Hassin Herman, Alison Debra

PARAMETERS CONTRIBUTING TO SEQUENTIAL EFFECTS UNDER MULTIPLE SCHEDULES OF REINFORCEMENT

City University of New York PH.D. 1984

PARAMETERS CONTRIBUTING TO SEQUENTIAL EFFECTS UNDER MULTIPLE SCHEDULES OF REINFORCEMENT

by

ALISON DEBRA HASSIN HERMAN

A dissertation submitted to the Graduate Faculty in Psychology in partial fulfillment of the requirements for the degree of Doctor of Philosophy, The City University of New York.

1984

This manuscript has been read and accepted for the Graduate Faculty in Psychology in satisfaction of the dissertation requirement for the degree of Doctor of Philosophy.

6 Feb 84
date

Chairman of Examining Committee

February 14 1984
date

Executive Officer

Supervisory Committee

The City University of New York

Abstract

Parameters Contributing To Sequential Effects Under Multiple Schedules Of Reinforcement

by

Alison Debra Hassin Herman

Advisors: Professor Bruce L. Brown

Professor Nancy S. Hemmes

The present investigation explored the discrepancy between two different sequential effects observed in multiple schedule paradigms. The following-high-density effect was defined when higher keypecking rates occurred in a target component which was followed by a component associated with a high density of reinforcement than during a target component which was followed by a component associated with a low density of reinforcement. The following-low-density effect was defined when higher keypecking rates occurred in a target component which was followed by a component associated with a low/zero density of reinforcement than during a target component which was followed by a component associated with a high density of reinforcement. In each of three experiments, pigeons were exposed to a multiple schedule containing two fixed two-component sequences. Each sequence was differentially cued during the initial component of each sequence. Across

all three experiments, a differential S-SR relation was introduced in the initial component by eliminating reinforcement in the terminal component of one sequence. The initial component was 6 sec in duration and was then systematically increased until equal in duration to the 30 sec terminal component of each sequence. In Experiment 1, with extinction schedules in the initial components and no differential stimuli in the terminal components, the following-high-density effect varied with the duration of the initial component. In Experiment 2, with a nonzero schedule of reinforcement in the initial components and no differential stimuli in the terminal components, the following-high-density effect and the following-low-density effect were observed at initial component durations greater than 6 sec. With a nonzero schedule of reinforcement in the initial components and differential stimuli in the terminal components, birds in Experiment 3 responded similarly to two birds in Experiment 2. When the initial component was short (6 sec), the following-high-density sequence was demonstrated. When the initial component was long (18 or 30 sec), the following-low-density effect was demonstrated. The duration of the initial component and the schedule of reinforcement in the initial component were determining factors for the type of following density effect obtained.

ACKNOWLEDGEMENTS

I would like to express my appreciation and gratitude to my husband Bruce for his incessant encouragement, patience, and selfess concern throughout my graduate education. Above all, I thank Bruce for his unwavering love and friendship.

Acknowledgement and appreciation to my dissertation sponsors, Dr. Bruce L. Brown and Dr. Nancy S. Hemmes for their assistance and valuable advice during this investigation and the preceding years. Special thanks to Dr. Bruce L. Brown who always made himself available for my countless inquiries and who added new insights and encouragements throughout this research.

I would like to thank Dr. Robert N. Lanson, Dr. Peter D. Balsam, and Dr. Gerry D. Lachter for their thorough review of this dissertation, their suggestions, and their thought-provoking comments. Their insights and ideas helped form the final version of this dissertation.

Appreciation and thanks to John Leong for his time and assistance in the statistical tests and graphics required in this research project. Stan Sham gave generously his time and skill with electromechanical equipment employed in this study.

To my family for their sincere concern, encouragement, and love I extend my appreciation and thanks. I would especially like to thank my father for his non-traditional attitudes in encouraging and supporting me to pursue my doctoral studies.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

GENERAL INTRODUCTION

Since the demonstration of behavioral contrast (Reynolds, 1961a), schedule interaction phenomena have been observed in a variety of multiple schedule paradigms and have remained a topic of much interest (Herrnstein, 1970; Rachlin, 1973; Reynolds, 1961a, 1961b, 1963; Terrace, 1966). More recent research in multiple schedules of reinforcement has focused upon the role of sequential factors in schedule interaction phenomena (e.g. Brown, Hemmes, Coleman, Hassin, and Goldhammer, 1982; Farley, 1980; Marcucella, 1981; Schwartz and Gamzu, 1977; Williams, 1979, 1981). Rates of responding in target components differed when the schedules of reinforcement which followed these components also differed. This recent literature has revealed two quite different sequential effects. The following-high-density effect was identified when higher keypecking rates occurred in a target component which was followed by a component associated with a high density of reinforcement than during a target component which was followed by a component associated with a low density of reinforcement. Brown et al. (1982) demonstrated higher keypecking rates in a target component which was followed by a component associated with a nonzero schedule of reinforcement than in a target component which was followed by a component associated with extinction (the following-high-density effect). The following-low- density effect was identified when higher

keypecking occurred in a target component which was followed by a component associated with a low/zero density of reinforcement than during a target component which was followed by a component associated with a high density of reinforcement (the following-low-density effect). Williams (1979) demonstrated higher keypecking rates in a target component which was followed by a component associated with extinction than in a target component which was followed by a component associated with a high density of reinforcement (the following-low-density effect). Since these two findings are contradictory, it is important to examine the contexts in which these findings were obtained.

Wilton and Gay (1969) showed that responding in one component of a multiple schedule varied as a function of the schedule of reinforcement operating in an immediately following component. Keypecking rate in a VI 5-min component which was followed by an extinction component was higher than in a VI 5-min component which was followed by a VI 1-min component (the following-low-density effect). Wilton and Gay suggested that multiple schedule interactions may vary as a function of the ordering of the components.

Williams (1979) expanded upon the finding of Wilton and Gay (1969) and investigated how component duration in a multiple schedule is functionally related to two types of schedule transitions. Williams examined component duration in a four-component multiple schedule designed to separate

the effects of the preceding schedule of reinforcement from those of the following schedule of reinforcement. In each four-component sequence, the reinforcement schedules for two of the components were identical (VI 3-min). Therefore, any difference in response rate during these two components, the target components, was described as being due to their location in the four-component sequence. In the sequence testing the role of the following schedule, the target components were each preceded half the time by a VI 1-min component, and half the time by an Ext component. Any influence of the preceding schedule was then equivalent for the target components. However, the schedules following the target components always differed, so that differences in response rate in the target components would be due to the reinforcement schedules in the following components. In the sequence testing the role of the preceding schedule, the target components were preceded by components containing different schedules of reinforcement, but the following components contained the same schedule of reinforcement. Hence, any difference in response rate during the target components would be due to the schedule of reinforcement in the preceding component.

Although the reinforcement schedule in the preceding component had no consistent effect upon behavior in the target components, the reinforcement schedule in the following component had a strong effect upon behavior in

these components. Pigeons displayed higher rates of responding during the target component which was followed by an extinction component than during the target component which was followed by a component containing a nonzero schedule of reinforcement (the following-low-density effect). Additionally, all pigeons demonstrated a reduction in response rate as the duration of all components was increased to 15, 60, and 180 sec. Williams suggested that the effect of component duration in multiple schedules is the result of the change in control by the following schedule of reinforcement. Williams proposed that responding during a component was inversely related to the "value" of the following component. The formulation of "value" incorporated both primary and secondary reinforcement. Accordingly, the relation between a component cue and the "average value" of the following component generates the following-low-density effect. Unfortunately, the mechanism which underlies the following-low-density effect remains unclear.

Using a variety of multicomponent schedules of (response- dependent or -independent) reinforcement similar to those used by Williams (1979, 1981), Farley (1980) functionally separated the effects of the preceding schedule, the effect of the following schedule, and the effect of the overall relative rate of reinforcement independent of the local transitions. Farley exposed

pigeons to multicomponent schedules such that the effect of eliminating reinforcement (Ext) from one of the components could be observed separately for the preceding and the following components. Pigeons displayed higher keypecking rates during a target component which was preceded by a component which was associated with the same or lower rate of reinforcement and was followed by an extinction component than when this sequence was reversed. Farley suggested that elevated rates of responding occur in one component when that component cue signals a greater rate of reinforcement than the components which temporally surround it. Rates of responding were substantial even though that component was followed by a component cue which signaled a decrease in overall reinforcer rate. Similarly to Williams (1979), Farley suggested that a cue associated with the occurrence of an impending extinction period has an increased ability to function as a conditioned reinforcer.

