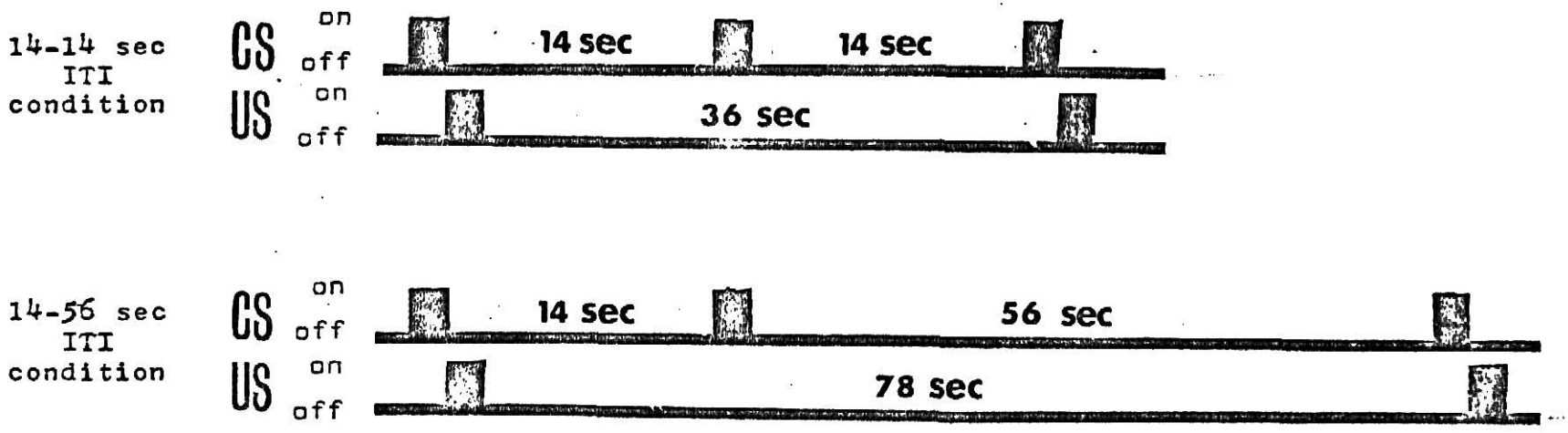


colors throughout training. Unpublished work (Perkins, personal communication) indicates that color of the CS is not an important determiner of rate of pecking in an autoshaping paradigm.

A second group, the 14 sec group, began with a 14-14 sec ITI condition. As Table 3b indicates, instead of simultaneously increasing the 14-14 sec ITI's to a 26-26 sec, the ITI's were changed to 14-56 sec to determine if increasing the positive ITI duration would improve performance. Subjects received 30 days of consecutive training on the 14-14 sec ITI condition and 18 days of consecutive training on the 14-56 sec ITI condition.

A third group, the differential cue group, served as a comparison condition for the 8 sec group to determine whether differential CS responding would be established with grain presentations occurring every 24 sec in the beginning of training (8-8 sec ITI condition) and be maintained as the ITI durations were increased. If responding occurred throughout the entire period between grain presentations or at least to CS presentations, then differential responding to differentially colored response-key presentations would be minimized. This differential cue group was similar to the 8 sec group with two exceptions: First, for the former the CS immediately preceding grain presentation was of a different color than was that following grain presentation (B-Y, R-B, G-R, or Y-G). Secondly, additional training was given on a 56-56 sec ITI

Table 3b
Summary of the prodedure for the 14 sec group
(Not drawn to scale)



condition with a 120 sec IRI. The only procedural irregularity was intermittant feeder malfunction on Day 17 for Subject 68. Subjects received a total of 24 days of training.

Results

The mean daily index of differential CS responding for all four birds in the differential cue group shown in Figure 3 reveals that performance was very similar for all conditions. Analysis of variance and post-tests on the treatments (Scheffe and planned orthogonal F comparisons) revealed no significant differences between conditions ($p > .05$). There were no significant interactions or main effect involving the days factor ($p > .05$). These results indicate that birds can easily discriminate between highly distinctive external stimuli in an autoshaping procedure when food presentations occur as often as every 24 sec; secondly, these conditions are conducive to maintenance of the same level of differential responding even though ITI's are increased.

Figure 4 presents the mean index of differential CS responding for each day for the 8 sec group. As Figure 4 depicts, indices of differential CS responding are inversely related to ITI duration, with nondifferential responding on the 26-26 sec ITI condition. This consistent decline contrasts to the findings of the differential cue group. With a 24 sec IRI (8-8 sec ITI condition) very few birds attained indices of 1.0 which were quite common for the differential cue group under similar ITI conditions.

Figure Caption

Figure 3. Mean index of differential CS responding for each day for the differential cue group. This index was obtained by averaging together the individual indices of differential CS responding (number of responses to CS+ divided by total number of responses to the CS- and CS+ for each day).

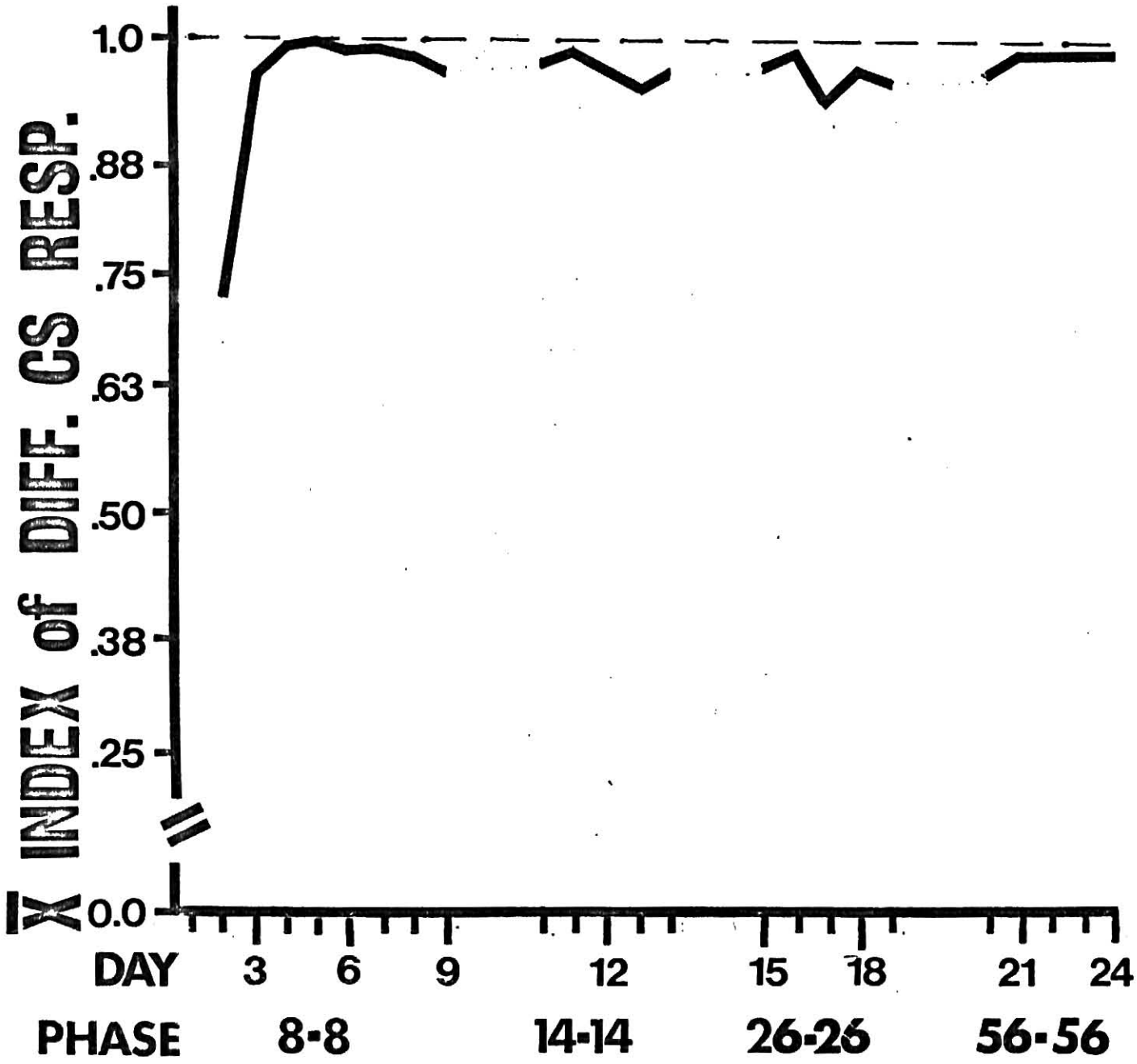
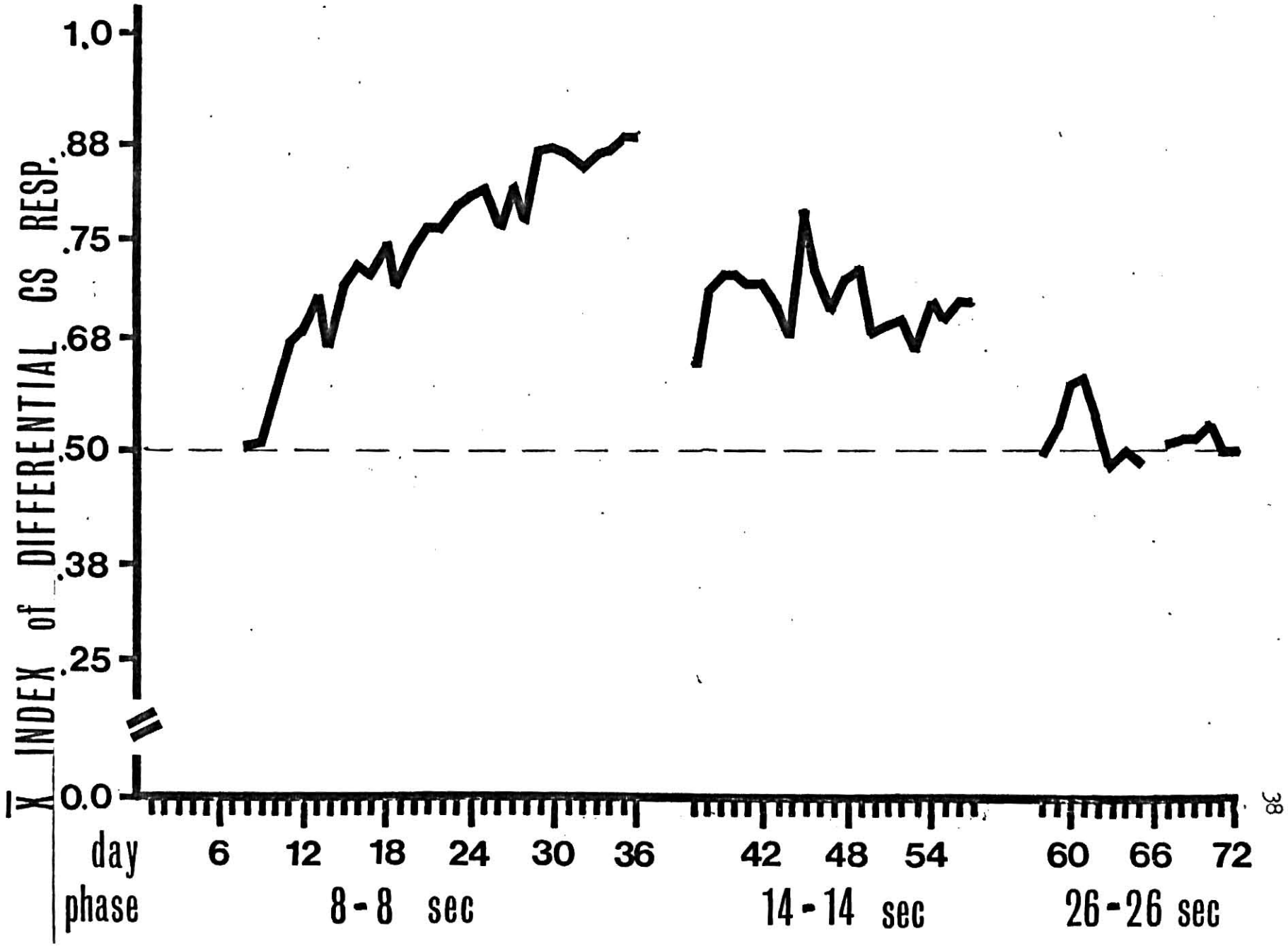

