THE EFFECT OF DURATION OF GRAIN PRESENTATION ON THE RATE OF PIGEONS' AUTOPECKING

by

ROBERT A. HANCOCK, JR.

B. A., University of Massachusetts, Amherst, 1971

A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Psychology

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1974

Approved by:

Charles C. Perkins Jr.
Major Professor

LD
2668
T4
1974
H35
c.2
Document

TABLE OF CONTENTS

THIS BOOK CONTAINS NUMEROUS PAGES WITH THE ORIGINAL PRINTING BEING SKEWED DIFFERENTLY FROM THE TOP OF THE PAGE TO THE BOTTOM.

THIS IS AS RECEIVED FROM THE CUSTOMER.

Acknowledgements

The present research was conducted during the author's tenure as a NIMH fellow (National Institute of Mental Health Experimental Training Grant MH-08359-06). The research was supported by National Science Foundation Grant GB-27595 awarded to Kansas State University with Charles C. Perkins, Jr. as principal investigator. The author would like to thank Drs. Franz Samelson and Jerome Frieman for their forbearance and help during the preparation of this thesis. The author would like to most especially thank his advisor, Charles C. Perkins, Jr., for support and encouragement.

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

Recently Brown & Jenkins (1968) obtained pecking on a response key by pigeons by presenting a brief signal on the key before the delivery of grain. On the average every 60 sec (range 30 - 90 sec) an 8 sec key lite was presented and followed by 4 sec of grain access. This procedure established and, for some birds in their Experiment IV, maintained key pecking without any programmed relationship between key pecking and the delivery of grain. This phenomenon will be called autopecking. Autopecking has been found with procedures where response independent grain delivery occurred at various intervals throughout the signal rather than just at its termination (Gamzu & Williams, 1971). Ricci (1973) using substantially longer key lite stimuli, 30 and 120 sec, also established and maintained autopecking. This thesis explores the effects of manipulating duration of grain access, a parameter which may affect the acquisition and steady state rate of autopecking and which has not been systematically explored.

The autopecking procedure is stimulus contingent and response independent as are the many procedures which are grouped under the heading of classical conditioning procedures. Not withstanding the procedural similarity, Brown & Jenkins remarked that some authors (Kimble, 1964) felt that the use of a classical conditioning procedure did not alone justify putting a phenomenon in the province of classical conditioning. They went on to suggest that "superstitious" key pecking might be playing some role in the phenomenon. Superstitious behavior is behavior which is reinforced, i.e., has its probability of occurrance increased, by its chance occurrance before the delivery of a reinforcer.

Williams & Williams (1969) showed that the stimulus contingent procedure, classical conditioning, and not the possible presence of adventitious reinforcement of key pecking was responsible for autopecking. They presented pigeons with an 8 sec key lite (on the average every 30 sec) followed by 4 sec of grain acess. Under some conditions a key peck during the key lite signal turned the signal off and cancelled the programmed grain presentation. This procedure which prevented the adventitious reinforcement of key pecks still established and maintained key pecking. This implies that autopecking is not simply a superstitious behavior (Skinner, 1948) but rather is established and maintained by the relationship between the signal and grain delivery.

The autopecking procedure is an instance of a classical conditioning procedure. In classical conditioning terminology, the key lite in an autopecking procedure is the conditioned stimulus (CS), grain the unconditioned stimulus (US), and key pecking during the CS the conditioned response (CR).

Thus in these terms this thesis was designed to determine if US duration has effects on pigeons' classically conditioned key pecking. With this in mind a brief review of the literature on the effects of US duration in classical conditioning is undertaken.

Increasing US duration may increase the magnitude of the CR. With dogs, the amount of a food US is positively related to the magnitude of the salivary CR (Wagner, Siegel, Thomas, & Ellison, 1964; Gantt, 1938; Kleschov, 1936). Shaefor & Gormezano (1972) found that the duration of a water US (constant flow for different durations) in the mouth affected the percentage of CSs that produced CRs, jaw movement in rabbits. A group that received 20 cc of water as a US made a greater percentage of CRs than 1 or 5 cc groups.

However the duration of a shock US did not produce differences in the amplitude of the CR, galvanic skin response, in two studies (Bitterman, Reed, & Krauskopf, 1952; Coppock & Chambers, 1959). Likewise Wegner & Zeaman (1958), reviewing a series of studies in which duration of shock US differed, found no differences in the amplitude of heart rate CRs attributable to US duration.

Reiss & Farrar (1973) paired CSs with two durations of shock. With response independent presentation of these CSs on a Sidman avoidance baseline, the CS associated with the longer shock produced greater conditioned facilitation, a greater increase in response rate, than did the CS paired with shorter shock.

Some studies have used increases in reinforcement value, i.e., positive conditioned reinforcement, or punishment value, i.e., conditioned aversiveness, to test the effects of CS-US pairings. In these procedures CSs are paired with appetitive or aversive events. Later the effects of those pairings are tested by making the CSs' presentation or removal contingent on a response. Overmeir (1966 a, b) found that CSs which had been followed by longer shock USs were more aversive than CSs which had been followed by shorter shocks, while Mowrer & Solomon (1954) found no reliable effects of the duration of a shock US. Likewise Wike (1966) reviewing studies manipulating the magnitude of positive reward (appetitive USs) concluded that greater amount or magnitude produces greater conditioned reinforcement strength.

Finally a negative relation between US duration and amplitude of the CR has been found. Runquist & Spence (1959) found more eyelid conditioning with a shorter US, air puff, than a longer one, but had to combine data from four experiments to get a reliable difference. Furthermore, as Gormezano & Moore (1962) have suggested, the procedure used by Runquist & Spence to discard "voluntary" responders may in fact bias the results against the longer duration. More recently, Frey & Butler (1973) found greater eyelid conditioning in rabbits with the shorter of three durations of shock. However, as they point out, duration was probably badly confounded with intensity (the shorter duration probably had a greater intensity) due to the shock generator used in the study. Thus these discrepant data are highly suspect.

In conclusion, some measures of the strength of the CR, amplitude, probability of occurrance, are positively correlated with the duration of the US, under some conditions. Under other conditions differences in US duration have not affected the strength of the CR. Whether this is due to a lack of sensitivity of the measures or because US duration is an irrelevant variable is not clear. This review suggests that, if duration of grain access has any effect on autopecking, rate would be expected to be higher under conditions with longer durations of grain access.

EXPERIMENT I

Experiment I was designed to determine if the duration of response independent grain access affects the rate of key pecking during signals preceding those grain presentations. The experiment consisted of three phases. Each subject was exposed to three different durations of grain access, one duration in each phase. Sequence effects were counterbalanced across subjects by using all six possible sequences of the three durations of the US. In all sessions with CS-US pairings, subjects were exposed to three different key lite stimuli. Two of the three were followed by grain; these two differed in the proportion of trials on which grain followed. These two CSs were employed to decrease the likelihood that "ceiling" or "floor" effects would "wash out" any possible US duration effects. That is if the CS which was followed by grain more often maintained such a high rate of pecking that no differences could be detected, it seemed unlikely that the CS which was followed by grain less often would be either at the same high level or support no pecking at all. The third CS was never followed by grain and acted as a discrimination control. In the event that no differences in responding to the other two CSs were found, much less responding to this CS would indicate that the CSs were discriminated.

METHOD

Subjects

Twelve naive White King pigeons obtained from a local supplier served as subjects. The birds were individually housed in a room with continuous illumination and maintained at 75% of ad lib weight. Water and grit were available in the home cages.