In contrast to these findings by Williams (1979) and Farley (1980) are the data of Brown, Hemmes, Coleman, Hassin, and Goldhammer (1982) and Marcucella (1981). Brown et al. (1982) investigated the control of keypecking by a differential stimulus-reinforcer (S-SR) relation in the context of a four-component multiple schedule. This procedure, termed the temporal separation procedure, used a four-component multiple schedule in which there were two fixed two-component sequences. Each sequence was

differentially cued by colored keylights during the initial components, which were 4, 6, or 8 sec in duration in different experiments. While reinforcers could be earned on a response-dependent schedule in the 30 sec terminal component of each sequence, responses were not reinforced in the initial component of either sequence. When reinforcement was eliminated (Ext) in the terminal component of one sequence, rate of keypecking increased in the initial component of the other sequence. That is, pigeons demonstrated higher response rates in the component which was followed by a component associated with a nonzero schedule of reinforcement than in the component which was followed by a component associated with extinction (the following-high-density effect). Brown et al. suggested that responding during the initial (target) component was dependent upon the differential relation between the stimuli in the initial components and the schedule of reinforcement in the terminal components, i.e. an S-SR contingency. Similar data were reported by Marcucella (1981). With a multiple schedule paradigm similar to Brown et al., Marcucella also demonstrated keypecking during a 1.5 sec cue which was followed by a 58.5 sec component containing a relatively high density of reinforcement. Marcucella also suggested that differential responding during the cue was controlled by a differential S-SR relation.

The foregoing review suggests that the discrepancy between the following-high-density effect and the following-low-density effect may be resolved by examining the procedural variables involved in each following density effect. Williams (1979) demonstrated that the following-low-density effect was functionally related to component duration (e.g. 15, 60, and 180 sec). Of note is that Williams always used components which were equal in duration and observed the following-low-density effect to be greater with short component durations. On the other hand, Brown et al. (1982) also speculated that the following-high-density effect might be related to component duration since increased responding was observed when the duration of the initial components was shortened across experiments (i.e. 8, 6, and 4 sec). Unlike Williams, Brown et al. always used a procedure in which the target components were very short relative to the following components. It is apparent, therefore, that one procedural variable which may be responsible for the type of following density effect obtained is the duration of the target component relative to the duration of the following component.

Whereas Williams demonstrated both the following-low-density effect and the following-high-density effect with target components which contained nonzero densities of reinforcement (i.e. VI 3-min), Brown et al. only demonstrated the following-high-density effect with target

components which were associated with extinction. However, Williams only demonstrated the following-high-density effect when his procedure was most similar to the procedure of Brown et al.-- when the target components but not the following components were differentially cued. Thus, two other procedural variables which appeared to have contributed to the discrepancy between the following-high- and following-low-density effects are the presence versus the absence of a nonzero schedule of reinforcement in the target components and the presence versus the absence of differential stimuli in all components of the multiple schedule.

The present investigation consists of three experiments which explore the apparent discrepancy between the following- high-density effect and the following-low-density effect. Each of the three experiments uses some version of the temporal separation procedure (Brown et al. 1982) to determine how the schedule of reinforcement operating in the target components, the duration of the target components, and the presence of differential stimuli in each component contribute to the type of following density effect obtained.

EXPERIMENT 1

Experiment 1 examined the influence of component duration as one variable potentially responsible for the type of following density effect observed. Pigeons were exposed to two fixed two-component sequences in which only the initial component of each sequence was differentially cued. Reinforcers could be earned on a response- dependent schedule in the terminal component of each sequence, but responses were not reinforced in the initial component of either sequence. Thus, the present experiment employed a procedure similar to that of Brown et al. (1982) since the target components were, at first, short relative to the duration of the terminal components; there were extinction schedules in the target components; and there were no differential cues in the terminal components. With the terminal component set at 30 sec in duration, the duration of the initial component was systematically increased from 6 sec to 30 sec in duration. Therefore, the present procedure was also similar to the procedure employed by Williams (1979). In his investigations, Williams (1979, 1981) used components which were equal in duration, and in specific instances, each component was not differentially cued by keylights.

If component duration is a determining factor for the type of following density effect obtained, then the following-high-density effect observed with relatively short

target components might give way to the following-low-density effect observed when the target components are equal in duration to the following components. At issue is whether the change in the duration of the initial component would systematically affect the rate of responding during the target components.

Method

Subjects

Four naive adult White Carneaux pigeons served as subjects in the present study. All birds were maintained at 80% of their free-feeding weights throughout the experiment. Water and grit were always available in their home cages.

Apparatus

The experiment was conducted in two standard three-key pigeon chambers (BRS/LVE). The right key could be transilluminated with various stimuli provided by display projectors (BRS/LVE IC-901). The left and center keys remained dark and responses directed toward these keys were not recorded and had no programmed consequences. Responses of at least .10N to the right key were recorded. The reinforcer was 2 sec access to mixed grain delivered by a food hopper located directly below the center key. The

houselight remained on during the entire session except during reinforcement when both the houselight and keylight were turned off and the food hopper was illuminated. Masking noise was provided by a fan in the chamber and white noise in the chamber and in the room containing the chamber. Electromechanical programming and recording equipment were located in an adjacent room.

Procedure

Pretraining: After all pigeons were trained to eat from the food hopper and to peck a white right side key, they were exposed to two sessions of continuous reinforcement in which 100 reinforcers were delivered in each session. All birds were then exposed to a random-interval (RI) 30-sec schedule in the presence of a white keylight. The RI 30-sec schedule was produced by using a t cycle duration of 3 sec, and a probability generator set at .10. A probability generator was sampled at the beginning of each 3 sec bin. Under this schedule, all birds were run for 55 minutes each day until they earned at least half of the reinforcers available during two consecutive sessions. All birds were then exposed to a four-component mixed schedule in which there were two fixed two-component sequences. The component stimuli employed in the experimental phases are shown in Table 1 and described below. In each sequence the initial component was first 6 sec in duration and was immediately followed by a 30 sec terminal component. Strict alternation

of sequences was maintained throughout the experiment. During this and all subsequent phases of the experiment, sessions were run 6 days a week, for 55 minutes each day.

Phase I: Following pretraining and during the next 42 sessions subjects were exposed to a mixed schedule of reinforcement in the presence of a white keylight. A session was terminated after 90 sequences were presented (55 minutes). Subjects' responses were never reinforced during the initial component of each sequence. Responses were reinforced on an RI 30-sec schedule of reinforcement during the terminal component of each sequence (mix Ext RI 30-sec). Once a reinforcer became available in a given component, it was held until earned for the duration of that component only. The durations of the initial and terminal components of each sequence were 6 and 30 sec, respectively.

Phase II: During this phase, the initial component of each sequence was cued by a white cross on a black background projected onto the response key. The terminal component of each sequence continued to be cued by a white keylight. The introduction of a cue during the initial component of each sequence converted the mixed schedule to a multiple schedule of reinforcement. The reinforcement schedules in each component were the same as those described in Phase I. For this Phase and Phases III through VI, each

session terminated after 90 sequences were presented. This phase lasted for 35 sessions.

Phase III: In this phase, each sequence was now differentially cued by red and green keylights during the initial component. The white keylight remained the cue for the terminal component of each sequence. The reinforcement schedules in each component were the same as those operative during Phases I and II. All birds were exposed to this sequence of stimuli for 35 sessions.

The common feature among Phases I, II, and III was the absence of a differential S-SR contingency between the cues in the initial components and the schedules of reinforcement in the terminal component of each sequence. Response rates during Phase III established a baseline for comparison with future manipulations.

Phase IV: An S-SR contingency was introduced by converting the reinforcement schedule in the terminal component of a sequence from an RI schedule to extinction. For two subjects the red-cued sequence was associated with extinction, while the green-cued sequence was associated with extinction for the other two subjects (see Table 1). All subjects were exposed to this phase for 30 sessions.

Phase V: The S-SR contingency was eliminated during this phase with the re-introduction of the RI 30-sec schedule in the terminal component of the sequence previously associated with extinction, i.e., a return to a baseline condition was instituted. All subjects were exposed to this phase for 30 sessions.

Phase VI: The S-SR contingency was re-introduced during this phase. However the correlation between component one cues and component two schedules was reversed from that prevailing in Phase IV. The two subjects who were originally exposed to a red-cued sequence associated with extinction, were, in this phase, exposed to a red-cued sequence associated with the RI 30-sec schedule of reinforcement, and a green-cued sequence associated with extinction. The other two subjects who were originally exposed to a green-cued sequence associated with extinction were, in this phase, exposed to a green-cued sequence associated with the RI 30-sec schedule of reinforcement and a red-cued sequence associated with extinction. All subjects were exposed to 25 sessions during this phase.

Phase VII: The duration of component one of each sequence was manipulated in Phase VII. All subjects were exposed to a new duration every 20 days in the following order: 12, 18, 30, and 6 sec. The number of sequences per

session were 76, 68, 54, and 90, respectively. In all other respects, conditions were the same as those in effect during the previous phase.

Phase VIII: Component one duration was held at 6 sec while the S-SR contingency was eliminated with the re-introduction of the RI 30-sec schedule of reinforcement in the terminal component of the sequence previously associated with extinction. This phase was terminated after 25 sessions.