1.0
.88
.75
.63
.50
.38
.25
0.0
X INDEX of DIFF. CS RESP.
DAY
3
6
9
12
15
18
21
24
PHASE
8-8
14-14
26-26
56-56

Figure Caption

Figure 4. Mean index of differential CS responding for each day for the 8 sec group. This index was obtained by averaging together the individual indices of differential CS responding (number of responses to the CS+ divided by total number of responses to the CS- and CS+ for each day).


1.0
.88
.75
.68
.50
.38
.25
0.0
X INDEX of DIFFERENTIAL CS RESP.
day
6
12
18
24
30
36
42
48
54
60
66
72
phase
8-8 sec
14-14 sec
26-26 sec

Subject 30's data were not included in Figure 4 from Day 50 through the end of training. Observation revealed that most of his pecking during the CS+ was off the key and not recorded, although his observed behavior was in other respects similar to the other subjects'. His inclusion in calculation of the mean indices until Day 49 did not, however, appreciability affect the data plotted in Figure 4.

For reasons cited above Bird 30 was eliminated from ANOVA and treatments post-test analyses. No main effects or interactions involving days or squads were significant when a 2 x 3 x 4 (squads x treatments x days) ANOVA with repeated measures on the last two factors was performed on each subject's indices for the last four days of each condition. A significant treatments effect was obtained ($F = 8.25$, df 2,10, $p < .01$). Post-tests on the treatments factor disclosed that asymptotic indices were inversely related to ITI length: differential responding to R and N trials on the 8-8 sec ITI condition was significantly different from that on the 14-14 sec ITI condition, which was significantly different from the 26-26 sec ITI condition (multiple F comparisons, Scheffe comparisons, $p < .01$).

Figures 5a and 5b present indices of differential CS responding for the individual subjects in the 8 sec group. Subject 30's data are not included after Day 49. Individual differences indicated by these figures reflect that subjects were not equally sensitive to ITI increases.

The mean daily indices of differential CS responding for

Figure Caption

Figure 5a. Daily individual indices of differential CS responding for Squad 1 of the 8 sec group. These indices were calculated for each subject by dividing the number of responses to the CS+ by the total number of responses to the CS- and CS+ for each day.

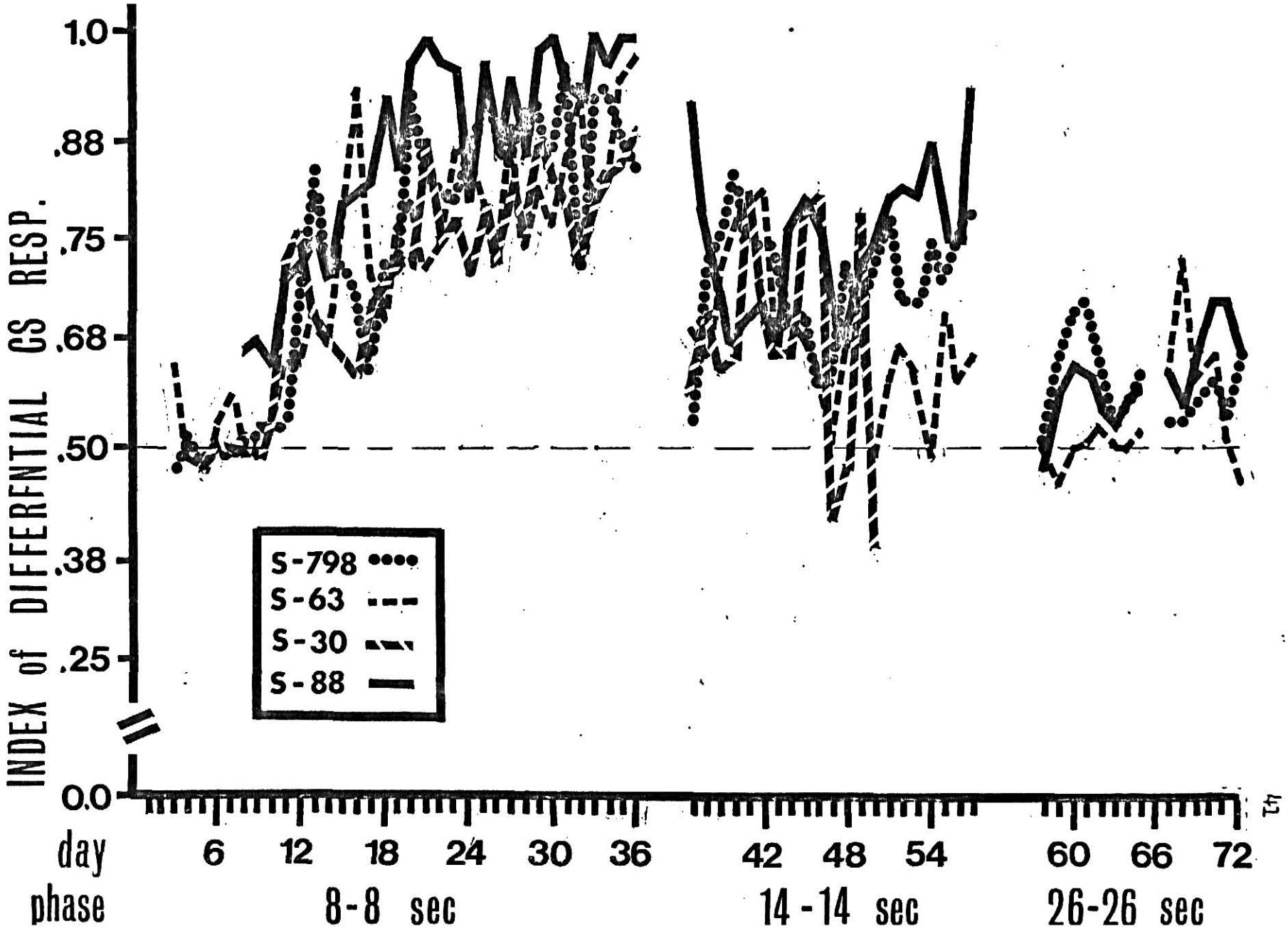
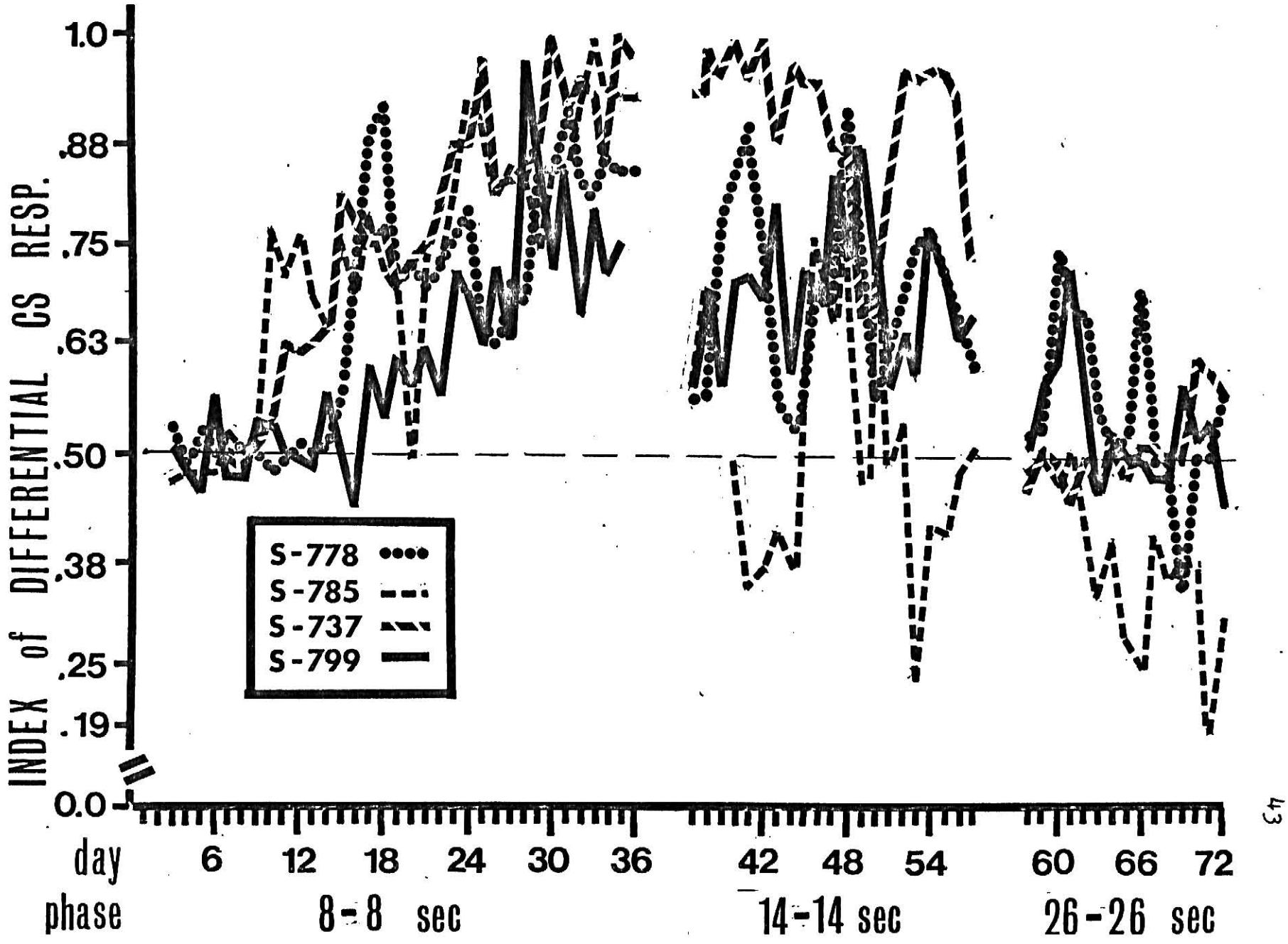