Apparatus

Four "identical" homemade pigeon intelligence panels were housed in four "identical" homemade chests, producing an experimental space approximately 34.3 cm x 38.1 cm x 30.5 cm (L x W x H). The floor was covered by masonite. The chests' interior, the steel intelligence panels on which keys and feeders were located, and the floors were painted machine gray. A window 7.6 cm x 12.7 cm, with a one way screen, in the wall to the right of the panel allowed observation of the subjects. Each chest was located inside a sound attenuating fiber board cubicle.

Three pigeon panels had one key opening 2.54 cm in diameter. The other key opening was 1.90 cm. All were centrally located approximately 22.85 cm above floor level. A transparent Gerbrands pigeon key 1.90 cm in diameter (the black mounting of the key covered the remainder of the key opening in three of the boxes) was employed as the manipulandum.

Key lite stimuli were presented by Industrial Electronic Engineers stimulus projectors. A 5.08 cm x 5.08 cm feeder opening was 3.8 cm above floor level in the center of the panel. A Lehigh Valley Electronics feeder was used to present grain. A photocell, located in the front lip of the feeder (Fernie, 1971), reliably signalled the presence of the bird's head in the feeder when food was accessable. A relay located behind the panel provided a feedback click for pecks of sufficient force (9 gms - 0.9 N) to be recorded. Masking noise was provided by noise from ventilating fans mounted on the chests and amplified white noise piped through a speaker mounted in the room containing the four cubicles. An intensity of 91 db (C scale - Sound Level Meter - General Radio Corp.) was measured in front of the magazine with chest and cubicle closed.

Illumination in the chest was provided through a "window" 6.35 cm in diameter in the ceiling of the experimental space, 16.5 cm from the panel and 15.2 cm from each side. Translucent gell shielded and diffused light from a 6 watt AC white bulb located directly above the window.

Control and recording equipment were in an adjacent room. One electro-mechanical tape reader controlled the sequence of events in all four boxes simultaneously.

Procedure

Subjects were assigned by lot to groups (1, 3, or 9) four subjects to a group , and boxes (1-4). For each bird, training sessions were at approximately the same time each day. Experimental sessions were at the same time for the same US duration.

Feeder Training: During feeder training sessions and all subsequent sessions, the houselite was on at all times except during feeder presentations when a white feeder lite illuminated the feeder.

Initially all subjects were trained to approach and eat from the feeder while the key was covered by gray tape. During these manual feeder training sessions, the bird was held with its head in the feeder with food available until it started to eat the 50% milo - 50% wheat grain mixture used throughout the experiment. When the bird began eating, the experimenter released it and carefully closed the door to the experimental chamber while the feeder was still operating. After the chest was closed and 10 - 15 sec had elapsed, feeder operation was interupted for 1 or 2 sec. If a bird failed to eat after this interuption, the experimenter opened the chest and again held the bird's head in the feeder until eating began. Gradually periods of interuption were lengthened and presentation periods shortened in such a way that the bird still approached and ate within 4 sec of feeder operation at intervals of approximately 30 sec.

If a subject failed to eat at the start of this session it was returned to its home cage and deprived until it would do so.

No subject took more than three sessions to complete manual feeder training.

During the next two sessions, subjects were exposed to automatic feeder training. This consisted of presentation of 1, 3, or 9 sec of grain access, depending on group assignment, at intervals that grain was presented during subsequent training. USs occurred on the same schedule outlined below but CSs were not presented.

In these sessions and all subsequent sessions, duration of feeder presentation was timed from the moment the pigeon broke the photoelectric switch by inserting its head into the feeder unless the response did not occur within 4 sec of feeder presentation. This provided finer control of the duration of eating time. The feeder was presented and if the bird's head was sensed by the photocell, up to 4 sec after presentation, that feeder's timer was started. If a bird had not inserted its head 4 sec after feeder presentation the timer was started by an external source. Birds seldom if ever failed to eat in 4 sec. Thus the feeder and houselite of each box operated independently. At the end of the timed interval, the feeder was retracted and the houselite turned back on.

During the second session of automatic feeder training, if a subject ate on at least 3 of the last 5 presentations, it was considered feeder trained. A failure to reach this criterion meant repetition of the automatic feeder training procedure until the criterion was met. While groups were run at the same time each day, subjects advanced through feeder training and into stimulus contingent training at their own rate. All subjects completed the entire feeder training sequence in three to five sessions, inclusive.

Stimulus Contingent Training (Classical Conditioning) - Phase 1 : Group assignment determined US duration during automatic feeder training and Phase 1. Durations for Groups 1, 3, and 9 were 1, 3, and 9 sec respectively; otherwise the procedure was identical for all groups.

Each of the 36 daily sessions in Phase 1 consisted of 54 key lite, CS, presentations 10 sec in duration. Each of three different CSs was presented 18 times. One, CS 9/18, was followed by the US on nine trials per session ($p(US|CS\ 9/18) = .500$). CS 1/18 was followed by the US on one trial per session ($p(US|CS\ 1/18) = .0555$). The third signal, CS 0/18, was never followed by the US ($p(US|CS\ 0/18) = 0.00$).

The interval from the termination of one CS (on negative trials) or of a US (on positive trials) to the next CS presentation was never less than 30 sec. On negative trials this intertrial interval, ITI, was exactly 30 sec, but on positive trials the following ITI could be as long as 34 sec. The 30 sec ITI was not initiated until all four subjects' feeder presentations were terminated. If for example, subject A started its feeder timer without delay and subject B did not put its head in the feeder, subject A's timer would time out four sec before subject B's introducing the conditions associated with the ITI; houselite on, no key lite, and no grain access; making the following ITI for subject A 34 sec.

CSs and USs were presented in a non predictable fashion. Each of nine different orders, tapes for the tape reader, was used for four randomly selected sessions in Phase 1. The orders were such that there were no systematic effects due to order of presentation of CSs and USs. The nine orders are shown in Appendix A.

The 54 CS presentations were broken up into 18 blocks of three CS presentations. Within each block, each CS was presented once; each of the six possible sequences of the three CSs was used three times, randomly determined, in each order. Those blocks in which CS 1/18 and CS 9/18 were to be followed by the US were then determined by lot.

One characteristic of these nine orders is that the probability that CS 1/18 will be followed by the US given that a US has already followed CS 1/18 is 0.00. This did not seem to present problems since Perkins (personal communication) has found that stimulus contingent key pecking is maintained throughout a session to a particular stimulus when only one of 20 presentations of that stimulus was followed by the US in each session. This was confirmed in the present study. Those subjects which responded during CS 1/18 showed no differences in their rates of responding after a CS 1/18 - US trial.

For each subject each CS was one of three possible figures. However not all possible combinations of CS and figure were used.

The same combinations were used for each group and combinations were confounded with box, experimental chamber, assignment. The combinations are shown in Figure 1.

<u>Stimulus Contingent Training - Phases 2 & 3</u> : At the end of Phase 1, training was discontinued for a period of seven days, but limited daily feeding maintained the 75% body weight. At the end of this period, Phase 2 commenced.

Phase 2 was "identical" to Phase 1 except that the US duration employed for individual subjects was changed and Phase 2 lasted only 18 sessions. Box assignment and CS-figure combinations were the same for each bird in all three phases.

During Phase 2 two subjects in the 1 sec condition had received the 9 sec US in Phase 1, Group 9, and the other two birds had received the 3 sec US, Group 3. The 3 sec condition was now made up of two subjects from Group 1 and two from Group 9. The 9 sec condition was made up of two from Group 1 and two from Group 3, as shown in Table 1.

At the end of Phase 2, another seven day break ensued. Phase 3 then began. It was a repetition of Phases 1 and 2 except that US duration assignment was again changed. While subjects maintained box assignment, they were changed to the US condition to which they had not previously been exposed. As can be seen in Table I, two birds received each of the six possible sequences of the three US durations. Phase 3 lasted 18 sessions.