Table 1

Summary of Conditions for Experiment 1

	Sequence A		Sequence B		
	In'tl. Co.	Term. Co.	In'tl. Co.	Term. Co.	Subjects
Phase I					
Cue	White	White	White	White	
Duration	6 sec	30 sec	6 sec	30 sec	
Schedule	Ext	RI 30-sec	Ext	RI 30-sec	1,2,3,4
Phase II					
Cue	Cross	White	Cross	White	
Duration	6 sec	30 sec	6 sec	30 sec	
Schedule	Ext	RI 30-sec	Ext	RI 30-sec	1,2,3,4
Phase III					
Cue	Red	White	Green	White	
Duration	6 sec	30 sec	6 sec	30 sec	
Schedule	Ext	RI 30-sec	Ext	RI 30-sec	1,2,3,4
Phase IV					
Cue	Red	White	Green	White	
Duration	6 sec	30 sec	6 sec	30 sec	
Schedule	Ext	Ext	Ext	RI 30-sec	1,2
Schedule	Ext	RI 30-sec	Ext	Ext	3,4
Phase V					
Cue	Red	White	Green	White	
Duration	6 sec	30 sec	6 sec	30 sec	
Schedule	Ext	RI 30-sec	Ext	RI 30-sec	1,2,3,4
Phase VI					
Cue	Red	White	Green	White	
Duration	6 sec	30 sec	6 sec	30 sec	
Schedule	Ext	RI 30-sec	Ext	Ext	1,2
Schedule	Ext	Ext	Ext	RI 30-sec	3,4
Phase VII					
Cue	Red	White	Green	White	
Duration	12 sec	30 sec	12 sec	30 sec	
Duration	18 sec	30 sec	18 sec	30 sec	
Duration	30 sec	30 sec	30 sec	30 sec	
Duration	6 sec	30 sec	6 sec	30 sec	
Schedule	as Phase VI	as Phase VI	as Phase VI	as Phase VI	1,2,3,4
Phase VIII					
Cue	Red	White	Green	White	
Duration	6 sec	30 sec	6 sec	30 sec	
Schedule	Ext	RI 30-sec	Ext	RI 30-sec	1,2,3,4

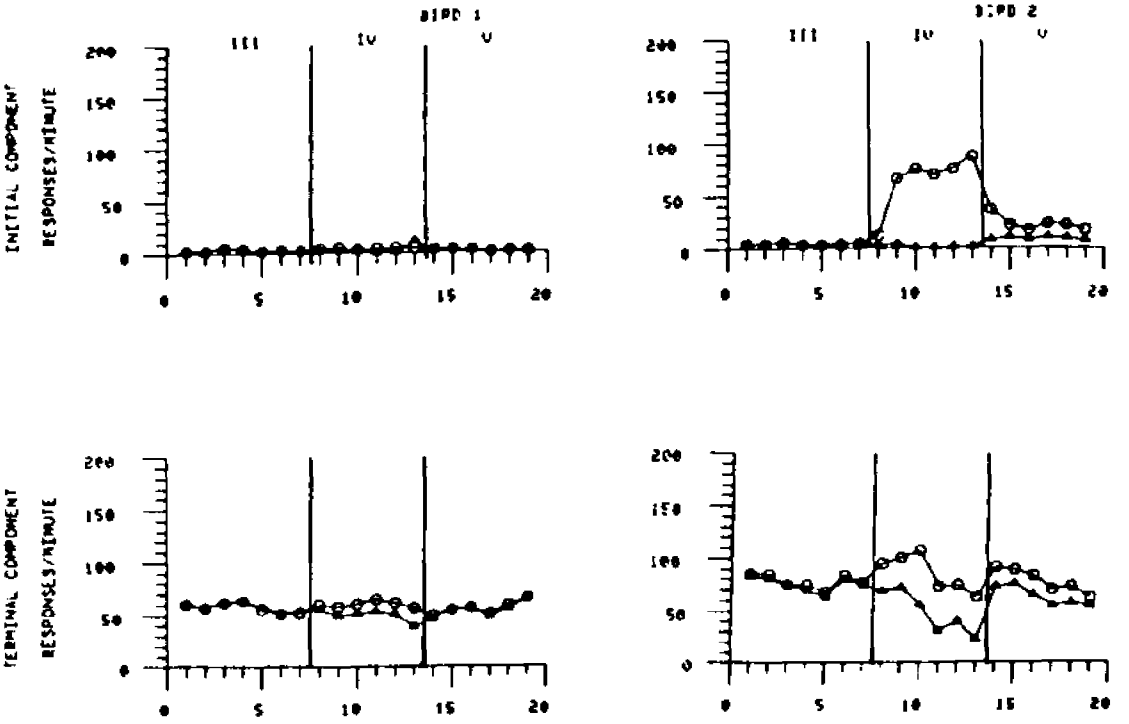
Results

With the introduction of an S-SR contingency (Phase IV), birds displayed an increase in responding in the initial component of the high-density sequence. Figure 1 presents mean response rate plotted over five-session blocks during Phases III, IV, and V for all birds. The upper graph for each bird presents performance during the initial components, and the lower graph presents performance during the terminal components.

With an S-SR contingency in Phase IV, Birds 2, 3, and 4 displayed higher rates of responding in the initial component that was followed by an RI component than in the initial component that was followed by an extinction component, i.e. a following-high-density effect was obtained. Differentiation of responding was also observed in the terminal components. When the S-SR contingency was removed (Phase V), response rates in the initial and terminal components approximated baseline levels. However, Bird 2 continued to display higher rates of responding during the sequence which had contained the RI 30-sec schedule in Phase IV.

As the duration of the initial component increased, the following-high-density effect diminished. Figure 2 presents the mean response rate during the initial component for the last ten sessions for each manipulation of component duration.

Figure 1. Rates of responding for four birds during Phases III, IV, and V of Experiment 1. Initial component rates during high- and low-density sequences are shown in the upper graphs, and the terminal component rates are shown in the lower graphs. Solid, vertical lines separate data from successive phases.



○ HIGH DENSITY △ LOW DENSITY

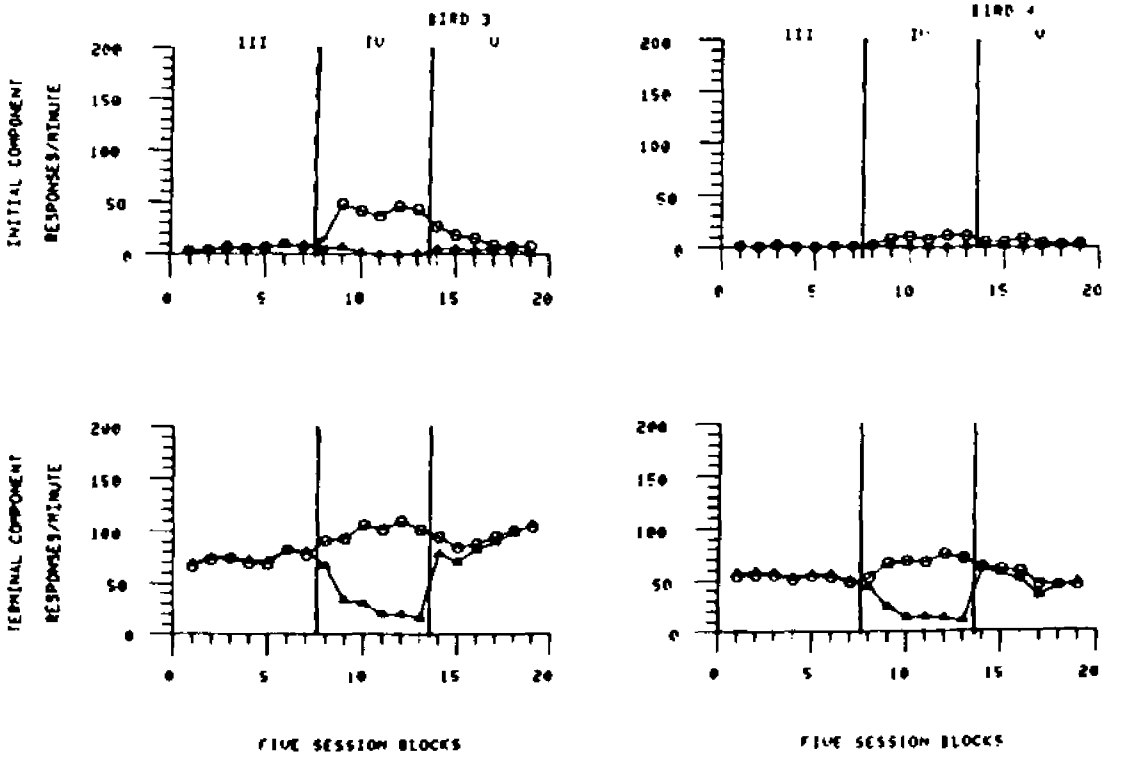
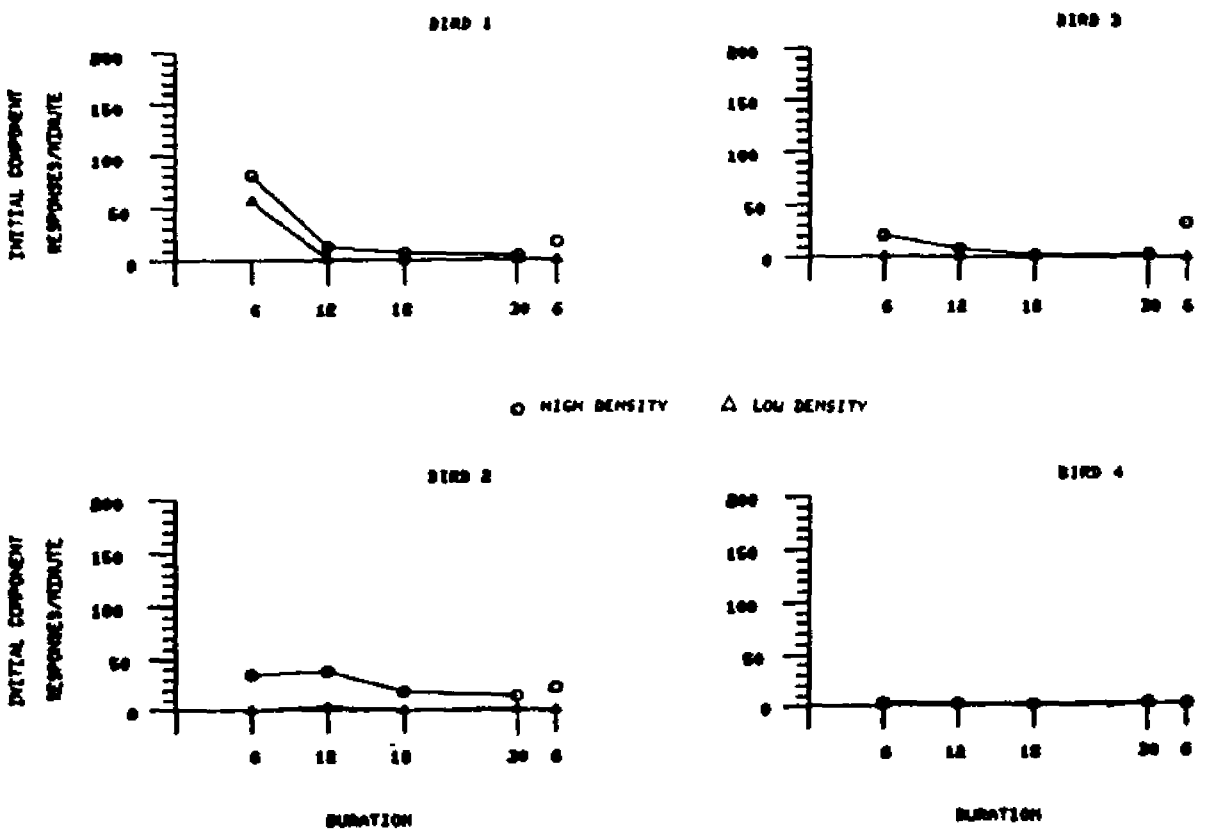