INDEX of DIFFERENTIAL CS RESP.
1.0
.88
.75
.68
.50
.38
.25
0.0
S-798
S-63
S-30
S-88
day
6
12
18
24
30
36
42
48
54
60
66
72
phase
8-8 sec
14-14 sec
26-26 sec

Figure Caption

Figure 5b. Daily individual indices of differential CS responding for Squad 2 of the 8 sec group. These indices were calculated for each subject by dividing the number of responses to the CS+ by the total number of responses to the CS- and CS+ for each day.


INDEX of DIFFERENTIAL CS RESP.
1.0
.88
.75
.63
.50
.38
.25
.19
0.0
S-778
S-785
S-737
S-799
day
6
12
18
24
30
36
42
48
54
60
66
72
phase
8-8 sec
14-14 sec
26-26 sec

the 14 sec group are presented in Figure 6. Due to off-key pecking to the CS+ Bird 10's data are not included from Day 37 through the end of training. In other respects his behavior was similar to the other subjects' and his inclusion up to this point was not solely responsible for the marked decrease in the indices when the 14-56 sec ITI condition was introduced. All of the birds evidenced nondifferential R and N trial responding on the first few days after ITI conditions were changed. Figures 7a and 7b present the daily individual indices and, again, individual differences are evident. A 2 x 2 x 4 (squads x treatments x days) ANCVA performed on the indices for the last four days of each condition disclosed no significant main effects or interactions involving either days or squads. A nonsignificant treatments effect ($F = 0.9$, df 1,5, $p > .05$) was obtained. A mean index for each subject for the last four days was obtained for the 14-14 sec ITI conditions of the 8 sec and 14 sec groups, and for the 14-56 sec ITI condition of the 8 sec group and the 16-56 sec ITI condition of Experiment I. Mann-Whitney U-tests showed that differential R and N trial responding on the 14-56 sec ITI condition was not reliably different from that of the 16-56 sec ITI condition of Experiment I ($U = 24$, $p > .05$). Likewise, differential responding of the 14 sec group on the 14-14 sec ITI condition did not differ from that of the 8 sec group on the 14-14 sec ITI condition ($U = 23$, $p > .05$).

ITI analyses

Event recordings for the last four days of each ITI condi-

Figure Caption

Figure 6. Mean index of differential CS responding for each day for the 14 sec group. This index was obtained by averaging together the individual indices of differential CS responding (number of responses to the CS+ divided by the total number of responses to the CS- and CS+ for each day).

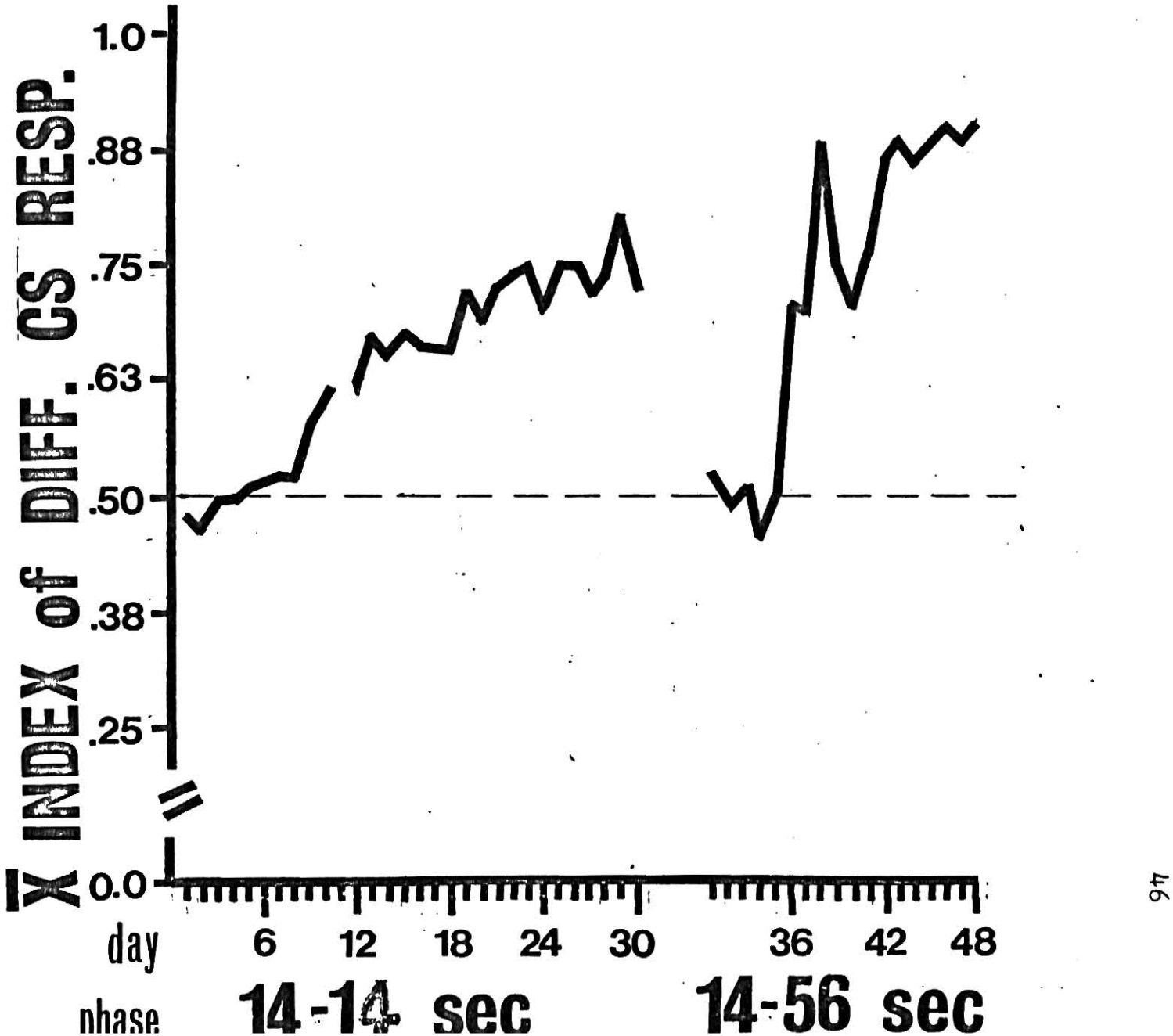

1.0
.88
.75
.63
.50
.38
.25
0.0
X INDEX of DIFF. CS RESP.
day
6
12
18
24
30
36
42
48
phase
14-14 sec
14-56 sec

Figure Caption

Figure 7a. Daily individual indices of differential CS responding for Squad 1 of the 14 sec group. These indices were calculated for each subject by dividing the number of responses to the CS+ by the total number of responses to the CS- and CS+ for each day.