Equipment failures and experimenter error produced depart-

THIS BOOK WAS BOUND WITHOUT PAGE 14.

THIS IS AS RECEIVED FROM CUSTOMER.

THIS BOOK CONTAINS NUMEROUS PAGES WITH DIAGRAMS THAT ARE CROOKED COMPARED TO THE REST OF THE INFORMATION ON THE PAGE.

THIS IS AS RECEIVED FROM CUSTOMER.

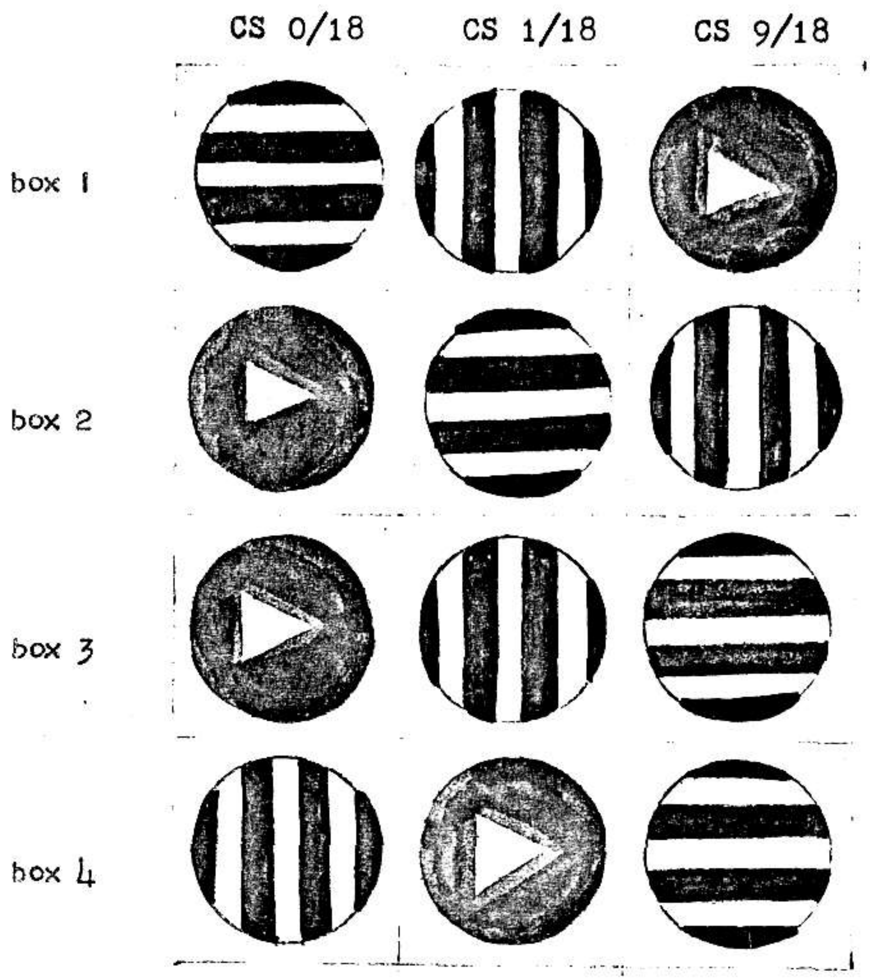

CS 0/18
CS 1/18
CS 9/18
box 1
box 2
box 3
box 4

TABLE I

SUMMARY OF EXPERIMENTAL DESIGN EXP I.

US DURATION	PHASE 1	PHASE 2	PHASE 3
1 sec	R1	P1	G1
	R2	G2	P2
	R3	P3	G3
	R4	G4	P4
3 sec	P1	G1	R1
	P2	R2	G2
	P3	G3	R3
	P4	R4	G4
9 sec	G1	R1	P1
	G2	P2	R2
	G3	R3	P3
	G4	P4	R4

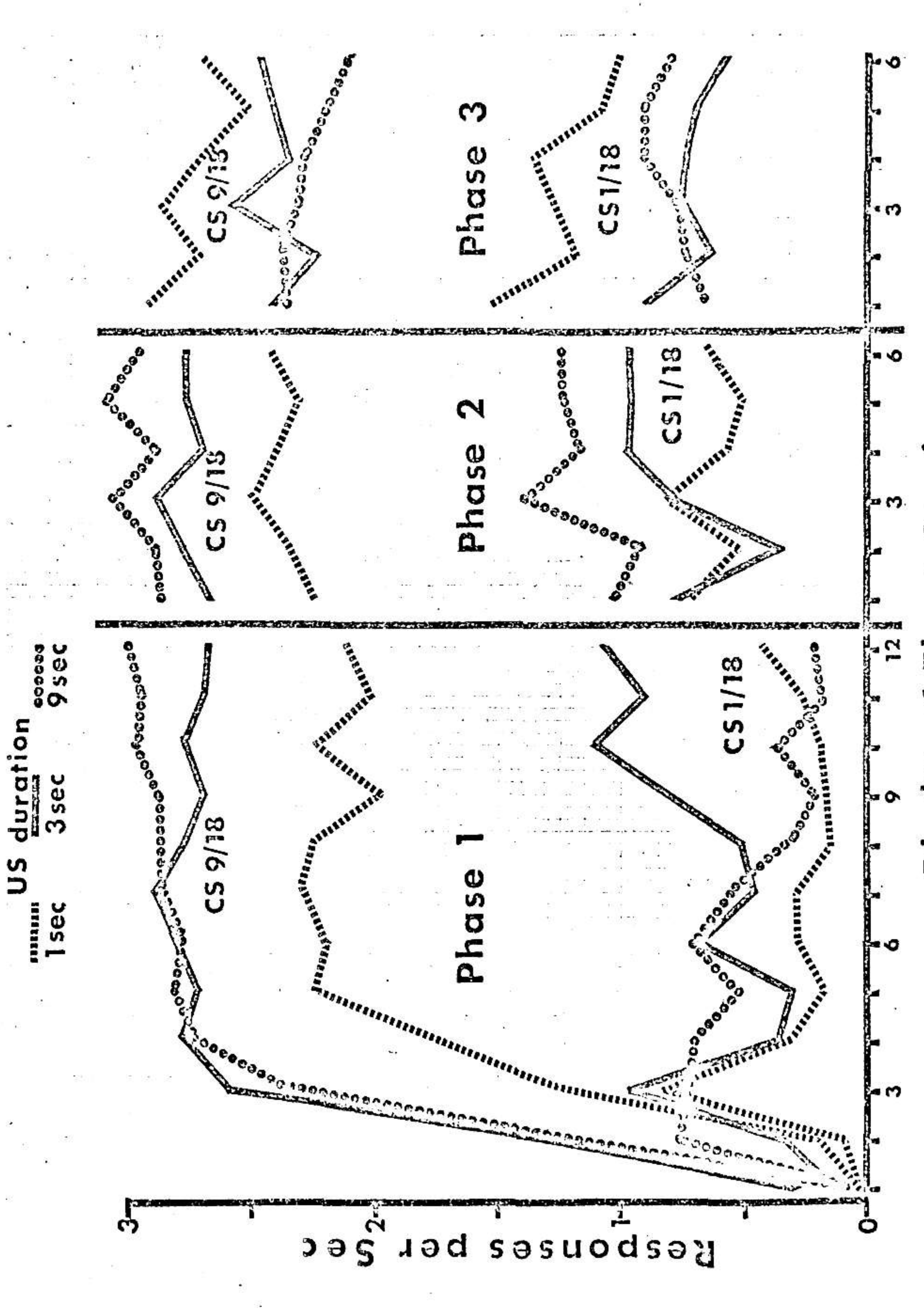
The letter - number combinations in the table refer to subjects. The letter indicates the US duration to which the subject was exposed in Phase I. The numeral denotes box assignment.

ures from the intended procedures. Group 1 (subjects R1, R2, R3, & R4) was not run daily throughout Phase 1. Overfeeding following session 17 necessitated a one day break between sessions 17 and 18. Group 3 in Phase 1 was exposed to a CS 0/18 presentation 5 min long in one session. Since these subjects, P1, P2, P3, and P4, had started stimulus contingent training on different calendar days, this long CS 0/18 occurred in session 11, 10, 12 and 12 respectively. Subject P4 missed an undeterminable number of grain presentations in session 13 of Phase 1. The houselite burned out for subject R3 during session 27 of Phase 1. Finally, in Phase 3 the houselite burned out during session 6 for subject R4 and was out throughout session 6 for subject G4.