Figure 2. Mean response rates of the last ten sessions of Phases VI and VII of Experiment 1. Each graph presents one bird's rate of responding during the initial component for each manipulation of the initial component duration.


BIRD 1
BIRD 3
INITIAL COMPONENT
RESPONSES/MINUTE
200
150
100
50
0
6
12
18
30
6
○ HIGH DENSITY
△ LOW DENSITY
BIRD 2
BIRD 4
DURATION

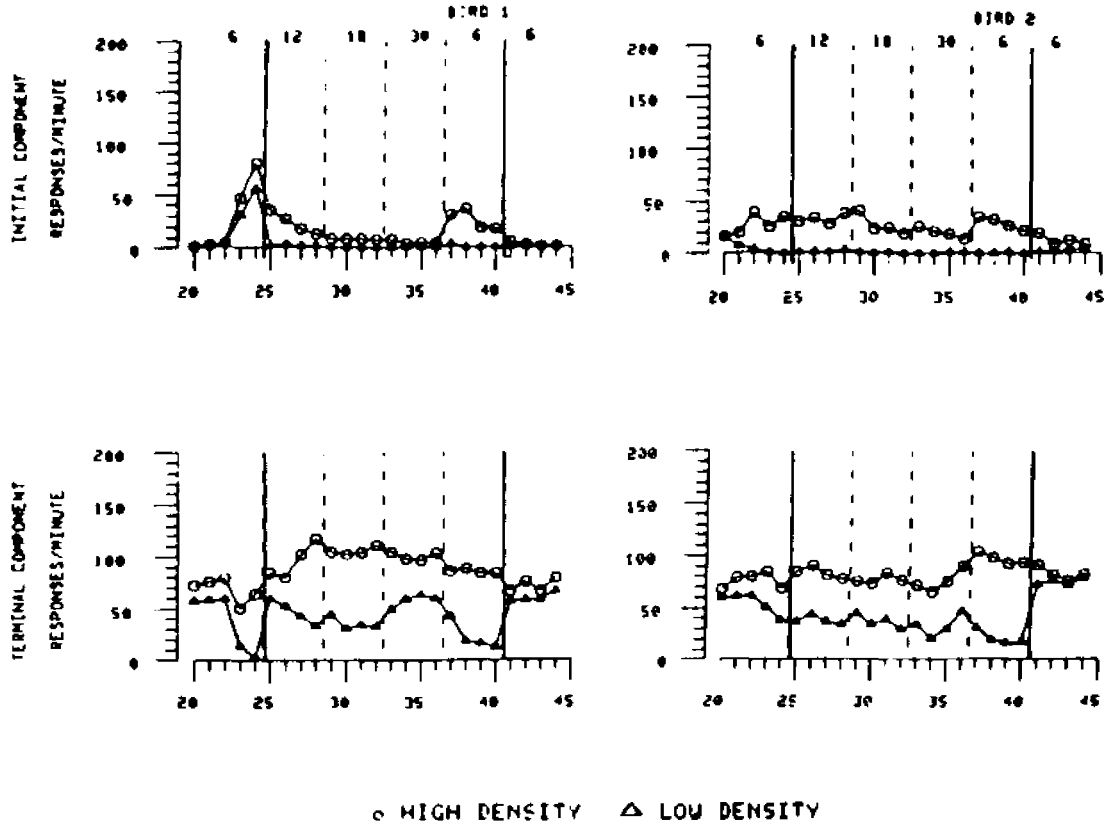
Throughout the change in initial component duration, differential responding was maintained. As the initial component increased in duration, Birds 1, 2, and 3 continued to display higher response rates in the initial component of the high-density sequence than in the initial component of the low-density sequence. However, rate of responding in the initial component of the high-density sequence did decrease as the initial component increased to 30 sec. When the duration of the initial component was returned to 6 sec, responding in the initial component of the high-density sequence increased.

To determine whether differential rates of responding between sequences of the initial components were related to component duration, the mean response rates of the last ten sessions for each duration of the initial component (6, 12, 18, and 30 sec) in Phases VI and VII were analyzed statistically. A duration x sequence analysis of variance revealed a reliable main effect of duration ($F(3,9) = 5.88$; $p < .01$) and a duration x sequence interaction ($F(3,9) = 3.54$; $p < .06$). Although this duration x sequence interaction did not reach a conventional level of significance, the following-high-density effect tended to diminish for all birds as the initial component increased in duration (see Figure 2). For example, when the initial component was 6 sec in duration, the mean response rates across subjects were 25.90 and .91 in the initial component

of the high-density and low-density sequences, respectively. When the initial component was 30 sec in duration, the mean response rates were 5.89 and .41 in these respective components (see Table D in Appendix).

These effects can also be seen in Figure 3 which presents mean response rate during both components plotted over five-session blocks during Phases VI, VII, and VIII. This figure also shows that responding during the terminal component of each sequence did not vary systematically with initial component duration. When the S-SR contingency was removed (Phase VIII), rates of responding in the initial and terminal components approximated baseline levels (Phase III). Temporal patterns of responding in the initial components are presented in Figures 10 and 11 in the Appendix. These data have not been reviewed in the text.

Figure 3. Rates of responding for four birds during Phases VI, VII, and VIII of Experiment 1. Initial component rates during high- and low-density sequences are shown in the upper graphs, and the terminal component rates are shown in the lower graphs. Solid, vertical lines separate data from successive phases. Dashed, vertical lines separate successive manipulations of the initial component duration.


BIRD 1
BIRD 2
BIRD 3
BIRD 4
INITIAL COMPONENT
RESPONSES/MINUTE
TERMINAL COMPONENT
RESPONSES/MINUTE
6 12 18 30 6 6
200
150
100
50
0
20 25 30 35 40 45
○ HIGH DENSITY △ LOW DENSITY
FIVE SESSION BLOCKS
FIVE SESSION BLOCKS

Discussion

The results of Experiment 1 are consistent with those of Brown et al. (1982). The introduction of an S-SR contingency with respect to initial component cues resulted in a higher rate of responding in the initial component of the high-density sequence than in the initial component of the low-density sequence. The following-high-density effect observed in the present study is similar to the data obtained by Brown et al. and Marcucella (1981).

The present results also showed the following-high-density effect to vary with the duration of the initial components. The following-high-density effect was larger when the initial components were relatively short (e.g. 6 sec). It should be noted, however, that the present results showed no evidence of a following-low-density effect. This is of interest since other studies (Wilton and Gay, 1969; Farley, 1980; Williams, 1979, 1981) have demonstrated the following-low-density effect using similar multiple schedule paradigms. Apparently, another procedural variable must be responsible for the discrepancy between results.

One likely possibility for the discrepancy between the two following density effects is the presence versus the absence of a nonzero schedule of reinforcement in the target components of a multiple schedule. Both Farley (1980) and Williams (1979) argued that responding during a component cue was dependent upon the signaled decrement in overall

reinforcer rate at the cue's termination. In the present study, the following-low-density effect may not have occurred since the presence of an extinction schedule in the initial components precluded a transition from a higher rate of reinforcement in the initial components to a lower rate of reinforcement in the terminal components. However, Williams (1979) also observed the following-high-density effect when the target components contained a nonzero schedule of reinforcement.