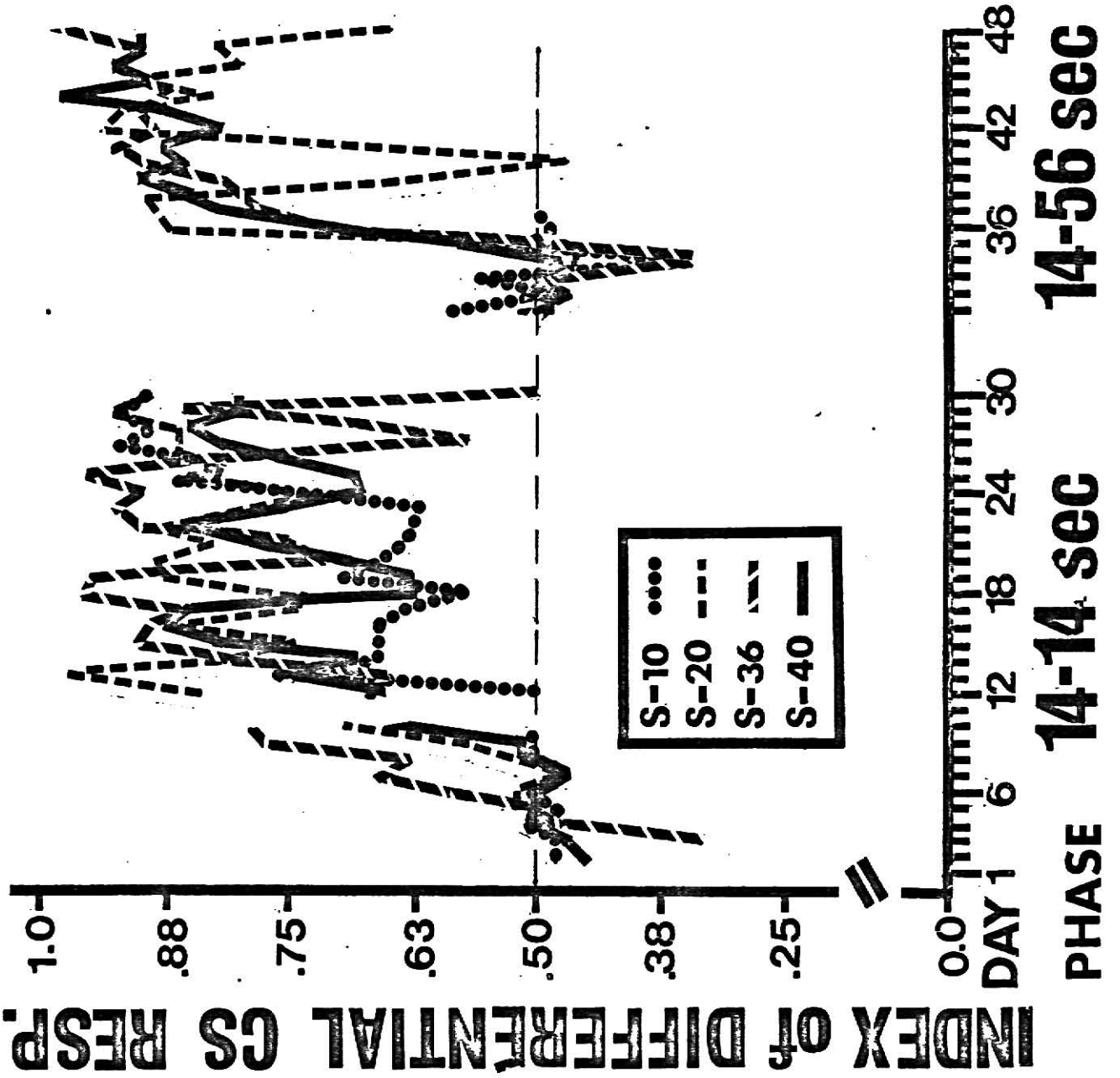
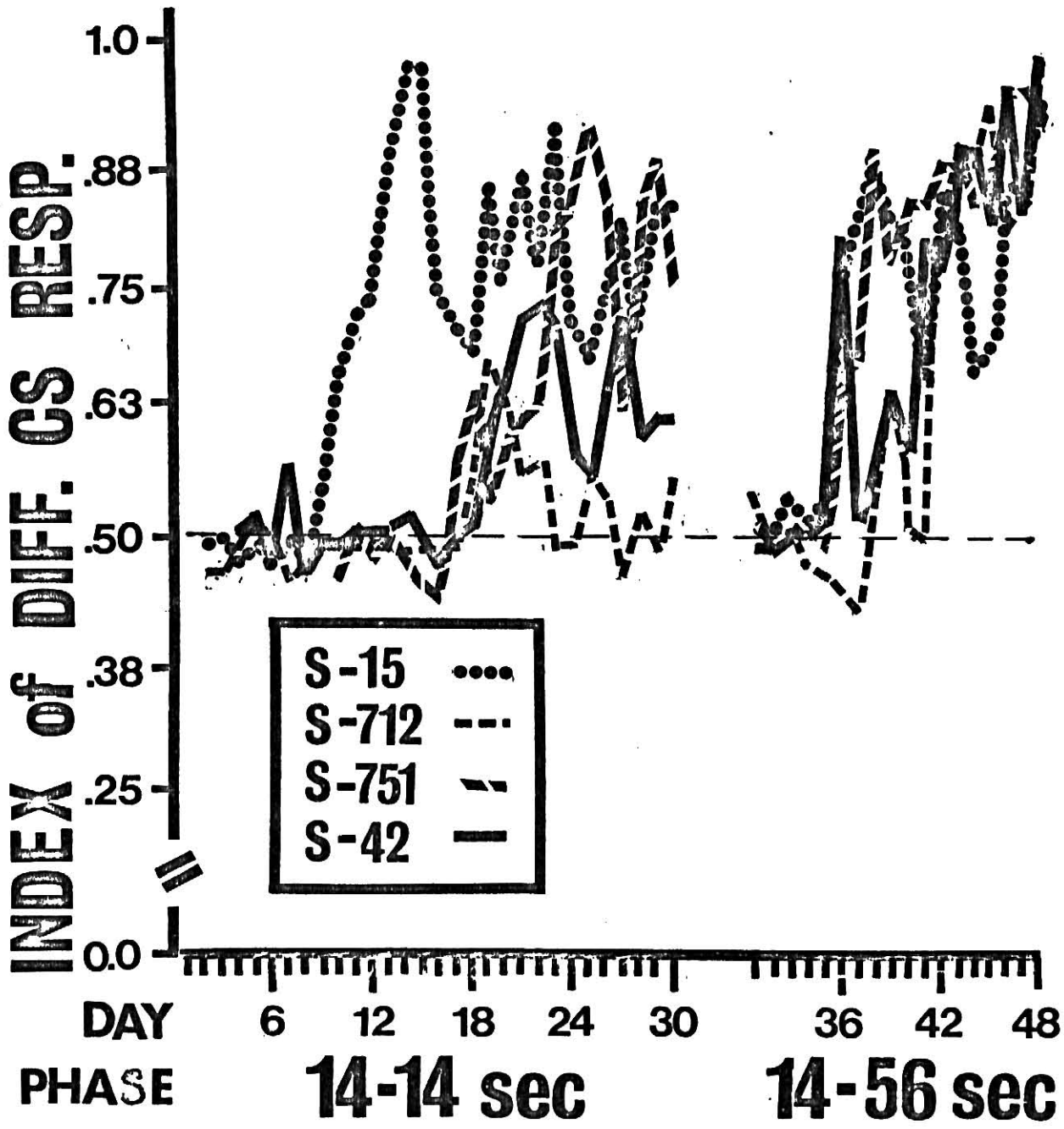

INDEX of DIFFERENTIAL CS RESP.
1.0
.88
.75
.63
.50
.38
.25
0.0
DAY 1
6
12
18
24
30
36
42
48
PHASE
14-14 sec
14-56 sec
S-10
S-20
S-36
S-40

Figure Caption

Figure 7b. Daily individual indices of differential CS responding for Squad 2 of the 14 sec group. These indices were calculated for each subject by dividing the number of responses to the CS+ by the total number of responses to the CS- and CS+ for each day.


INDEX of DIFF. CS RESP.
1.0
.88
.75
.63
.50
.38
.25
0.0
S-15
S-712
S-751
S-42
DAY
6
12
18
24
30
36
42
48
PHASE
14-14 sec
14-56 sec

tion were examined and a mean index of differential ITI responding was obtained for each subject by dividing the mean amount of negative ITI's on which there was at least one response by the sum of the mean number of occassions on which responding occurred to both the negative and positive ITI's. For all conditions except the 14-56 sec ITI condition of the 14 sec group, these data were obtained for equal negative and positive ITI conditions. It should be noted that this measure differs from the ITI rate measure used in Experiment I and the measure of differential responding to CS's. Each type of ITI occurred 29 times during a daily session. Tables 4, 5, and 6 present these data as well as the daily number of trials on which a subject responded at least once to the positive and negative ITI's for the differential cue group, the 8 sec group, and the 14 sec group, respectively.

Examination of the mean data presented in Table 4 for the differential cue group parallels the trend for positive ITI responding seen in Experiment I. With the exception of the 26-26 sec ITI condition, two-tailed multiple t-tests performed on the mean ITI indices described above showed that the birds responded to significantly more positive ITI's (8-8, $p < .01$; 14-14, $p < .05$; 26-26, $p > .05$; 56-56, $p < .01$). Although Bird 68, a low responder, deviated from this trend, the other three subjects of the differential group on the 26-26 sec ITI condition responded more to the positive than negative ITI's. Due to mechanical failure no data was available for the last session of the 8-8 sec ITI condition (Day 9) such that analyses for

TABLE 4

Daily indices and mean indices of differential ITI responding for the last four days of each ITI condition for each subject in the 8 sec group. Daily indices were calculated by dividing the number of negative ITI's on which there was at least one response by the sum of the number of negative and positive ITI's to which there was at least one response. No data was available for Day 9 of the 8-8 sec ITI condition.

ITI Condition		8-8					14-14					26-26					56-56				
	Day	6	7	8	9	$\bar{X}$	11	12	13	14	$\bar{X}$	16	17	18	19	$\bar{X}$	21	22	23	24	$\bar{X}$
Subject																					
29	-ITI	2	7	1	-	3.33	20	14	11	16	15.25	8	17	18	16	14.75	9	8	14	14	11.25
	+ITI	19	25	9	-	17.67	28	26	24	26	26.0	17	16	22	21.0	19.0	12	13	18	16	14.75
51	-ITI	29	22	13	-	21.3	21	21	21	19	20.5	2	1	0	1	1.0	28	29	27	28	28.0
	+ITI	29	29	29	-	29.0	29	28	28	29	28.5	9	7	9	9	8.5	29	29	29	29	29.0
68	-ITI	0	0	0	-	0	0	0	0	0	0	0	0	1	1	.5	8	2	1	10	5.25
	+ITI	0	0	0	-	0	6	3	3	3	3.75	1	0	0	0	.25	23	1	3	15	10.5
70	-ITI	25	20	12	-	19.0	28	23	15	12	19.5	14	9	20	19	15.5	4	20	8	19	12.75
	+ITI	29	28	29	-	28.67	29	29	29	29	29.0	23	24	28	26	25.25	6	29	18	29	20.5

TABLE 5

Daily indices and mean indices of differential ITI responding for the last four days of each ITI condition for each subject in the 8 sec group. Daily indices were calculated by dividing the number of negative ITI's on which there was at least one response by the sum of the number of the negative and positive ITI's to which there was at least one response. Blank entries indicate unavailability of data.