RESULTS

Figure 2 shows the mean rate of responding in three session blocks to CS 1/18 and CS 9/18 by the four subjects in each US condition in each phase. The data from the last six sessions of each phase were chosen to test for US duration effects. Steady state, absence of systematic changes, seems to have been reached by these sessions. The trend for decreased responding to CS 9/18 under the 9 sec US condition in Phase 3 is attributable to a single subject, who was dropped from the analysis (see below). Table II shows the mean rate of responding per sec by each subject during the presentation of each CS

Figure 2. Mean rate of responding to CS 1/18 and CS 9/18 in blocks of three sessions as a function of US duration.



US duration
1sec
3sec
9sec
CS 9/18
CS 1/18
Phase 1
Phase 2
Phase 3
Responses per Sec
Blocks of Three Sessions
0
1
2
3
3
6
9
12
3
6
3
6

TABLE II

MEAN RATE OF RESPONDING PER SEC TO EACH CS ON THE LAST SIX DAYS OF EACH PHASE IN EXP I.

SEQUENCE OF US DURATIONS	SUBJECT	US/CS	1 SEC			3 SEC			9 SEC		
			0/18	1/18	9/18	0/18	1/18	9/18	0/18	1/18	9/18
1 3 9	R1		0.031	0.002	2.029	0.116	0.052	2.620	0.005	0.065	2.681
	R3*		0.005	0.086	1.491	0.021	0.130	2.064	0.004	0.065	0.688
1 9 3	R2		0	0.434	2.102	0.021	0.215	2.666	0	1.047	2.858
	R4		0.273	0.898	2.707	0.105	1.782	2.067	0.033	2.306	2.738
3 9 1	P1		0	0.035	2.021	0	0	2.858	0	0.062	3.491
	P3		0.004	1.998	2.731	0.098	0.791	2.699	0.011	1.794	3.096
3 1 9	P2		0	1.247	2.256	0.001	1.688	2.143	0.002	1.316	2.146
	P4		0.147	0.792	2.441	0.009	1.502	3.103	0.209	2.068	3.173
9 1 3	G1		0	0	2.351	0.003	0	3.116	0.002	0.002	3.202
	G3		0.013	0.314	1.458	0.002	0.604	1.790	0.003	0.473	2.352
9 3 1	G2		0.085	0.221	1.978	0.016	0.136	2.406	0.002	0.036	2.607
	G4		1.260	1.973	3.762	0.021	3.577	4.025	0.051	0.308	3.818

* - This subject's data were omitted from some analyses (see text).

on the last six sessions of each phase. Inspection of Table II reveals a rather consistent pattern of increased responding to the CS with the higher probability that the US will follow. However US duration effects are not immediately obvious. Also substantial individual differences in autopecking are found.

Apriori, an ANOVA was planned excluding responding to CS 0/18 because CS 0/18 was never followed by grain and thus could not be directly affected by US duration. Also variability under the CS 0/18 is considerably lower than under the other US conditions (due to the low level of responding) and thus including this condition would violate the homogeneity of variance assumption of the ANOVA. Ten of 12 subjects responded more to CS 1/18 than CS 0/18 and 12 of 12 responded more to CS 9/18 than CS 0/18. From the expansion of the binomial, these results deviate from chance with a two tailed probability of .039 and $<$ .001 respectively. Responding to CS 0/18 ($\bar{X}$ = .071 responses per sec) is significantly less than CS 1/18 ($\bar{X}$ = .777 responses per sec) or CS 9/18 ($\bar{X}$ = 2.548 responses per sec) responding; demonstrating that the key lite stimuli were discriminated.

The ANOVA conducted on the data in Table II (not including CS 0/18 responding) indicated that US probability (CS 1/18 vs CS 9/18) produced a significant main effect. Table III is a summary table for this ANOVA. Sequence, US duration, and <u>all</u> interactions involving sequence, US duration, and US

TABLE III

ANOVA OF THE MEAN RATE OF RESPONDING ON THE LAST SIX DAYS OF EACH PHASE (12 SUBJECTS).

SOURCE OF VARIATION	df	MEAN SQUARE	F	p
BETWEEN SUBJECTS				
Sequence of US durations	5	2.12620	1.022	0.4802
Error (Ss w/in Sequence)	6	2.08068		
WITHIN SUBJECTS				
US probability	1	56.38469	61.759	0.0005
US probability X Sequence	5	.52253	.572	0.7225
Error (Ss w/in Sequence X US probability)	6	.91298		
US duration	2	.66074	2.574	0.1164
US duration X Sequence	10	.31979	1.246	0.3538
Error (Ss w/in Sequence X US duration)	12	.25672		
US probability X US duration	2	.16523	.845	0.5433
US probability X US duration X Sequence	10	.27045	1.383	0.2927
Error (Ss w/in Sequence X US probability x US duration)	12	.19548		

probability did not produce any differences that were significant. In subsequent analyses, on the basis of this ANOVA, sequence as a variable was collapsed across. Newman-Keuls pairwise comparisons between possible combinations of US durations (1 vs 3, 3 vs 9, 1 vs 9) did not indicate any significant differences when tests were conducted on every sequence and at both levels of US probability and on overall means.

During the course of the study, one subject, R3, showed a rapid drop in responding during Phase 3, its 9 sec US condition. Observation of this subject revealed that it was pecking the intelligence panel and not making key contact. For example, during an average CS 9/18 trial, this subject struck the key or wall at least 15 times but only 2 or 3 responses were counted on the counters. Another ANOVA was conducted collapsing across sequence of US durations and omitting subject R3 to determine if US duration had significant effects. Means for these data are shown in Table IV. Table V is this ANOVA's summary table.

As Table V reveals US probability produced a significant main effect. However differences due to US duration and its interaction with US probability were not significant. Newman-Keuls pairwise comparisons did not disclose any significant effects due to US duration.

One characteristic of the above data analysis is that only the absolute differences in subjects' autopecking have been used to test for US duration effects. That is the absolute amount

TABLE IV

MEAN RATE OF RESPONDING PER SEC
ON THE LAST SIX DAY OF EACH PHASE
IN EXP I (11 SUBJECTS).

	US DURATION			
	1 SEC	3 SEC	9 SEC	$\bar{X}$
CS 1/18	.7195	.9406	.8615	.8405
CS 9/18	2.3487	2.6812	2.9238	2.6512
$\bar{X}$	1.5341	1.8109	1.8927	

TABLE V

ANOVA OF THE MEAN RATE OF RESPONDING ON THE LAST SIX DAYS OF EACH PHASE (11 SUBJECTS).