The results of Experiment 1 and those of Williams (1979) raise the question of how the type of the following density effect is related to the schedule of reinforcement operating in the target components. It appears that the presence versus the absence of a nonzero schedule of reinforcement in the target component cannot itself resolve the discrepancy between the following-high-density and low-density effects. However, Williams observed both following density effects using equal component durations whereas the present study, as well as Brown et al. (1982), only observed the following-high-density effect when component durations were unequal. Therefore, the presence of a nonzero schedule of reinforcement in the target components and the duration of the target components may jointly determine the type of following density effect obtained.

Experiment 2 studied the influence of a nonzero schedule of reinforcement in the initial component as a determining

factor for the type of following density effect obtained. At issue is whether the change in the duration of the initial component would systematically affect the rate of responding during target components which contain a positive reinforcement schedule.

EXPERIMENT 2

Method

Subjects

Four naive adult White Carneaux pigeons served as subjects. All birds were maintained at 80% of their free-feeding weights throughout the experiment. Water and grit were always available in their home cages.

Apparatus

The apparatus was the same as in Experiment 1.

Procedure

The procedure was the same as in Experiment 1 with one exception. During all experimental phases, animals' responses were reinforced on an RI 150-sec schedule of

reinforcement during the initial component of each sequence. As in Experiment 1, responses were reinforced on an RI 30-sec schedule of reinforcement during the terminal component of each sequence. The RI schedules were obtained using a t cycle duration of 3 sec, and probability generators set at .10 and .02 for RI 30-sec and RI 150-sec schedules, respectively. The component stimuli employed in the experimental phases are shown in Table 2.

Table 2

Summary of Conditions for Experiment 2

	Sequence A		Sequence B		
	In'tl. Co.	Term. Co.	In'tl. Co.	Term. Co.	Subjects
Phase I					
Cue	White	White	White	White	
Duration	6 sec	30 sec	6 sec	30 sec	
Schedule	RI 150-sec	RI 30-sec	RI 150-sec	RI 30-sec	5,6,7,8
Phase II					
Cue	Cross	White	Cross	White	
Duration	6 sec	30 sec	6 sec	30 sec	
Schedule	RI 150-sec	RI 30-sec	RI 150-sec	RI 30-sec	5,6,7,8
Phase III					
Cue	Red	White	Green	White	
Duration	6 sec	30 sec	6 sec	30 sec	
Schedule	RI 150-sec	RI 30-sec	RI 150-sec	RI 30-sec	5,6,7,8
Phase IV					
Cue	Red	White	Green	White	
Duration	6 sec	30 sec	6 sec	30 sec	
Schedule	RI 150-sec	Ext	RI 150-sec	RI 30-sec	5,6
Schedule	RI 150-sec	RI 30-sec	RI 150-sec	Ext	7,8
Phase V					
Cue	Red	White	Green	White	
Duration	6 sec	30 sec	6 sec	30 sec	
Schedule	RI 150-sec	RI 30-sec	RI 150-sec	RI 30-sec	5,6,7,8
Phase VI					
Cue	Red	White	Green	White	
Duration	6 sec	30 sec	6 sec	30 sec	
Schedule	RI 150-sec	RI 30-sec	RI 150-sec	Ext	5,6
Schedule	RI 150-sec	Ext	RI 150-sec	RI 30-sec	7,8
Phase VII					
Cue	Red	White	Green	White	
Duration	12 sec	30 sec	12 sec	30 sec	
Duration	18 sec	30 sec	18 sec	30 sec	
Duration	30 sec	30 sec	30 sec	30 sec	
Duration	6 sec	30 sec	6 sec	30 sec	
Schedule	as Phase VI	as Phase VI	as Phase VI	as Phase VI	5,6,7,8
Phase VIII					
Cue	Red	White	Green	White	
Duration	6 sec	30 sec	6 sec	30 sec	
Schedule	RI 150-sec	RI 30-sec	RI 150-sec	RI 30-sec	5,6,7,8

Results

With the introduction of an S-SR contingency (Phase IV and VI), some birds displayed an increase in rate of responding in the high-density sequence. Figure 4 presents mean response rates plotted over five-session blocks during Phases III, IV, and V for all birds. The format for this figure is the same as that for Figure 1 of Experiment 1.

With an S-SR contingency in Phase IV, only Bird 5 showed an increase in response rate in the initial component of the high-density sequence (the following-high-density effect). Although there was an RI 150-sec schedule of reinforcement in the initial component of each sequence, Birds 6, 7, and 8 demonstrated little responding during these components, hence no reinforcers were earned. Response rate differences were also observed in the terminal components. All birds displayed higher rates of responding in the terminal component of the high-density sequence than in the low-density sequence.

When the S-SR contingency was removed (Phase V), response rates in the initial and terminal components approximated baseline levels. Bird 5 continued to display a higher rate of responding in both components of the sequence which had contained the RI 30-sec schedule than in the sequence which had contained the extinction schedule in Phase IV. Bird 6 continued to display a higher rate of responding in the terminal component of the sequence which

had contained the RI 30-sec schedule than in the sequence which had contained extinction in Phase IV. In comparison with the data of Birds 2, 3, and 4 of Experiment 1, the added schedule of reinforcement in the initial component of each sequence did not serve to systematically strengthen responding in the 6 sec initial component.

As the duration of the initial component increased, two of the four birds displayed an increase in rate of responding in the initial component of the low-density sequence which exceeded the value of the rate of responding in the initial component of the high-density sequence. Figure 5 presents the mean response rates during the initial component for the last ten sesssions of each manipulation of the initial component duration.

As the initial component increased in duration to 12, 18, and 30 sec, Birds 5 and 6 displayed an increase in rate of responding in the initial component of each sequence. Response rates during the initial component of the low-density sequence were higher than those during the initial component of the high-density sequence (the following-low-density effect). When the initial component was again 6 sec in duration, Bird 5 displayed an increase in rate of responding in the initial component of the high-density sequence, while Bird 7 displayed a reduction in rate of responding in the initial component of the high-density sequence. Birds 6 and 8 did not display any change in rate of responding in the initial components.

Figure 4. Rates of responding for four birds during Phases III, IV, and V of Experiment 2. Initial component rates during high- and low-density sequences are shown in the upper graphs, and the terminal component rates are shown in the lower graphs. Solid, vertical lines separate data from successive phases.