	ITI Condition	8-8					14-14					26-26				
	Day	33	34	35	36	$\bar{X}$	54	55	56	57	$\bar{X}$	69	70	71	72	$\bar{X}$
Subject																
798	-ITI	0	0	0	0	0	0	0	0	0	0	1	-	1	-	1
	+ITI	1	1	1	1	1	2	3	1	1	1.75	5	-	1	-	3
63	-ITI	2	0	3	0	1.25	2	3	1	0	1.5	13	-	8	-	10.5
	+ITI	23	29	26	29	26.75	5	10	8	4	6.75	27	-	29	-	28
30	-ITI	-	0	1	0	.33	1	0	0	0	.25	3	-	0	-	1.5
	+ITI	-	29	14	4	15.67	2	0	0	0	.5	7	-	5	-	6
88	-ITI	4	0	2	0	1.5	3	1	4	3	2.75	7	-	5	-	6
	+ITI	29	28	29	29	28.75	19	24	19	29	22.75	28	-	29	-	28.5
778	-ITI	0	0	1	0	.25	1	2	2	0	1.25	6	7	-	19	10.67
	+ITI	3	0	1	1	1.25	8	14	6	3	7.75	27	27	-	29	27.67
785	-ITI	1	0	5	5	2.75	1	0	1	1	.75	3	2	-	12	5.67
	+ITI	29	29	29	29	29	3	1	1	6	2.75	14	23	-	24	20.3
737	-ITI	-	0	0	0	0	0	0	0	3	.75	0	0	-	0	0
	+ITI	-	5	6	6	5.67	0	0	0	2	.5	0	0	-	0	0
799	-ITI	0	0	0	0	0	0	0	0	0	0	0	0	-	-	0
	+ITI	0	0	0	0	0	0	0	0	0	0	0	0	-	-	0

TABLE 6

Daily indices and mean indices of differential ITI responding for the last four days of each ITI condition for each subject in the 14 sec group. Daily indices were calculated by dividing the number of negative ITI's on which there was at least one response by the sum of the number of the negative and positive ITI's to which there was at least one response.

	ITI Condition	14-14					14-56				
	Day	27	28	29	30	$\bar{X}$	45	46	47	48	$\bar{X}$
Subject											
10	-ITI	9	7	3	12	7.75	0	0	1	0	.25
	+ITI	26	16	16	15	18.25	20	16	12	19	16.75
20	-ITI	1	1	2	2	1.5	0	0	0	0	0
	+ITI	22	25	26	26	24.75	29	29	29	29	29
36	-ITI	2	1	0	0	.75	0	0	0	0	0
	+ITI	0	0	0	1	.25	2	0	0	0	.5
40	-ITI	0	0	0	0	0	0	0	0	1	.25
	+ITI	0	0	0	1	.25	17	17	9	22	16.25
15	-ITI	3	7	0	5	3.75	12	3	3	2	5.0
	+ITI	27	29	29	29	28.5	29	29	29	28	28.75
712	-ITI	13	0	2	2	4.25	3	2	4	0	2.25
	+ITI	25	29	28	29	27.75	29	29	29	29	29
751	-ITI	5	6	1	0	3.0	1	3	0	1	1.25
	+ITI	3	3	0	0	1.5	28	29	25	29	27.75
42	-ITI	8	4	1	0	3.25	4	4	3	0	2.75
	+ITI	29	28	29	28	28.5	29	29	29	29	29

this condition was based on three instead of four days.

Positive ITI responding for the differential cue group was not primarily confined to the second half of the positive ITI as in Experiment I nor was it inhibited during the first few seconds after CS- offset. Typically, if there was responding during the positive ITI, it began at CS- offset and continued throughout the interval. Bird 68 was the sole exception in that he made few ITI responses and maintained no consistent negative or positive ITI response patterning on the 8-8 sec and 26-26 sec ITI conditions. On the 14-14 sec ITI condition, however, what few responses he made to the positive ITI's were confined to the period just before CS+ onset.

In contrast to the negative ITI results of the other groups of this study, Table 4 indicates that Birds 29 and 70 of the differential cue group responded a great deal to the negative ITI. When these birds pecked during the negative ITI they pecked throughout the CS+, negative and positive ITI's, but seldom to the CS-. Bird 15 of the 14 sec group was the only other bird to demonstrate this type of ITI responding which occurred on five R-N-R trial sequences on Day 30.

As seen in Table 5 little negative ITI responding occurred for the 8 sec group in contrast to the differential cue group and the birds responded to significantly more positive ITI's for all conditions (two-tailed t-tests, $p < .01$). Informal analyses revealed that although positive ITI responding was generally inhibited only for the first few seconds following CS- offset, Birds 30 and 778 confined almost all of their

positive ITI responding to the last half of the positive ITI. The latter pattern of positive ITI responding is similar to that of Experiment I.

Due to mechanical failure and experimenter error, the above analyses for the 8 sec group were based on data of either two or three of the last four days for the 26-26 sec ITI condition and on three days for Birds 737 and 30 for the 8-8 sec ITI condition as Table 5 indicates. Responding on these days was similar enough to that of the last six days on which event recording were available for these conditions to yield a reasonably accurate estimate of the birds' ITI behaviors.

Consistent with the positive ITI results from the other groups of Experiments I and II, multiple t-tests performed on the mean indices for each subject in Table 6 demonstrated that the 14 sec group responded significantly more to the positive than negative ITI's on the 14-14 ($p < .05$) and the 14-56 sec ($p < .01$) sec ITI conditions. Like the 8 sec group their was no consistent patterning of negative ITI responding.

The pattern of positive ITI responding on the 14-14 sec ITI condition was similar to the pattern of responding obtained for the 8 sec group. Responding began at or soon after CS- offset and continued throughout the interval. In contrast, the pattern of positive ITI responding seen in Experiment I was present on the 14-56 sec ITI condition in that more than half of the responding occurred to the second half of the positive ITI.

TABLE 7

Summary of Results of Experiments I and II

Experiment	CS condition	Training	CS results	ITI results
I	nondifferential	0-56; 4-56; 8-56; 16-56; 32-56; 56-56; 0-56	Differential responding to R and N trials decreased as the negative ITI was increased. Original behavior was recovered when the 0-56 sec ITI condition was reintroduced.	For all conditions there was more responding to the positive than negative ITI's. Two-thirds or more of positive ITI responding occurred in the second half of the positive ITI.
II	differential	8-8; 14-14; 26-26; 56-56	No decrease in differential R and N trial responding as ITI's were increased.	In general, more responding to the positive than negative ITI's. Two birds responded to both ITI's, R trials, but not on N trials.
8 sec group	nondifferential	8-8; 14-14; 26-26	Decrease in differential R and N trial responding as ITI's were increased.	More responding to positive than negative ITI's; two birds responded more during second than first half of positive ITI's; other 6 responded at CS- offset.

TABLE 7 (continued)

Experiment	CS condition	Training	CS results	ITI results
14 sec group	nondifferential	14-14; 14-56	Similar behavior on both ITI conditions.	More responding to positive than negative ITI's. Positive ITI responding on 14-14 sec ITI condition like that of 8 sec group; positive ITI responding on 14-56 sec ITI condition like that of Experiment I.

DISCUSSION

For the equal ITI conditions differential R and N trial responding was inversely related to increases in ITI length. In addition, previous equal ITI training did not alter the obtained degree of differential R and N trial responding when the negative and positive ITI's were each of 14 sec duration (8 and 14 sec groups). This effect of trial massing is similar to that of the response-dependent runway studies when odor is controlled (Katz, Woods, & Carrithers, 1966) and to the difference between the studies of Holmes and Gormezano (1970) and Poulos, Sheafor, and Gormezano (1971) using a classically conditioned jaw movement in the rabbit as the conditioned response. However, for the latter two studies the length of the variable intertrial interval was confounded with US magnitude.

According to Capaldi (1967) the aftereffects of the presence or absence of reward serve as the principal cue for differential R and N trial responding. The effect of trial massing in the present study may be explained if one assumes that the distinctiveness of these R and N trial aftereffects decreases with the passage of time. However, the present equal ITI results do not rule out an explanation based on an increasing probability of responding as a positive function of time since the last reinforcement. The responding obtained for any one ITI condition could be thus accounted for, and the decrease in differential R and N trial responding as the ITI's

were increased could be due to increased time since last reinforcement. However, the immediacy with which most birds began responding at the beginning of the positive ITI following N trial offset and the contrast in the observed behaviors following offset of the N trial as compared to offset of the R trial is suggestive, but not conclusive evidence, that the after-effects of an R and N trial served as important cues for differential ITI responding for equal ITI conditions.

As compared with the equal ITI conditions the additional cue of time since last trial was present for the unequal ITI conditions. The addition of this time cue may have been primarily responsible for the improved differential responding in Experiment I. For the time parameters used in the present study for the unequal ITI conditions, the duration of the negative ITI was less than that of the positive ITI, suggesting that the relative proportion of negative to positive ITI duration may be important in facilitating R and N trial responding. This could be examined by using ITI and IRI time parameters longer and shorter than the ones used in the present study and varying the ratio of the negative and positive ITI durations. It is not known if results similar to those obtained in the present unequal ITI durations would be obtained if the negative ITI were longer than the positive ITI.

Two explanations similar to those offered for the equal ITI results may be offered for the obtained differential ITI and R and N trial responding and the patterning of the positive ITI responding of the unequal ITI conditions. Both the latter

ITI and differential R and N trial responding can be accounted for if one assumes that the probability of responding increases with time since last reinforcement. An explanation in terms of the aftereffects of presence or absence of food on the previous trial also applies here. A third explanation of the obtained responding based on the time since the last trial is also applicable to the unequal ITI conditions. The birds may be using as a basis for their responding the rule that they do not respond after each trial for a period equal to or greater than the length of the negative ITI. As the negative ITI approaches the positive ITI in duration, differential R and N trial responding on the basis of such cues would become impossible. The decrease or lack of differential R and N trial responding would then be accounted for by assuming that the distinctiveness of R and N trials decreases with time.

It should be noted that all of the above cues--time since reinforcement, time since last trial, presence or absence of food--were present in the unequal ITI conditions and may have been used as cues for responding. Although the present study does not separate out the relative importance of these cues for differential ITI and R and N trial responding, use of a condition in which the negative ITI is 56 sec and the positive ITI 14 sec (56-14 sec ITI condition) would. The ITI preceding the N trial (56 sec) is the longer for the latter condition, in contrast to the procedure used for the unequal ITI conditions in the present study. If the relative difference in

negative and positive ITI durations is important in facilitating differential R and N trial responding, then differential CS responding similar to that obtained for the 16-56 sec ITI condition of Experiment 1 and the 14-56 sec ITI condition of the 14 sec group is expected. If the birds are responding primarily on the basis of time since the last trial, responding should begin approximately 14 sec after grain retraction (R trial offset). If the time since reinforcement is a more important determiner of responding, then an increasing amount of responding or at least some responding should occur to the latter half of the negative ITI preceding the onset of the N trial. If the tendency to autopeck increases as time since reward increases, an increase in responding to the CS- as compared with that obtained for the present study for the 14-56 and 16-56 sec ITI conditions is also expected.