SOURCE OF VARIATION	df	MEAN SQUARE	F	p
WITHIN SUBJECTS				
US probability	1	54.09898	69.700	0.0001
Error (US probability X Ss)	10	.77617		
US duration	2	.77781	2.817	0.0822
Error (US duration X Ss)	20	.27616		
US duration X US probability	2	.27721	1.263	0.3044
Error (US duration X US probability X Ss)	20	.21948		

of change in a subject's autopecking due to US duration has been considered, but its change relative to the overall amount of responding by that subject has not. Using an absolute change measure gives a much greater weight to the performance of subjects with high rates. Therefore the data were analyzed in such a way that the magnitude of the difference in autopecking due to changes in US duration would be a function of a subject's baseline responding rate to the shorter duration.

Three relative rate measures for each of 11 subjects (data from R3, the pigeon which pecked off the key, were not included) were calculated. One relative rate for each pairwise comparison of durations was computed. Each subject's mean rate of responding during the last six days of the phase with the longer US duration was divided by the mean rate of responding during the last six days of that phase and the last six days of the phase for the shorter duration. For example, to compare the 3 sec and 1 sec phases, the mean rate during the 3 sec phase asymptote was divided by the mean rate during the 3 sec asymptote plus the mean rate during the 1 sec phase asymptote. When this relative rate measure has a value of .500, rate are equal in both phases, US duration has no effect. Ratios higher than .500 indicate there was more responding under the conditions with longer US duration (see Table VI).

_t_ tests were employed to determine if the mean relative rates differed significantly from .500. The 9 sec and 3 sec USs both produced significantly more responding than the 1 sec

TABLE VI

RELATIVE RATES OF RESPONDING
DURING CS 1/18 & CS 9/18 IN EXP 1.

SUBJECT		US CONDITIONS IN COMPARISON		
		3 sec US / 1 + 3 sec US	9 sec US / 1 + 9 sec US	9 sec US / 3 + 9 sec US
R1		.568	.575	.509
R2		.532	.606	.575
R4		.516	.583	.567
P1		.582	.634	.554
P3		.424	.508	.584
P2		.522	.497	.475
P4		.588	.618	.532
G1		.570	.577	.507
G3		.575	.615	.541
G2		.536	.546	.510
G4		.570	.418	.352
	$\bar{X}$ =	.543	.562	.518
	t (10 df) =	3.031	3.172	.924
	$p <$	.02	.01	n. s.

US (t values, p values, and means are in Table VI). That is these US conditions had relative rates, in comparison to the 1 sec US, significantly above .500. The relative rate for 9 sec vs 3 sec did not differ significantly from .500. The alpha level problem that occurs when conducting multiple t tests is somewhat alleviated by the levels of significance achieved. The probability of finding at least one test significant at the .02 level given that three tests are conducted is equal to .058. While this figure does exceed the traditional .05 level, the probability is low enough that the two tests that found significant differences were used to reject the null hypothesis. US duration did not produce differences in absolute rates that were significant at conventional levels but did on relative rates.

Manipulating US duration produced significant differences in relative rates of autopecking. However US duration seems to be a relatively unimportant variable. While means of .543 and .562 differ significantly from .500 and indicate a significant US duration effect on behavior, they represent a relatively small change in behavior. Inspection of the mean response rates under the three US durations (Table IV) shows that increasing the US by a factor of three in one case, 3 sec vs 1 sec, increased responding only 1.18 times (1.8109/1.5341) and in the other case, 9 vs 3 sec, had no reliable effects. Making the US nine times longer only increased responded 1.23 times (1.8927/1.5341).

The failure to find a large effect due to US duration does not seem to be due to a "ceiling" effect under the 9 sec condition. If a "ceiling" were present, greater effect of US duration would be found by reducing response rates. However inspection of Table II reveals that in 9 of 11 subjects (R3 excluded) the magnitude of the difference in responding due to US duration was larger during CS 9/18 than during CS 1/18. CS 1/ 18 responding was well below CS 9/18 responding, but showed no greater effect of US duration than did CS 9/18 in 9 of 11 cases. Therefore the failure to find strong US duration effects can not be attributed to the inability of the animal to respond more during the 9 sec US condition. Also the paradigm is sensitive to other effects. US probability had marked effects. Responding to CS 9/18 was 3.15 (from Table IV, 2.6512/.8405) times greater than responding to CS 1/18 and this increase was probably limited by a "ceiling" effect.

EXPERIMENT II

Manipulation of US duration between sessions produced only small behavioral effects of perhaps questionable reliability. Experiment II was designed to determine if manipulating US duration within a session produces reliable differences in autopecking. Subjects were exposed to 1 and 9 sec US durations following different CSs. This within sessions procedure might maximize US duration effects by making the magnitude of the difference between US durations more salient. Also additional feeder lites were added, so that 1 sec USs and 9 sec USs could be accompanied by differentially colored feeder lites. Each subject was run under differential (D) and non-differential (ND) feeder lite conditions. Mariner & Thomas (1969) found a greater difference in responding to multiple schedule components, which differed in the duration of response contingent grain presentations, with differential feeder lites (intensity was varied). This D condition was included to further maximize US duration effects.

METHOD

Subjects

Four naive homing pigeons and four White King pigeons, which had served as pilot subjects in Experiment I five months earlier, were maintained under the same conditions as in Experiment I. One White King pigeon died during the experiment.

Apparatus

Two of the four boxes from Exp I were modified and used in this experiment. A new feeder cover housed red and green lites (Sylvania 24 V ESB bulbs with colored covers) which could be lit during feeder presentations. Thus illumination of grain was by red, green, or white lites.

Procedure

Both groups of subjects were assigned by lot to pairs, D/ND or ND/D, and boxes, 2 or 3. Thus one homing pigeon and one White King were assigned to each of the four possible combinations of feeder lite condition and box.

Feeder Training: Each subject was feeder trained as in Exp I except that two different durations of access to grain were presented, 1 and 9 sec. Also, during the second session of automatic feeder training, subjects in group D/ND were exposed to differential feeder lites. Red and green feeder lites were correlated with the two US durations (see below). Subjects in group ND/D had a white feeder lite for both durations. If a subject ate on at least three of the last five feeder presentations of each duration in the second session of automatic feeder training, it was considered feeder trained. All subjects completed feeder training in three to five sessions.

Stimulus Contingent Training - Phase 1: For all subjects each of 36 daily sessions consisted of 180 CS presentations. Two CSs were presented 90 times. CS 9 was occasionally followed by 9 sec of grain access; CS 1 occasionally by a 1 sec US. Both CSs were followed by the US on an unpredictable 9 trials each session (one in ten trials). CSs were 10 sec in duration and were seperated from the termination of the previous event by an ITI of 30 - 34 sec. The CSs were three horizontal or vertical white lines on a black background. Subjects in box 2 had vertical lines associated with the 9 sec US and horizontal lines associated with the 1 sec US. Subjects in box 3 had the reverse.

CSs and USs were presented in six irregular orders. These orders were tapes for the tape reader. Three orders were determined by lot with the following restraints. The 180 trials were broken up into 9 blocks, within which each CS occurred 10 times and was followed by the US once. The order of CSs and occurrance of USs were determined strictly by lot within these blocks. These orders are shown in Appendix B. Three additional orders were created from the first three by exchanging all CS 9 and CS 1 trials; that is CS 9 trials became CS 1 trials and vice versa. US presentations occurred at the same trials, but were, of course, of the other duration. This mirror imaging insured that if any systematic effects of order of presentation of CSs and USs were present that the effects would operate on both CSs equally. All six orders were presented equally often.

Grain presentations were accompanied by differentially colored feeder lites for pairs D/ND. For the subjects in box 2, a red lite accompanied the 9 sec US and a green lite the 1 sec US. The subjects in box 3 had the reverse. Both US durations were accompanied by a white lite for pairs ND/D.