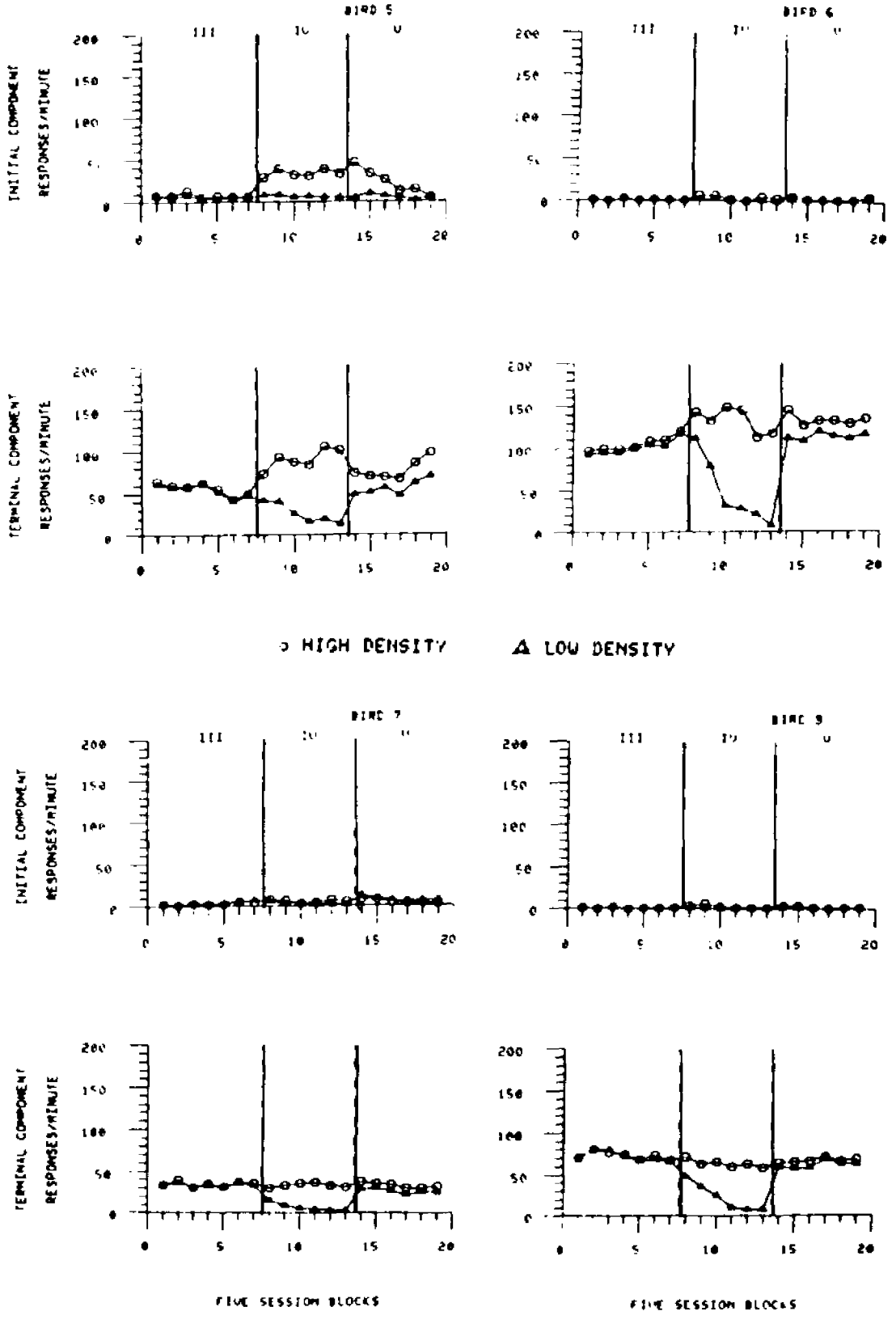
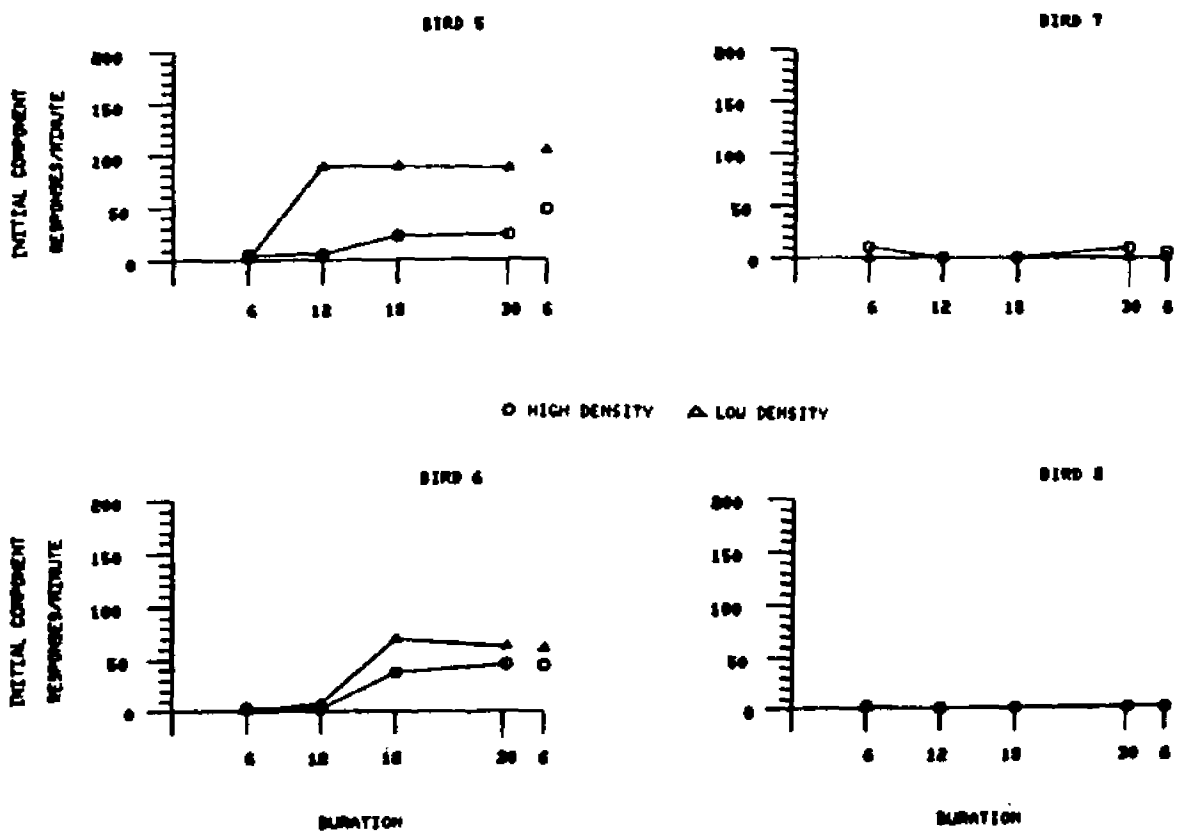

BIRD 5
BIRD 6
BIRD 7
BIRD 9
INITIAL COMPONENT
RESPONSES/MINUTE
TERMINAL COMPONENT
RESPONSES/MINUTE
HIGH DENSITY
LOW DENSITY
FIVE SESSION BLOCKS
FIVE SESSION BLOCKS

Figure 5. Mean response rates of the last ten sessions of Phases VI and VII of Experiment 2. Each graph presents one bird's rate of responding during the initial component for each manipulation of the initial component duration.


BIRD 5
BIRD 7
INITIAL COMPONENT
RESPONSES/MINUTE
200
150
100
50
0
6
12
18
30
6
○ HIGH DENSITY △ LOW DENSITY
BIRD 6
BIRD 8
DURATION

To determine whether differences in rates of responding between sequences of the initial component were reliably related to the duration of the initial component, the mean response rates of the last ten sessions for each duration of the initial component during Phases VI and VII were subjected to a duration x sequence analysis of variance. This analysis revealed no reliable effects. Differences in the rates of responding observed at each duration of the initial component did not differ significantly across all durations of the initial component ($F(3,9) < 1.0$). However, only two of the four birds displayed substantial rates of responding in the initial component of either sequence (see Table E in Appendix).

Figure 6 presents mean response rate during both components plotted over five-session blocks during Phases VI, VII, and VIII. The format for this figure is the same as that for Figure 3 of Experiment 1. As observed in Figure 5, Birds 5 and 6 demonstrated the following-low-density effect when the initial components were extended. Interestingly, Bird 7 responded similarly to birds in Experiment 1, displaying a higher rate of responding in the initial component of the high-density versus the low-density sequence as the initial component duration increased. Across subjects, rates of responding during the terminal component of each sequence showed no systematic change across durations. With the increase in duration, rates of

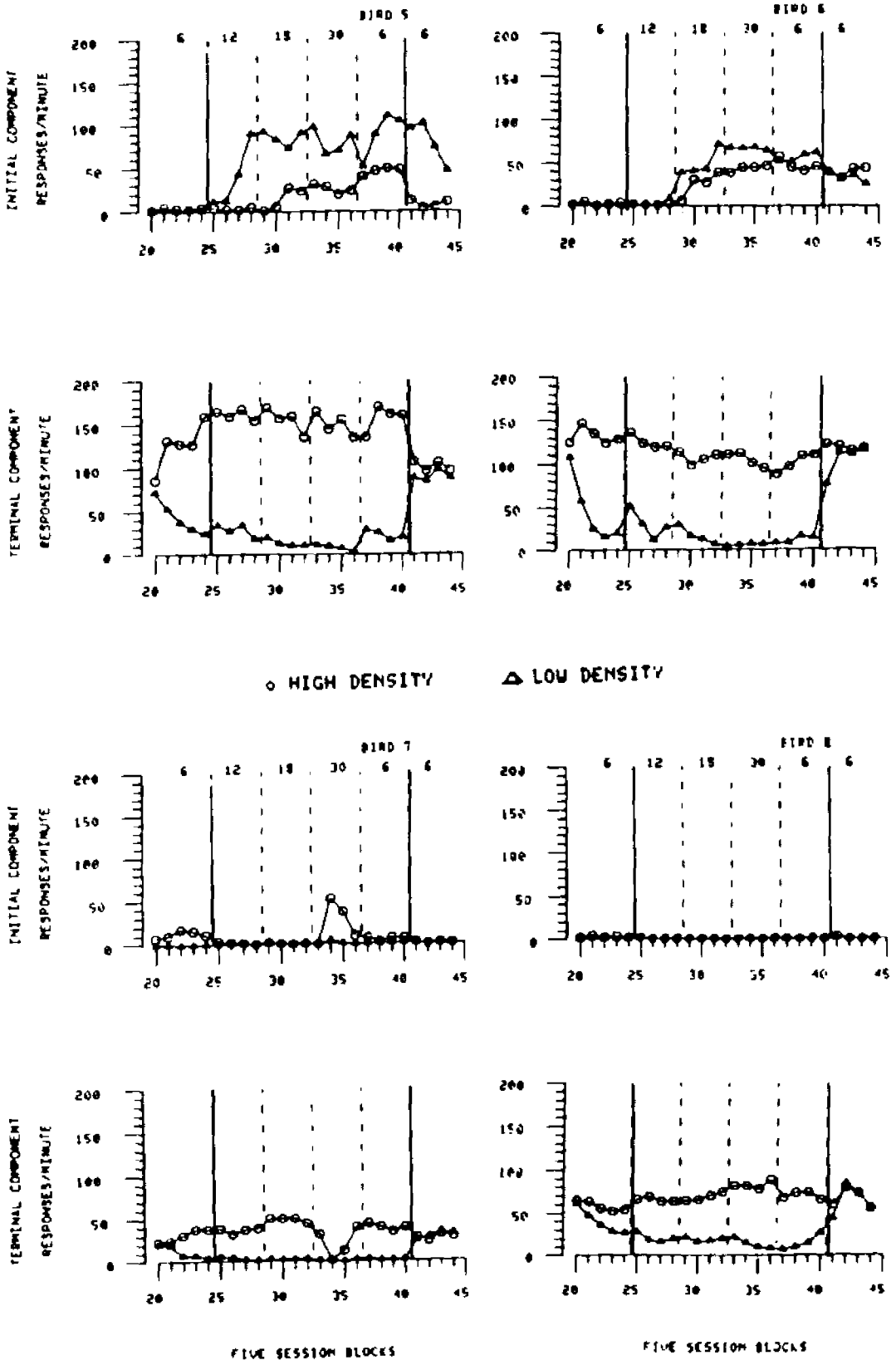
responding during the terminal component of the high-density sequence were higher than during the terminal component of the low-density sequence.