The off-key pecking to the CS+ which developed in some of the birds in this study occurred frequently enough to be worthy of future investigation. A change in stimulus conditions in the form of ITI length or feeder malfunction correlated with the development of this behavior in the present study. Wasserman (1973) has likewise reported off-key pecking in one bird when stimulus conditions were changed from a response-key illumination, no house light condition to a response-key illumination plus house light condition. In pilot work for Experiment 1 of the present study, one bird began off-key pecking after the negative ITI was increased from 0 to 4 sec. Similar results were obtained for subject 9 of Experiment 1,

Subject 30 of the 8 sec group, and ubject 10 of the 14 sec group when stimulus conditions were changed. The development of off-key pecking to the CS+ also correlated with feeder malfunction in preliminary work for Experiment 1 and may have been involved in the development of off-key pecking to the CS+ for Subject 30 of the 8 sec group. A similar change in the keypecking topography was noted by Dunham, Mariner, and Adams (1969). They punished on-key pecking and obtained a general enhancement in off-key pecking for most birds tested. In both cases the tendency to autopeck in a food related situation remained although a change in the autopeck topography occurred.

It is interesting to note that for all birds who off-key pecked, the off-key responding developed only to the CS+ and not to the CS-, with the degree of off-key pecking ranging from slight in some instances to almost total in others. Frequent observation of all groups revealed that if responding to the CS- occurred, the pecking was directed at and struck the key in all cases. It was not uncommon for off-key pecking to the CS+ to be followed by on-key pecking to the CS- on the next N trial.

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APPENDIX A

Total number of daily responses to the CS+ and CS- for Experiment I.
To obtain responses per min, divide each entry by 2.0.
Blanks indicate that data was unavailable
or incorrectly recorded.

Squad I		0-56 ITI condition										4-56 ITI condition						
Day		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
S-9	CS+	0	70	172	186	154	212	232	159	139	172	198	181	188	217	249	227	209
	CS-	0	44	38	3	1	3	0	0	2	0	19	10	16	4	53	30	7
S-11	CS+	19	216	220	221	243	232	234	254	245	222	239	209	238	261	232	193	178
	CS-	57	86	18	1	0	0	0	25	5	3	25	9	78	44	27	37	6
S-21	CS+	50	295	288	230	266	292	279	252	238	234	313	317	290	302	291	303	339
	CS-	79	248	61	0	0	0	13	1	18	9	57	13	17	4	1	17	17
S-36	CS+	78	89	103	127	93	88	87	107	136	127	137	84	129	215	210	254	256
	CS-	46	16	0	1	0	3	5	1	0	0	175	125	57	186	84	47	48

APPENDIX A (continued)

Squad I (continued) 4-56		8-56 ITI condition													16-56	
Day		18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
S-9	CS+	210	219	224	193	240	226	217	175	197	190	-	166	171	211	177
	CS-	13	9	3	36	51	1	2	0	3	21	-	24	16	47	21
S-11	CS+	189	250	222	176	168	145	140	120	123	90	-	86	127	78	102
	CS-	2	19	4	56	22	13	22	10	7	10	-	10	2	24	20
S-21	CS+	336	340	323	311	322	310	308	289	240	252	236	269	296	299	266
	CS-	3	24	36	66	7	3	3	1	0	22	53	18	2	26	241
S-36	CS+	267	236	261	306	310	247	247	251	220	204	156	227	197	227	197
	CS-	26	14	21	63	10	17	20	15	24	33	16	16	37	63	58

APPENDIX A (continued)

Squad I (continued)		16-56 ITI condition								32-56 ITI condition						
Day		33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
S-9	CS+	163	169	114	119	118	140	103	117	138	98	111	131	140	131	111
	CS-	16	12	2	3	2	56	40	8	132	46	16	13	40	25	45
S-11	CS+	118	117	116	102	72	102	104	153	150	130	104	94	113	98	136
	CS-	42	63	24	19	24	14	12	15	145	123	71	33	66	48	55
S-21	CS+	273	250	274	272	306	290	284	286	286	274	260	195	183	91	108
	CS-	266	219	103	38	127	121	43	49	130	201	71	71	126	58	81
S-36	CS+	202	220	274	209	253	259	254	216	185	163	153	177	184	138	117
	CS-	60	37	28	12	1	43	21	5	148	137	172	130	164	135	109

APPENDIX A (continued)

Squad I (continued)

		32-56			56-56 ITI condition									0-56	
Day		48	49	50	51	52	53	54	55	56	57	58	59	60	61	62
S-9	CS+	146	79	153	187	119	121	160	214	150	177	201	121	92	139	123
	CS-	61	17	47	129	105	53	106	100	118	154	160	175	92	1	0
S-11	CS+	121	107	113	104	167	177	130	129	134	137	177	141	148	172	131
	CS-	129	58	90	87	163	189	174	107	161	145	180	161	147	0	1
S-21	CS+	156	156	133	119	103	130	171	164	150	159	173	148	137	198	175
	CS-	64	46	37	125	106	110	188	199	166	204	201	117	180	38	12
S-36	CS+	120	114	132	99	129	161	165	62	93	87	148	140	108	182	160
	CS-	171	194	158	147	139	176	143	94	113	117	178	160	116	5	2

APPENDIX A (continued)

Squad I (continued) 0-56 ITI condition

Day		63	64	65	66	67	68
S-9	CS+	69	59	43	21	42	41
	CS-	10	5	3	28	15	9
S-11	CS+	193	145	190	209	207	179
	CS-	0	0	3	3	2	0
S-21	CS+	204	212	260	179	198	225
	CS-	1	4	4	2	0	5
S-36	CS+	161	229	270	252	237	250
	CS-	8	0	0	0	1	1

APPENDIX A (continued)

Squad II		0-56 ITI condition										4-56 ITI condition						
Day		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
S-49	CS+	0	135	131	143	171	182	182	176	206	277	323	333	334	336	335	325	373
	CS-	0	76	5	5	1	3	0	0	0	0	135	28	26	61	40	16	130
S-50	CS+	135	302	326	338	356	356	397	387	382	389	360	375	391	373	340	386	342
	CS-	95	101	2	1	0	1	0	0	0	0	153	19	166	149	114	36	34
S-63	CS+	0	100	133	217	246	280	324	307	331	321	344	363	309	343	342	379	358
	CS-	0	67	22	3	4	5	4	6	11	4	59	6	27	43	10	14	10
S-71	CS+	73	138	188	192	177	229	238	266	242	241	254	199	217	218	246	264	252
	CS-	25	46	11	4	0	0	1	0	0	1	47	28	17	4	12	4	1

APPENDIX A (continued)

Squad II (continued) 4-56					8-56 ITI condition									16-56	
Day		18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
S-49	CS+	381	394	379	394	407	420	398	416	425	405	411	413	404	412	428
	CS-	65	12	13	45	74	128	102	37	66	74	29	38	25	24	40
S-50	CS+	350	332	318	330	369	371	348	399	382	390	400	367	355	346	335
	CS-	18	33	85	58	35	161	102	25	10	7	16	16	9	146	240
S-63	CS+	364	378	389	406	431	440	445	447	424	435	461	470	468	475	527
	CS-	24	46	35	74	24	51	22	18	19	8	12	19	19	29	2
S-71	CS+	249	267	273	262	267	278	265	261	289	284	296	228	223	244	198
	CS-	14	2	5	51	35	21	17	5	16	10	3	22	9	20	21

APPENDIX A (continued)

Squad II (continued)		16-56 ITI condition								32-56 ITI condition						
Day		33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
S-49	CS+	416	412	416	411	391	419	441	432	420	420	401	379	407	385	381
	CS-	347	90	98	115	185	56	51	48	154	127	277	324	274	134	326
S-50	CS+	321	309	312	306	325	295	301	307	247	254	226	224	193	195	286
	CS-	139	119	84	64	55	230	90	50	212	96	64	132	146	72	139
S-63	CS+	497	512	466	503	483	493	505	517	518	524	465	490	191	184	230
	CS-	23	188	80	41	29	19	44	8	103	17	176	231	178	57	22
S-71	CS+	219	228	216	205	237	222	232	221	200	178	194	184	180	170	148
	CS-	21	15	4	8	3	22	4	11	34	29	115	65	74	81	84

APPENDIX A (continued)

Squad II (continued)		32-56			56-56 ITI condition										0-56	
Day		48	49	50	51	52	53	54	55	56	57	58	59	60	61	62
S-49	CS+	183	299	397	400	355	354	279	312	333	337	371	328	360	383	408
	CS-	124	165	183	392	338	356	292	294	349	327	370	341	376	119	181
S-50	CS+	275	206	202	279	334	328	281	261	350	372	319	329	313	283	342
	CS-	100	76	26	220	320	290	316	243	328	354	315	303	311	25	114
S-63	CS+	292	277	333	333	301	324	367	344	359	371	387	252	303	259	238
	CS-	25	39	32	361	355	344	326	257	224	302	264	180	197	36	3
S-71	CS+	129	151	129	158	163	176	196	181	157	142	159	151	137	163	182
	CS-	109	51	70	169	158	176	182	210	151	135	157	148	135	0	0

APPENDIX A (continued)

Squad II (continued) 0-56 ITI condition

Day		63	64	65	66	67	68
S-49	CS+	413	375	420	392	390	407
	CS-	100	51	45	60	26	16
S-50	CS+	313	320	371	339	328	304
	CS-	63	56	6	2	3	2
S-63	CS+	276	260	250	262	288	230
	CS-	1	1	0	0	0	0
S-71	CS+	133	118	138	152	121	147
	CS-	0	1	0	0	0	0

APPENDIX B

Total number of daily responses to the CS+ and CS- for the differential cue group. To obtain responses per min, divide each entry by 2.0.