Stimulus Contingent Training - Phase 2 : Phase 2 was identical to Phase 1 except that for all subjects CSs were reversed, the figure for CS 1 became the figure for CS 9 and vice versa, and pairs ND/D now had differential feeder lites and pairs D/ND did not. This phase was 12 daily sessions long.

Again some procedural deviations occurred. In Phase 1, all USs were omitted for subject H D/ND 3 in session 12. Subject K ND/D 3 was 20 - 30 gms overweight for sessions 17 - 19 and subject K D/ND 2 had a one day break between sessions 22 and 23 (it was 40 gms overweight). Equipment failure caused departure from the intended procedure in Phase 2. CS 1 was presented intermittently to subjects K ND/D 2 and K ND/D 3 in session 5. Subjects H D/ND 2 and H D/ND 3 each had one 5 min long ITI in session 8 and 7 respectively. This procedural deviation produced no noticeable effects on responding.

RESULTS

Since US duration only had significant effects on relative rates in Experiment I, only analysis of the relative rates in Experiment II was planned. A relative rate was computed from each subject's data from each session. (Absolute rates were sufficiently high to make this appropriate - see Table IX.) The number of responses to CS 9 was divided by the total number of responses to both CSs. Figure 3 shows group mean relative rates for each session of both phases. The atypical data points at sessions 17 - 19 in Phase 1 and session 5 in Phase 2 are attributable to the overweight subject, K ND/D 3, and the failure to present CS 1 respectively. While absolute rates for individual subjects (not shown) did show session to session fluctuation in a great many cases, systematic trends in absolute rates, individual relative rates, or mean relative rates were not present after session 20 in Phase 1 and session 6 or 7 in Phase 2. Bird K D/ND 2 died during Phase 2 but remained healthy through session 9. Therefore the data from the last three sessions of Phase 1 and, since the data after session 9 for K D/ND 2 were not available, from sessions 7 - 9 of Phase 2 were chosen as the asymptote at which to test for effects. Table VII shows the mean relative rates for each subject at asymptote in both phases. These means were computed by taking a mean of the three daily relative rates for each subject from the three asymptotic sessions in both phases.

Figure 3. Mean relative rate for each group during each session of both phases in Exp II (see text for further explanation).

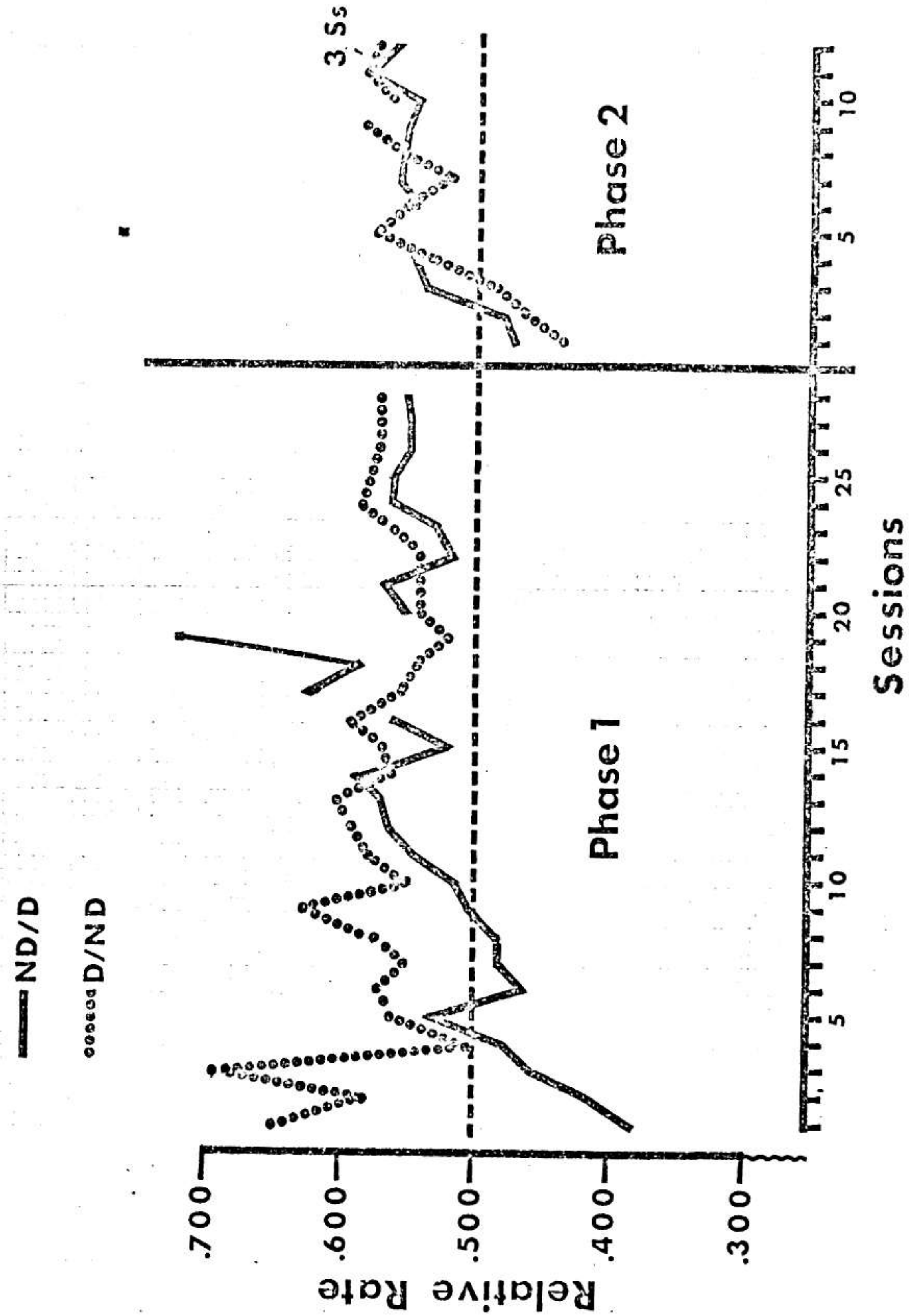

ND/D
D/ND
3 Ss
Phase 1
Phase 2
Relative Rate
.700
.600
.500
.400
.300
Sessions
5
10
15
20
25
5
10

TABLE VII

MEAN RELATIVE RATE OF RESPONDING
AT ASYMPTOTE FOR EACH PHASE IN EXP II.

SUBJECT	ND	D	(ND + D)/2
K ND/D 2	.566	.512	.539
K ND/D 3	.482	.628	.555
K D/ND 2	.495	.545	.520
K D/ND 3	.583	.576	.580
H ND/D 2	.516	.526	.521
H ND/D 3	.651	.571	.611
H D/ND 2	.574	.621	.598
H D/ND 3	.562	.536	.549
		$\bar{X}$ =	.559

An ANOVA on the mean relative rates was conducted to determine if the confounded variables of strain and previous experience, differential feeder lites (D vs ND), or their interaction produced significant differences. They did not, as shown in Table VIII. A *t* test on the mean relative rate at the asymptote of both phases indicated that the mean for 8 subjects of .559 differs significantly from .500 (t = 4.88, 7 df, $p < .005$). Thus US duration is again found to produce significant effects on the relative rate of autopecking. However behaviorally, presenting 9 times as much grain has made just a small difference in overall responding. Table IX shows the group mean rate of responding to CS 1 and CS 9. Subjects responded, on the average, to CS 9, 2.372 times per sec which is an increase of only 1.21 times over the rate to CS 1, 1.953.