When the S-SR contingency was removed (Phase VIII), only Birds 7 and 8 demonstrated a return to a baseline level (Phase III) of responding during the initial and terminal component of each sequence. Birds 5 and 6 only demonstrated a return to a baseline level of responding during the terminal component of each sequence. These birds continued to display a higher than baseline rate of responding in the initial component of each sequence.

In contrast to Birds 5 and 6, Birds 7 and 8 rarely made contact with the RI 150-sec schedule in the initial components (see Table G in Appendix). During the last five sessions of Phases VI and VII, Birds 7 and 8 earned totals of 19 and 3 reinforcers, respectively, in the initial components. Whereas, in these same phases, Birds 5 and 6 earned totals of 140 and 114 reinforcers, respectively, in the initial components. When the duration of the initial component was returned to 6 sec (Phase VII), Birds 5 and 6 continued to display higher response rates in the initial component of the low-density sequence than in the initial component of the high-density sequence. Hence, these birds did not demonstrate a return of the following-high-density effect. However, Birds 5 and 6 had also earned a greater number of reinforcers in the initial components across the

different durations of these components. During the last five sessions of Phave VIII, Birds 5 and 6 earned a total of 13 and 15 reinforcer, respectively, in the initial components, while in Phase III these birds earned a total of 3 and 2 reinforcers, respectively, in the initial components during the last five sessions. Temporal patterns of responding in the initial components are presented in Figures 12 and 13 in the Appendix. These data have not been reviewed in the text.

Figure 6. Rates of responding for four birds during Phases VI, VII, and VIII of Experiment 2. Initial component rates during high- and low-density sequences are shown in the upper graphs, and the terminal component rates are shown in the lower graphs. Solid, vertical lines separate data from successive phases. Dashed, vertical lines separate successive manipulations of the initial component duration.


BIRD 5
BIRD 6
BIRD 7
BIRD 8
INITIAL COMPONENT
TERMINAL COMPONENT
RESPONSES/MINUTE
6 12 18 30 6 6
200
150
100
50
0
20 25 30 35 40 45
○ HIGH DENSITY
△ LOW DENSITY
FIVE SESSION BLOCKS

Discussion

The results of Experiment 2 stand in opposition to those of Experiment 1 and to those of Marcucella (1981) and Brown et al. (1982). Whereas Experiment 1 demonstrated the following-high-density effect and its variation with the change in initial component duration, some birds in Experiment 2 demonstrated both following density effects with the same manipulation of component duration. Birds 5 and 7 demonstrated the following-high-density effect when the initial component was relatively short, and Birds 5 and 6 demonstrated the following-low-density effect when the initial component was extended. However, when the initial component was returned to 6 sec in duration, none of the birds demonstrated the return of the following-high- density effect. Birds 5 and 6 continued to demonstrate the following-low-density effect.

As mentioned in the results of Experiment 2, the insertion of the RI 150-sec schedule of reinforcement in the initial component did not serve to notably strengthen responding in the 6 sec initial components; few reinforcers were earned. Apparently, when the initial components were short in duration, birds did not make contact with this lean schedule of reinforcement and possibly associated the initial components with the absence of reinforcement. When the initial components increased in duration, Birds 5 and 6

began to make contact with the reinforcement schedule in the initial component. At the same time, rate of responding in the initial component of each sequence increased, with the increase in the initial component of the low-density sequence exceeding that in the initial component of the high-density sequence (the following-low-density effect). The fact that the following-low-density effect appeared when the birds earned a substantial number of reinforcers in the extended initial components suggests that the presence of a nonzero schedule of reinforcement, along with component duration, may co-determine the type of following density effect.

A review of the procedure used might explain why only two of the four birds demonstrated both following- high- and low-density effects. The temporal separation procedure might be considered a three component multiple schedule since there are only three-component cues--red, green, and white. The lack of a following-low-density effect for two birds implies that the duration and type of reinforcement schedule in the target component might not be the only factors responsible for the following-low-density effect. Williams (Experiments 2 & 3, 1979) and the present Experiment 1 demonstrated the following-high-density effect when the following components were both associated with the same cue. However, Williams consistently demonstrated the

following-low-density effect when all components were differentially cued. It is apparent that another possibility for the lack of the following-low-density effect for two birds in Experiment 2 as well as the discrepancy between the two following density effects may be the presence versus the absence of differential stimuli in the terminal components of each sequence in the temporal separation procedure. Hence, the presence of a nonzero schedule of reinforcement in the target components, the duration of the target components, and the presence/absence of differential stimuli in the terminal components may all determine the type of following density effect.

The addition of differential stimuli in the terminal components to the temporal separation procedure, as employed in Experiment 2, makes the upcoming Experiment 3 similar in procedure to other multiple schedule paradigms, especially Williams (1979). Experiment 3 also investigated the influence of component duration as a determining factor in the type of following density effect obtained. The question raised is whether response rates in the target components would be systematically affected by the change in initial component duration. Also of interest is whether the presence of a nonzero schedule of reinforcement in the target components and the presence of differential stimuli in the following components also influence the type of following density effect obtained.

EXPERIMENT 3

Method

Subjects

Four naive adult White Carneaux pigeons served as subjects in the present study. All birds were maintained at 80% of their free-feeding weights throughout the experiment. Water and grit were always available in their home cages.

Apparatus

The apparatus was the same as in Experiments 1 and 2.

Procedure

The procedure was the same as in Experiment 2 with one exception. During Phase III, each sequence was differentially cued by red and green keylights during the initial component. The white keylight remained the cue for the terminal component of each sequence. However, after the first five sessions following the introduction of the colored keylights in the initial components, an additional set of colored keylights was introduced in the terminal components of each sequence. For these subjects, sequences were differentially cued by red and green keylights during the initial components, and by blue and yellow keylights

during the terminal components. Thus, each component of a sequence was differentially cued. Initially, all subjects displayed a response bias in favor of the yellow and green cues, although there had been no change in reinforcement schedules during this phase. For this reason a white circle was projected onto the blue keylight in order to brighten this cue. With this change three out of the four animals recovered their non-differential response rates within the initial component and within the terminal component of each sequence. Only Subject 11 continued to display a higher response rate during the green-yellow cued sequence. Subjects were exposed to this sequence of stimuli for 30 sessions; a total of 35 sessions for Phase III (as in Experiments 1 and 2). The component stimuli employed in the experimental phases are shown in Table 3.

Table 3

Summary of Conditions for Experiment 3

	Sequence A		Sequence B		
	In'tl. Co.	Term. Co.	In'tl. Co.	Term. Co.	Subjects
Phase I					
Cue	White	White	White	White	
Duration	6 sec	30 sec	6 sec	30 sec	
Schedule	RI 150-sec	RI 30-sec	RI 150-sec	RI 30-sec	9,10,11,12
Phase II					
Cue	Cross	White	Cross	White	
Duration	6 sec	30 sec	6 sec	30 sec	
Schedule	RI 150-sec	RI 30-sec	RI 150-sec	RI 30-sec	9,10,11,12
Phase III					
Cue	Red	Blue	Green	Yellow	
Duration	6 sec	30 sec	6 sec	30 sec	
Schedule	RI 150-sec	RI 30-sec	RI 150-sec	RI 30-sec	9,10,11,12
Phase IV					
Cue	Red	Blue	Green	Yellow	
Duration	6 sec	30 sec	6 sec	30 sec	
Schedule	RI 150-sec	RI 30-sec	RI 150-sec	Ext	9,10
Schedule	RI 150-sec	Ext	RI 150-sec	RI 30-sec	11,12
Phase V					
Cue	Red	Blue	Green	Yellow	
Duration	6 sec	30 sec	6 sec	30 sec	
Schedule	RI 150-sec	RI 30-sec	RI 150-sec	RI 30-sec	9,10,11,12
Phase VI					
Cue	Red	Blue	Green	Yellow	
Duration	6 sec	30 sec	6 sec	30 sec	
Schedule	RI 150-sec	Ext	RI 150-sec	RI 30-sec	9,10
Schedule	RI 150-sec	RI 30-sec	RI 150-sec	Ext	11,12
Phase VII					
Cue	Red	Blue	Green	Yellow	
Duration	12 sec	30 sec	12 sec	30 sec	
Duration	18 sec	30 sec	18 sec	30 sec	
Duration	30 sec	30 sec	30 sec	30 sec	
Duration	6 sec	30 sec	6 sec	30 sec	
Schedule	as Phase VI	as Phase VI	as Phase VI	as Phase VI	9,10,11,12
Phase VIII					
Cue	Red	Blue	Green	Yellow	
Duration	6 sec	30 sec	6 sec	30 sec	
Schedule	RI 150-sec	RI 30-sec	RI 150-sec	RI 30-sec	9,10,11,12