		8-8 ITI condition									14-14 ITI condition				
Day		1	2	3	4	5	6	7	8	9	10	11	12	13	14
S-29	CS+	0	1	15	87	184	299	317	192	223	183	260	250	233	199
	CS-	1	6	2	2	1	1	1	1	0	2	2	3	9	3
S-51	CS+	0	1	141	243	255	264	286	272	313	305	296	272	275	285
	CS-	0	1	16	7	6	9	5	12	10	7	4	8	12	0
S-68	CS+	52	77	45	47	69	72	103	90	93	67	82	91	49	79
	CS-	17	17	0	0	0	0	0	0	1	1	0	0	0	0
S-70	CS+	0	87	218	260	297	306	308	311	325	317	325	296	269	290
	CS-	0	7	0	5	10	15	10	27	42	23	17	44	47	75

APPENDIX B (continued)

		26-26 ITI condition						56-56 ITI condition			
Day		15	16	17	18	19	20	21	22	23	24
S-29	CS+	208	195	199	208	272	226	243	218	216	185
	CS-	2	2	1	3	2	0	2	8	13	1
S-51	CS+	282	191	156	104	60	242	252	218	248	235
	CS-	5	0	0	0	0	2	12	3	2	1
S-68	CS+	67	40	39	60	65	52	76	98	83	38
	CS-	0	0	13	9	7	10	1	0	0	0
S-70	CS+	243	248	253	237	116	134	109	239	187	280
	CS-	38	21	14	19	18	7	0	7	1	16

APPENDIX C

Total number of daily responses to the CS+ and CS- for the 8 sec group.
To obtain responses per min, divide each entry by 2.0.
Blanks indicate that data was unavailable or incorrectly recorded.

Squad I — 8-8 ITI condition

Day		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
S-798	CS+	4	2	25	168	285	296	293	321	358	308	315	333	354	356	340	347	297
	CS-	0	1	27	154	295	295	302	320	333	269	278	192	66	154	146	162	216
S-63	CS+	0	-	167	161	193	175	210	191	236	245	237	193	220	225	246	254	231
	CS-	0	-	123	166	206	163	182	198	219	229	169	137	116	136	72	25	103
S-30	CS+	0	0	0	5	25	163	285	395	477	405	354	395	382	429	438	490	473
	CS-	0	0	0	3	27	158	284	367	487	366	143	128	103	239	298	352	248
S-88	CS+	0	0	0	0	0	0	5	77	248	299	311	307	342	349	376	411	389
	CS-	0	0	0	0	0	0	8	49	155	208	137	126	112	150	105	108	91

APPENDIX C (continued)

Squad I (continued) — 8-8 ITI condition

Day		18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
S-798	CS+	339	314	273	271	324	316	292	312	312	268	309	299	315	292	255	288
	CS-	139	137	27	52	73	79	55	63	2	49	38	34	55	14	97	30
S-63	CS+	257	228	242	225	225	237	234	234	238	184	244	242	247	243	229	241
	CS-	144	68	61	83	77	39	35	57	87	22	84	53	76	41	20	57
S-30	CS+	504	440	380	334	362	357	331	318	346	376	359	358	369	354	350	328
	CS-	212	166	149	52	123	109	140	83	127	83	115	54	79	88	137	85
S-88	CS+	405	370	311	322	291	279	253	303	357	371	126	362	411	386	408	412
	CS-	42	74	16	7	15	19	69	15	69	27	384	8	1	39	46	2

APPENDIX C (continued)

Squad I (continued) 8-8 14-14 ITI condition

Day		34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49
S-798	CS+	273	292	309	318	297	266	227	278	273	271	258	247	275	242	247	268
	CS-	25	35	56	279	111	84	47	94	96	96	145	140	216	194	103	132
S-63	CS+	218	233	239	260	237	267	266	273	276	275	286	281	219	276	259	294
	CS-	43	18	9	152	150	106	74	69	61	164	163	175	156	269	164	158
S-30	CS+	351	333	346	364	355	235	256	188	91	57	29	51	43	25	24	31
	CS-	65	57	45	300	199	171	172	44	37	40	20	14	11	34	26	9
S-88	CS+	400	427	423	397	400	357	331	328	322	328	353	383	343	359	399	427
	CS-	16	4	5	40	108	172	219	183	166	202	111	96	107	183	279	187

APPENDIX C (continued)

Squad I (continued)		14-14 ITI condition								26-26 ITI condition				
Day		50	51	52	53	54	55	56	57	58	59	60	61	62
S-798	CS+	240	265	257	260	251	249	247	235	253	239	232	270	269
	CS-	90	75	127	136	84	112	77	61	229	171	123	130	190
S-63	CS+	204	288	265	219	109	167	162	75	277	260	271	274	312
	CS-	214	224	187	165	115	91	128	54	275	301	268	261	276
S-30	CS+	18	13	10	6	2	2	0	0	0	0	0	0	3
	CS-	27	14	19	15	4	4	0	0	0	0	0	0	10
S-88	CS+	398	423	400	372	398	430	470	470	430	431	466	458	481
	CS-	131	103	92	95	62	145	159	43	464	357	341	344	432

APPENDIX C (continued)

Squad I (continued) — 26-26 ITI condition

Day		63	64	65	66	67	68	69	70	71	72
S-798	CS+	274	261	265	-	294	243	268	266	252	257
	CS-	231	221	188	-	259	219	223	212	227	184
S-63	CS+	302	280	299	-	276	287	286	295	303	282
	CS-	290	279	276	-	198	106	215	206	278	320
S-30	CS+	7	4	0	-	1	7	7	6	2	5
	CS-	8	4	1	-	2	8	5	12	3	5
S-88	CS+	449	462	467	-	454	461	505	492	467	501
	CS-	410	391	380	-	359	408	354	237	228	340

APPENDIX C (continued)

Squad II — 8-8 ITI condition

Day		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
S-778	CS+	0	-	215	281	342	363	359	378	422	402	399	403	410	372	393	420	414
	CS-	0	-	194	290	321	363	356	361	420	413	399	386	411	362	306	195	54
S-785	CS+	5	-	233	247	212	263	226	196	192	177	176	147	117	131	136	125	127
	CS-	0	-	264	263	229	289	206	199	167	54	64	48	55	75	46	40	36
S-737	CS+	0	0	0	0	1	42	162	220	348	359	347	355	339	318	413	404	425
	CS-	0	0	0	0	0	38	161	225	334	314	209	227	211	178	99	128	142
S-799	CS+	0	0	1	19	144	198	188	137	234	216	196	168	202	126	144	173	130
	CS-	0	0	2	18	159	238	151	147	255	219	167	171	210	137	119	165	163

APPENDIX C (continued)

Squad II (continued) — 8-8 ITI condition

Day		18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
S-778	CS+	371	334	301	314	326	323	288	280	288	268	315	275	307	295	259	310
	CS-	35	142	113	142	121	101	70	151	174	116	152	57	60	34	44	72
S-785	CS+	176	147	158	147	163	126	105	117	140	159	139	123	136	109	93	133
	CS-	68	69	159	54	63	31	11	14	33	30	29	42	26	19	9	2
S-737	CS+	441	323	329	333	340	361	314	334	361	324	360	316	316	318	334	346
	CS-	135	150	135	112	86	52	45	13	77	66	75	45	2	32	22	31
S-799	CS+	185	132	151	154	182	184	139	177	192	144	201	155	176	174	175	263
	CS-	136	111	106	119	116	147	56	85	118	57	117	6	36	65	32	136

APPENDIX C (continued)

Squad II (continued) 8-8 14-14 ITI condition

Day		34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49
S-778	CS+	264	332	323	342	363	351	364	349	349	356	313	332	333	345	326	350
	CS-	44	60	58	276	303	101	75	45	105	287	275	225	142	160	38	91
S-785	CS+	137	176	172	107	114	-	131	86	75	82	74	127	208	176	143	83
	CS-	11	15	14	83	52	-	142	169	132	116	125	83	65	99	40	95
S-737	CS+	340	266	275	195	223	141	100	261	251	250	172	237	219	251	166	184
	CS-	66	0	11	127	20	3	4	3	16	3	23	10	13	17	25	27
S-799	CS+	207	215	229	183	233	204	184	189	131	148	136	172	107	113	131	168
	CS-	58	87	77	144	108	158	84	81	63	37	96	68	53	20	49	33

APPENDIX C (continued)

Squad II (continued)		14-14 ITI condition								26-26 ITI condition				
Day		50	51	52	53	54	55	56	57	58	59	60	61	62
S-778	CS+	342	334	356	354	341	390	364	360	364	376	381	294	315
	CS-	267	214	186	119	107	152	200	246	330	339	132	149	169
S-785	CS+	145	87	86	19	26	76	133	109	48	37	37	17	32
	CS-	55	92	76	64	37	109	143	110	53	39	42	17	42
S-737	CS+	175	90	134	170	99	169	155	96	225	166	205	171	186
	CS-	90	21	5	9	4	9	13	55	267	158	214	205	191
S-799	CS+	167	117	171	89	121	121	97	102	182	164	164	111	127
	CS-	77	88	107	62	37	51	56	56	173	131	106	42	88

APPENDIX C (continued)

Squad II (continued) 26-26 ITI condition

Day		63	64	65	66	67	68	69	70	71	72
S-778	CS+	307	315	296	312	297	321	333	329	375	303
	CS-	262	317	276	152	305	334	331	332	368	246
S-785	CS+	27	47	33	33	62	49	68	57	15	36
	CS-	55	70	82	101	91	86	102	90	70	79
S-737	CS+	156	135	105	178	128	111	188	199	101	180
	CS-	182	127	115	174	124	110	197	138	75	150
S-799	CS+	92	130	141	186	128	149	140	180	207	180
	CS-	99	122	139	196	146	171	112	165	182	221

APPENDIX D

Total number of daily responses to the CS+ and CS- for the 14 sec group.
To obtain responses per min, divide each entry by 2.0.
Blanks indicate that data was unavailable.