Again this small effect due to US duration cannot be attributed solely or mainly to a "ceiling" effect under the 9 sec US condition. Table IX shows each subject's mean rate of responding to CS 1 and CS 9 at asymptote in each phase. (The mean relative rates were means of relative rates calculated daily and not relative rates of mean responding. Thus these mean rates were not the data from which mean relative rates were calculated.) While two subjects, H ND/D 2 and H D/ND 3, may be at a ceiling under the 9 sec condition, the rest do not seem to be. Also even those subjects which show the largest relative differences due to US duration, H ND/D 3 and

TABLE VIII

ANOVA OF ASYMPTOTIC RELATIVE RATES IN EXP II.

SOURCE OF VARIATION	df	MEAN SQUARE	F	p
BETWEEN SUBJECTS				
Strain confounded with experiance	1	.001806	< 1	n.s.
Error (Ss w/in Strain)	6	.002696		
WITHIN SUBJECTS				
D vs ND	1	.000462	< 1	n.s.
D vs ND X Strain	1	.002117	1.64	n.s.
Error (Ss w/in Strain X D vs ND)	12	.001292		

TABLE IX

MEAN NUMBER OF RESPONSES PER SEC AT ASYMPTOTE IN BOTH PHASES OF EXP II.

SUBJECTS	FEEDER LITE CONDITION					
	D		ND		$\bar{X}$	
	CS 1	CS 9	CS 1	CS 9	CS 1	CS 9
K ND/D 2	1.670	1.767	1.879	2.446	1.774	2.106
K ND/D 3	.700	1.136	1.114	1.042	.907	1.089
K D/ND 2	2.261	2.708	2.320	2.277	2.290	2.492
K D/ND 3	2.014	2.743	.548	.690	1.281	1.716
H ND/D 2	2.933	3.252	2.886	3.076	2.910	3.164
H ND/D 3	.466	.612	.326	.594	.396	.603
H D/ND 2	1.521	2.487	1.444	1.931	1.482	2.209
H D/ND 3	4.397	5.076	4.774	6.125	4.586	5.600
				$\bar{X}$ =	1.953	2.372

H D/ND 2, actually exhibit little effect when compared to the relative difference in US durations and neither of these subjects is close to a ceiling. The largest relative difference, H ND/D 3's, represents an increase of CS 9 over CS 1 responding of only 1.52 times (.603/.396).

DISCUSSION

These two experiments demonstrate that, within the range of duration of grain presentations employed (1 - 9 sec of eat-time), autopecking is relatively unaffected by the duration of grain presentation. Also durations greater than 9 sec would probably have no greater effects since 9 sec grain presentations had no statistically reliable effects in comparison with 3 sec grain presentations. Large changes in duration produced small changes in behavior. Analysis of the data revealed that the small amount of behavior change was not due to "ceiling" effects. However US probability had marked effects. In Experiment I, differences in autopecking between all three levels, $p\ (US \mid CS) = 0$, .0555, & .5, were statistically significant and behaviorally large.

The results obtained here are consistent with the relationships between responding and US duration in other stimulus contingent, classical conditioning, experiments where CSs related to the consumption of appetitive USs were measured. Shaefor & Gormezano (1972) found that jaw movement CRs in rabbits were more likely to occur (higher percent CR) but were not significantly different in amplitude (degree of deflection of a pen electronically linked to jaw movement) under conditions with longer durations USs, water flow. Unfortunately none of the measures they used are directly comparable to rate of autopecking. However these results do suggest that greater conditioning is found with longer USs. Wagner et al (1964) found that increasing the magnitude of a food US, 1 vs 6 Dog Yummies, and thus eating time, increased the amplitude of a salivary CR in dogs. This measure is comparable since it was dependent on the rate of salivation. Wagner et al's data suggest that autopecking rate, responses per unit of time, would be higher. The results here fit well, there is a small but statistically significant increase in rate of autopecking, CR amplitude, as a function of increasing US duration.

The data reported here are also consistent with data gathered by Perkins (personal communication) that increasing US probability increases autopecking. Gonzales (1973) has recently reported data which show an unreliable tendency for a higher US probability, 100 vs 25%, to support a higher rate of autopecking. Gonzales' failure to find significant differences is probably due to the small number of subjects, three, he had in each of his groups.

The data analysis indicated that, within the range in which variables were manipulated, US probability effects were greater than US duration effects. Holding US duration constant and increasing the probability of US presentation by a factor of nine increased the rate of autopecking by a factor greater than three. However holding US probability constant and increasing US duration by a factor of nine only increased autopecking rate about 1.3 times.

The greater effect of US probability can be demonstrated further. In Experiment I, CS 9/18 in 1 sec US phases was followed by the same amount of grain per amount of CS time as CS 1/18 in 9 sec US phases. That is in both cases, 180 sec of CS was followed by nine sec of grain. The difference is, in one case, CS 9/18, US probability is high and US duration low, while, in the other, CS 1/18, US duration is high and US probability low. The mean rate of autopecking for 11 subjects, R3 excluded, to CS 1/18 during 9 sec US phases was .8615. The mean rate to CS 9/18 during 1 sec US phases was 2.3487. The difference is significant (related measures $\underline{t}$ (10 df) = 5.279, $p < .005$).

Equal amounts of eating time, 9 sec, led to markedly different rates of autopecking. That is holding other things constant, pitting a high, and in this case not too high, US probability vs a long US duration produced more responding under the conditions with the higher probability. This strongly suggests that under some conditions less grain would produce more autopecking. For example a CS that was followed by 1 sec of grain on 8 in 20 presentations might support more autopecking than a CS that is followed by 10 sec of grain once in 20 presentations; even though the later CS would be followed by 2 sec less of grain access. Autopecking is clearly not proportional to the amount of food available.

These results have implications for other investigations into the autopecking phenomenon. The failure to find strong effects due to US duration suggests that autopecking researchers can use minimal grain durations. In both experiments, rates of responding during CSs followed by only one sec of grain access are sufficient to provide a baseline for the detection of effects due to other variables. Reducing the duration of grain presentations, to allow the presentation of more of them, would be a simple way to increase the number of autopecking trials per session and decrease the number of sessions needed to reach asymptote. Thus relevant data may be gathered more quickly.

REFERENCES

Bitterman, M. E., Reed, P., & Krauskopf, J. The effect of the duration of the unconditioned stimulus upon conditioning and extinction. American Journal of Psychology, 1952 65, 256-262.

Brown, P. L., & Jenkins, H. M. Auto-shaping of the pigeon's key-peck. Journal of the Experimental Analysis of Behavior, 1968, 11, 1-8.

Coppock, H. W., & Chambers, R. M. GSR conditioning: an illustration of useless distinction between "types" of conditioning. Psychological Reports, 1959, 5, 171-177.

Fernie, R. W. A device for measuring food-magazine behavior in the pigeon. Journal of the Experimental Analysis of Behavior, 1971, 16, 409-410.

Frey, R. W., & Butler, C. S. Rabbit eyelid conditioning as a function of unconditioned stimulus duration. Journal of Comparative and Physiological Psychology, 1973, 85, 289-294.

Gamzu, E., & Williams, D. R. Classical conditioning of a complex skeletal response. Science, 1971, 171, 923-925.

Gantt, W. H. The nervous secretion of saliva; the relation of the conditioned response to the intensity of the unconditioned stimulus. American Journal of Physilogy, 1938, 123, 74. (Abstact)

Gonzales, F. A. Effects of partial reinforcement (25 %) in an autoshaping procedure. Bulletin of the Psychonomic Society, 1973, 2, 299-301.

Gormezano, I., & Moore, J. W. Effect of instructional set and UCS intensity on the latency, percentage, and form of the eyelid response. Journal of Experimental Psychology, 1962, 63, 487-494.