Squad I — 14-14 ITI condition

Day		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
S-10	CS+	1	121	230	309	299	269	308	337	353	329	-	297	278	259	263	275	215
	CS-	0	132	245	292	308	256	328	333	346	319	-	292	185	136	135	139	129
S-20	CS+	0	0	2	6	38	153	157	171	201	268	-	268	217	293	236	223	293
	CS-	1	1	1	9	34	133	171	163	151	90	-	55	7	75	82	44	102
S-30	CS+	0	0	16	91	153	157	179	191	202	248	-	349	308	343	288	282	221
	CS-	0	0	32	100	153	117	92	112	60	68	-	181	170	93	35	40	47
S-40	CS+	0	68	194	248	284	261	238	248	228	272	-	248	215	278	294	309	291
	CS-	0	86	221	239	291	258	253	229	213	150	-	125	75	139	71	51	53

APPENDIX D (continued)

Squad I (continued)		14-14 ITI condition														14-56	
Day		18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
S-10	CS+	188	182	146	125	156	147	125	134	120	157	98	118	57	89	47	53
	CS-	140	80	76	70	90	91	43	21	29	14	13	12	7	64	55	43
S-20	CS+	330	318	348	379	298	239	216	238	210	243	249	240	205	209	277	276
	CS-	124	50	50	85	43	57	91	52	49	42	43	20	26	207	301	285
S-30	CS+	152	149	118	172	147	139	114	108	136	64	86	90	83	106	151	155
	CS-	7	8	49	57	19	12	12	6	31	50	42	15	83	99	147	159
S-40	CS+	314	325	285	311	293	309	317	305	300	275	301	309	323	316	323	308
	CS-	189	193	131	92	48	101	154	141	96	63	60	81	84	329	335	313

APPENDIX D (continued)

Squad I (continued) — 14-56 ITI condition

Day		34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
S-10	CS+	44	23	15	11	7	16	10	15	22	7	2	7	6	7	8
	CS-	87	21	16	11	14	18	15	11	35	27	19	13	41	22	25
S-20	CS+	300	226	211	221	178	161	155	130	117	109	156	128	112	99	126
	CS-	356	223	31	30	21	90	176	57	7	9	35	13	30	22	69
S-30	CS+	63	159	102	116	173	175	158	89	83	124	128	123	129	85	143
	CS-	123	162	39	35	46	40	20	8	11	16	21	19	11	9	4
S-40	CS+	286	329	304	303	303	284	307	270	287	256	279	264	277	265	246
	CS-	304	209	101	61	36	29	49	37	67	35	10	28	20	32	30

APPENDIX D (continued)

Squad II — 14-14 ITI condition

Day		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
S-15	CS+	9	151	224	237	239	227	232	235	248	252	257	235	246	228	236	227	206
	CS-	16	157	224	260	252	244	239	256	215	131	94	83	35	10	8	78	84
S-712	CS+	0	14	177	264	219	299	329	303	300	289	284	314	299	313	291	257	264
	CS-	0	16	199	276	208	298	366	318	310	306	301	316	311	326	306	295	273
S-751	CS+	0	0	0	0	0	0	0	0	0	0	36	231	270	306	274	257	254
	CS-	0	0	0	0	0	0	0	0	0	0	40	255	278	305	291	299	212
S-42	CS+	0	0	2	67	168	169	206	235	240	263	242	291	306	324	288	275	299
	CS-	0	0	6	65	155	176	165	259	249	265	242	280	294	398	292	303	287

APPENDIX D (continued)

Squad II (continued) — 14-14 ITI condition — 14-56

Day		18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
S-15	CS+	200	180	173	218	214	219	241	206	258	243	262	265	253	246	294	249
	CS-	93	33	55	33	60	25	95	99	91	55	103	54	53	241	281	216
S-712	CS+	252	263	271	258	218	230	207	253	192	182	237	184	202	216	253	272
	CS-	219	130	170	209	181	229	212	212	173	203	217	195	175	192	263	259
S-751	CS+	235	312	309	257	240	242	192	221	189	210	195	180	197	231	251	161
	CS-	140	282	238	170	148	65	43	22	34	136	35	25	62	214	260	154
S-42	CS+	314	356	298	377	374	350	381	376	369	386	394	425	429	339	350	360
	CS-	304	246	167	147	135	151	282	311	202	149	290	291	290	351	365	368

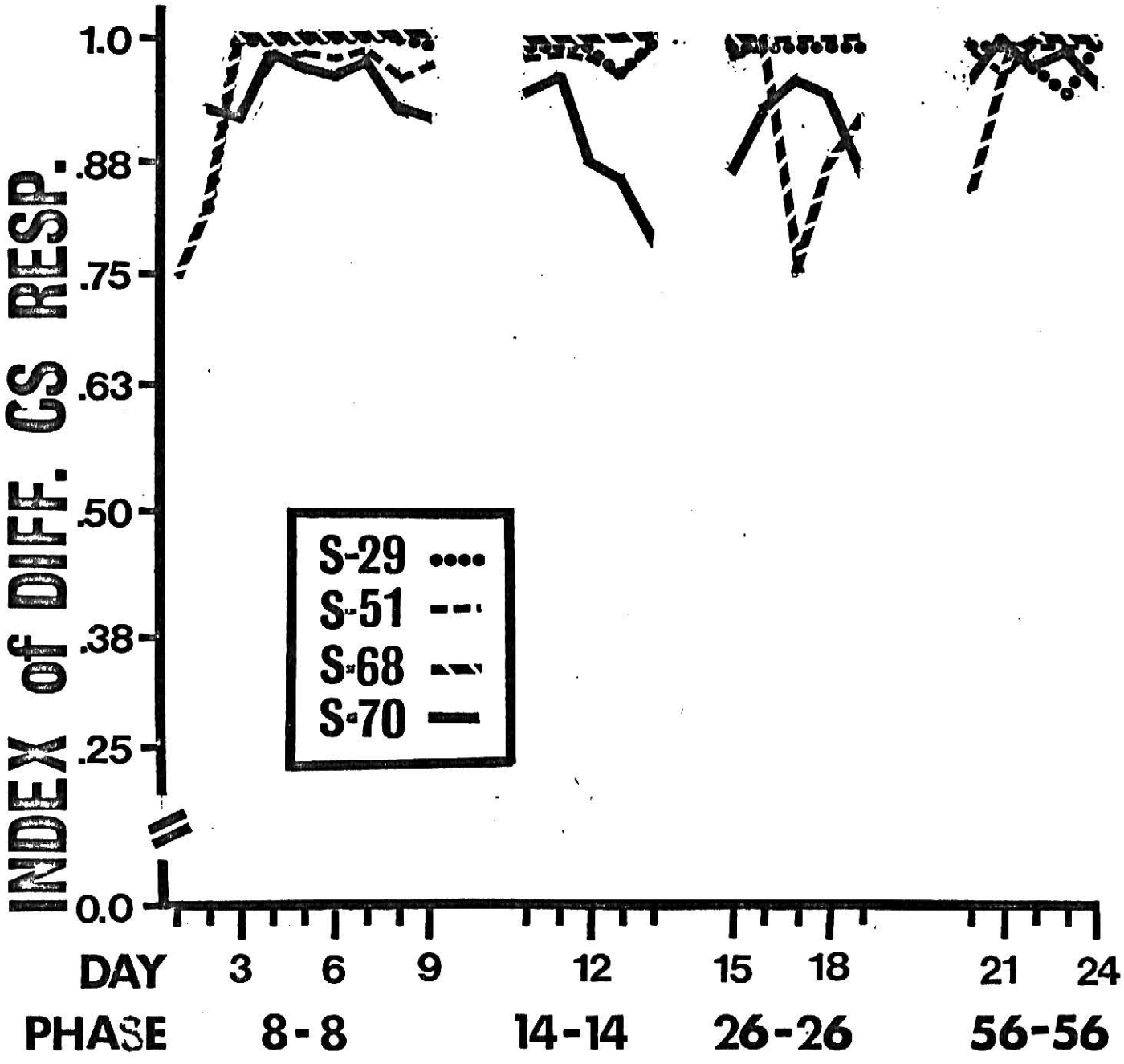
APPENDIX D (continued)

Squad II (continued) — 14-56 ITI condition

Day		34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
S-15	CS+	237	223	238	186	282	271	209	268	275	264	258	242	254	247	295
	CS-	221	197	79	113	39	56	69	138	49	63	138	102	48	38	26
S-712	CS+	211	152	188	118	125	163	174	104	176	258	172	157	134	93	120
	CS-	238	177	102	156	109	101	159	102	46	28	25	13	31	17	2
S-751	CS+	198	226	117	63	73	100	162	131	157	119	148	127	169	79	128
	CS-	192	238	58	33	9	28	33	27	22	17	28	18	11	5	15
S-42	CS+	363	380	401	383	377	366	350	364	355	331	335	356	385	381	367
	CS-	360	369	101	352	288	211	279	84	96	47	45	80	33	71	40

Figure Caption

Appendix E. Daily individual indices of differential CS responding for the differential cue group. Each subject's index was obtained by dividing the number of responses to the CS+ by the total number of responses to the CS- and CS+ for each day.


INDEX of DIFF. CS RESP.
1.0
.88
.75
.63
.50
.38
.25
0.0
S-29
S-51
S-68
S-70
DAY
3
6
9
12
15
18
21
24
PHASE
8-8
14-14
26-26
56-56

SINGLE-ALTERNATION RESPONSE-INDEPENDENT LEARNING IN THE PIGEON

by

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B. A., University of California, Santa Barbara, 1971

AN ABSTRACT OF A MASTER'S THESIS

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ABSTRACT

Pigeons were given response independent single alternation training in which every other CS presentation (response key illumination) was followed by food (US) presentation. Both equal and unequal intertrial interval (ITI) durations between R to N and N to R trials were used.

Experiment I investigated differential responding in both unequal and equal ITI case with nondifferential CS presentations by successively increasing the ITI between R to N trials (negative ITI) from 0 sec to 4, 8, 16, 32, and 56 sec, while holding the ITI between N to R trials (positive ITI) constant at 56 sec. Experiment II consisted of three groups. The 8 sec group received nondifferential CS's and was trained only on equal ITI conditions and these ITI's were successively increased from 8 sec to 14 sec and from 14 to 26 sec. A second nondifferential CS group, the 14 sec group, began with the most spaced equal ITI condition to which the 8 sec group had responded differentially. This condition was subsequently changed to an unequal ITI condition by increasing the ITI preceding the R trial from 14 to 56 sec to determine whether the unequal ITI condition would facilitate discrimination in spite of an increase in the interreinforcement interval (IRI). A third group, the differential cue group, served as a comparison condition for the 8 sec group to determine if differential R and N trial responding would develop with very short IRI's in the beginning of training and be maintained as the ITI's

were increased. This group received differential stimuli for R and N trials.

With equal ITI conditions greater massing of trials facilitated differential responding to R and N trials. This effect was independent of previous equal ITI training. When differential stimuli were employed on R and N trials, no decrement in differential R and N trial responding occurred as ITI's were increased. Differential responding to R and N trials for the unequal ITI conditions was inversely related to the difference between the negative and positive ITI's; the latter was independent of previous equal or unequal ITI training. Several alternative explanations of the results were offered as well as a method of separating out the alternatives for the unequal ITI results.