Kimble, G. A. Comment. Psychonomic Science, 1964, 1, 40.

Kleschov, S. V. (The dependence of the magnitude of conditioned food reflexes upon the amount of unconditioned reinforcement.) Trud. Fiziol. Lab. Pavlova, 1936, 6, 27-53. Cited by Wagner, A. R., Siegel, S., Thomas, E., & Ellison, G. D. Reinforcement history and the extinction of a conditioned salivary response. Journal of Comparative and Physiological Psychology, 1964, 58, 354-358.

Mariner, R. W., & Thomas, D. R. Reinforcement duration and peak shift in post-discrimination gradients. Journal of the Experimental Analysis of Behavior, 1969, 12, 759-766.

Mowrer, O. H., & Solomon, L. N. Contiguity vs. drive reduction in conditioned fear: the proximity and abruptness of drive reduction. American Journal of Psychology, 1954, 67, 15-25.

Overmier, J. B. Differential transfer of control of avoidance responses as a function of UCS duration. Psychonomic Science, 1966, 5, 25-26. (a)

Overmier, J. B. Instrumental and cardiac indices of Pavlovian fear conditioning as a function of US duration. Journal of Comparative and Physiological Psychology, 1966, 62, 15-20. (b)

Reiss, D., & Farrar, C. H. US duration, conditioned acceleration, multiple CS measurement, Pavlovian R-R laws in rats. Journal of Comparative and Physiological Psychology, 1973, 82, 144-151.

Ricci, J. A. Key pecking under response-independent food presentations after long simple and compound stimuli. Journal of the Experimental Analysis of Behavior, 1973, 19, 509-516.

Runquist, W. N., & Spence, K. W. Performance in eyelid conditioning as a function of UCS duration. Journal of Experimental Psychology, 1959, 57, 249-252.

Shaefor, P. J., & Gormezano, I. Conditioning the rabbit's (oryctolagus cuniculus) jaw movement response: US magnitude effects on URs, CRs, and psuedo-CRs. Journal of Comparative and Physiological Psychology, 1972, 81, 449-456.

Skinner, B. F. "Superstition" in the pigeon. Journal of Experimental Psychology, 1948, 38, 168-172.

Wagner, A. R., Siegel, S., Thomas, E., & Ellison, G. D. Reinforcement history and the extinction of a conditioned salivary response. Journal of Comparative and Physiological Psychology, 1964, 58, 354-358.

Wegner, N. & Zeaman, D. Strength of cardiac conditioned responses with varying unconditioned stimulus duration. Psychological Review, 1958, 65, 238-241.

Wike, E. L. Secondary Reinforcement: Selected Experiments. New York: Harper & Row, 1966, pp. 423-425.

Williams, D. R., & Williams, H. Auto-maintenance in the pigeon: sustained pecking despite contingent non-reinforcement.

APPENDIX A

THE NINE ORDERS (TAPES) OF CSs AND USs USED IN ALL THREE PHASES OF EXP I.

BLOCKS

ORDER	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	9̲10	910	19̲0	9̲01̲	091	19̲0	19̲0	901	109	019̲	109	091	910	091	019	019̲	109̲	9̲01
2	190	9̲01	9̲01	9̲01	091	019	19̲0	910	109	091	9̲10	9̲1̲0	019	19̲0	019	109̲	091	109
3	901	901	9̲10	019	9̲10	9̲10	109	019̲	09̲1	19̲0	190	9̲10	091	109̲	19̲0	091	1̲09	019
4	910	19̲0	9̲01	019̲	109	019̲	9̲01	09̲1	091	109	190	09̲1	109̲	9̲01̲	910	190	019	9̲10
5	1̲9̲0	910	109	910	9̲01	09̲1	09̲1	109	901	19̲0	109̲	019	091	019	019̲	9̲01	9̲10	190
6	190	9̲01	19̲0	9̲01	1̲09̲	910	109̲	09̲1	901	019̲	019	190	910	910	091	019̲	109	09̲1
7	19̲0	910	910	910	09̲1	019	1̲9̲0	109	9̲01	**109̲**	019	901	19̲0	9̲01	019̲	109	09̲1	091
8	9̲01	9̲01	190	019̲	190	109	019	9̲10	901̲	910	09̲1	091	109̲	019̲	190	9̲10	109	09̲1
9	019̲	19̲0	109	910	109̲	019	091	9̲10	901	901	109̲	9̲10	9̲01	091	01̲9	190	09̲1	19̲0

The numbers "0", "1", and "9" refer to CS **0**/18, CS 1/18, and CS 9/18 respectively. When the number is underlined, "_", the appropriate CS is followed by a US.

APPENDIX B

BLOCK	ORDER (TAPE) 1	ORDER (TAPE) 3
1	$\underline{1}99199199911119\underline{9}1119$	$91\underline{1}199191919919111\underline{9}9$
2	$19199919\underline{1}191199191\underline{9}1$	$11991199\underline{1}9199911\underline{9}191$
3	$1\underline{9}9\underline{1}9191119199199191$	$1\underline{9}19991999\underline{1}119919111$
4	$11\underline{9}911199\underline{1}9999111199$	$991\underline{91}119199111191999$
5	$\underline{9}9\underline{1}91919991119911119$	$911\underline{1}191111199991999\underline{9}$
6	$999911911911\underline{91}919191$	$\underline{91}119991919119199911$
7	$19\underline{1}1911911911991999\underline{9}$	$9111911191999919\underline{1}1\underline{9}9$
8	$119199991919\underline{9}9\underline{1}11911$	$\underline{9}9999\underline{1}11111199911991$
9	$91\underline{19}9919911919191191$	$19911\underline{9}919919\underline{1}9199111$

BLOCK	ORDER (TAPE) 2
1	$11111991\underline{9}9191\underline{1}999199$
2	$9\underline{9}9919111119919\underline{1}9191$
3	$191999911\underline{1}1\underline{9}19119199$
4	$91111919119\underline{1}9919\underline{9}919$
5	$11191\underline{9}1199\underline{1}991919919$
6	$99111\underline{9}191991\underline{1}9919119$
7	$99919\underline{1}11911191\underline{9}11999$
8	$9991111991919191\underline{9}91\underline{1}$
9	$191999\underline{91}191111919991$

These are the three randomly determine orders of CSs and USs. The number "9" represents a CS 9 trial; the number "1" a CS 1 trial. Underlined "_" numbers represent trials on which USs were presented. The other three orders were arrived at by substituting "9"s for "1"s and vice versa in this table.

THE EFFECT OF DURATION OF GRAIN PRESENTATION ON THE RATE OF PIGEON'S AUTOPECKING

by

ROBERT A. HANCOCK, JR.

B. A., University of Massachusetts, Amherst, 1971

AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Psychology

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1974

ABSTRACT

Two experiments were conducted to determine the effects of the duration of grain presentations in autopecking procedures. In the first experiment, grain duration was manipulated within subjects but between sessions. In the second experiment, grain duration was manipulated within sessions and within subjects. The probability that a key lite signal would be followed by grain was also manipulated within subjects-within sessions in the first experiment.

Grain durations of 3 and 9 sec both produced rates of autopecking significantly above rates produced by a 1 sec condition, in Experiment I. However these two durations did not reliably differ in comparison with each other. Grain probabilities of 0, 0.055, 0.5 supported rates of autopecking that were significantly different from each other. In Experiment II, 9 sec grain presentations produced rates reliably higher than rates with 1 sec grain presentations.

Further data analysis revealed that the same relative increases in grain probability produced greater increases in autopecking than did the same relative increases in grain duration. Grain probability was concluded to be a more potent variable than grain duration.