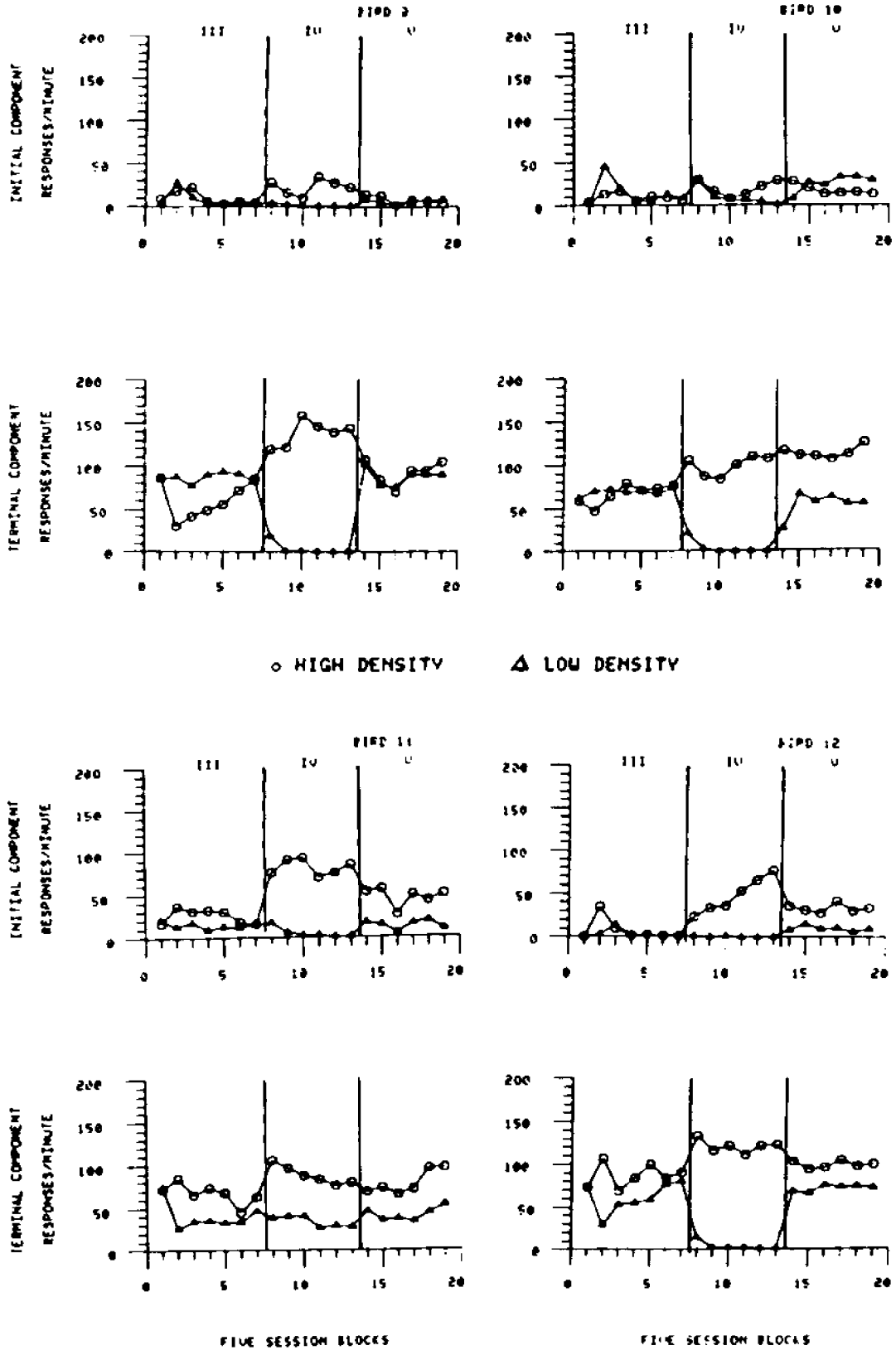
Results

As in Experiments 1 and 2, the introduction of an S-SR contingency led to higher rates of responding in the initial component of the high-density sequence than in the initial component of the low-density sequence. Figure 7 presents mean response rates plotted over five-session blocks during Phases III, IV, and V. The format for this figure is the same as that for Figure 4 of Experiment 2.

With the introduction of an S-SR contingency in Phase IV, all birds demonstrated the following-high-density effect. Additionally, all birds displayed higher rates of responding in the terminal component of the high-density sequence than in the terminal component of the low-density sequence.

When the S-SR contingency was removed in Phase V, Birds 9 and 10 demonstrated a return to baseline rates of responding. Birds 11 and 12 continued to display higher rates of responding in the sequence which had contained the RI 30-sec schedule in Phase IV. Of special note is that all birds earned larger totals of reinforcers in the initial components during Phases IV and V than during Phase III (see Table H in Appendix). The lack of a recovery of baseline levels of responding in the initial components suggests control by the increased exposure to the RI 150-sec schedule of reinforcement.

Figure 7. Rates of responding for four birds during Phases III, IV, and V of Experiment 3. Initial component rates during high- and low-density sequences are shown in the upper graphs, and the terminal component rates are shown in the lower graphs. Solid, vertical lines separate data from successive phases.


BIRD 9
BIRD 10
BIRD 11
BIRD 12
III
IV
V
INITIAL COMPONENT
TERMINAL COMPONENT
RESPONSES/MINUTE
0
50
100
150
200
0
5
10
15
20
○ HIGH DENSITY
△ LOW DENSITY
FIVE SESSION BLOCKS

When the initial component duration was extended, higher rates of responding occurred in the initial component of the low-density sequence than in the initial component of the high-density sequence. Figure 8 presents the mean response rates during the initial component for the last ten sessions of each manipulation of duration.

As the duration of the initial component increased from 6 to 12, 18, and 30 sec, all birds displayed an increase in rate of responding in the initial component of the low-density sequence to a value that exceeded the rate in responding in the initial component of the high-density sequence (the following-low-density effect).

When the initial component was 12 sec in duration, initial component rates of responding for all birds became more similar. That is, the magnitude of the following-high-density effect, observed at 6 sec, appeared to diminish. The following-high-density effect, observed at 6 and 12 sec, was statistically reliable, as shown by a t test on the difference scores for response rates in the target components ($t(3) = 4.10$; $p < .05$). When the initial component was longer in duration (18 and 30 sec), rates of responding in the initial component of the high- and low-density sequences increased. However, rates of responding in the initial component of the low-density sequence were higher than in the initial component of the

high-density sequence (the following-low-density effect). The following-low-density effect, observed at 18 and 30 sec, was statistically reliable, as shown by a t test on the difference scores for response rates in the target components ($t(3) = 3.35$; $p < .05$). When the initial component was again 6 sec in duration, all birds continued to respond in the initial component of each sequence, but only Birds 11 and 12 displayed an increase in response rate in the initial component of the high-density sequence.

As in Experiments 1 and 2, the mean response rates of the last ten sessions of each duration of the initial component during Phases VI and VII were subjected to a duration x sequence analysis of variance. There was a reliable main effect of sequence; rates of responding between sequences of the initial component were reliably different (F (1,3) = 27.33; $p < .01$). The analysis also revealed a significant duration x sequence interaction. Differential rates of responding in the initial component of the high- and low-density sequences were reliably different at each initial component duration (F (3,9) = 13.73; $p < .001$). When the initial component was extended, the mean response rate in the initial component of the low-density sequence was higher than the mean response rate in the initial component of the high-density sequence (see Table F in Appendix).

Figure 9 presents mean response rates during both components plotted over five-session blocks during Phases VI, VII, and VIII. The format for this figure is the same as that for Figure 6 of Experiment 2. As mentioned previously, all birds demonstrated the following-low-density effect when the initial component was extended. However, rate of responding during the terminal component of each sequence was unaffected by the change in initial component duration. When the initial component was returned to 6 sec in duration, Birds 11 and 12 displayed the return of the following- high-density effect, and Birds 9 and 10 continued to display the following-low-density effect. There was no difference in the total number of reinforcers obtained in the initial components across birds which could have accounted for the difference in recovery rates of responding among birds (see Table H in Appendix).

When the S-SR contingency was removed (Phase VIII), only Birds 11 and 12 approximated a return to baseline levels (Phase III) of responding in the initial and terminal component of each sequence. Birds 9 and 10 maintained differential responding in the initial components, but approximated return to baseline levels of responding during the terminal component of each sequence. Of note is that Birds 9 and 10 earned totals of 8 and 9 reinforcers, respectively, in the initial components during the last five

sessions of Phase VIII, whereas during the last five sessions of Phase III these birds only earned totals of 1 and 4 reinforcers, respectively, in the initial components. Thus, these birds earned the expected number of reinforcers (i.e. 9) during Phase VIII, but not during Phase III (see Table H). Temporal patterns of responding in the initial components are presented in Figures 14 and 15 in the Appendix. These data are not reviewed in the text.

Figure 8. Mean response rates of the last ten sessions of Phases VI and VII of Experiment 3. Each graph presents one bird's rate of responding during the initial component for each manipulation of the initial component duration.

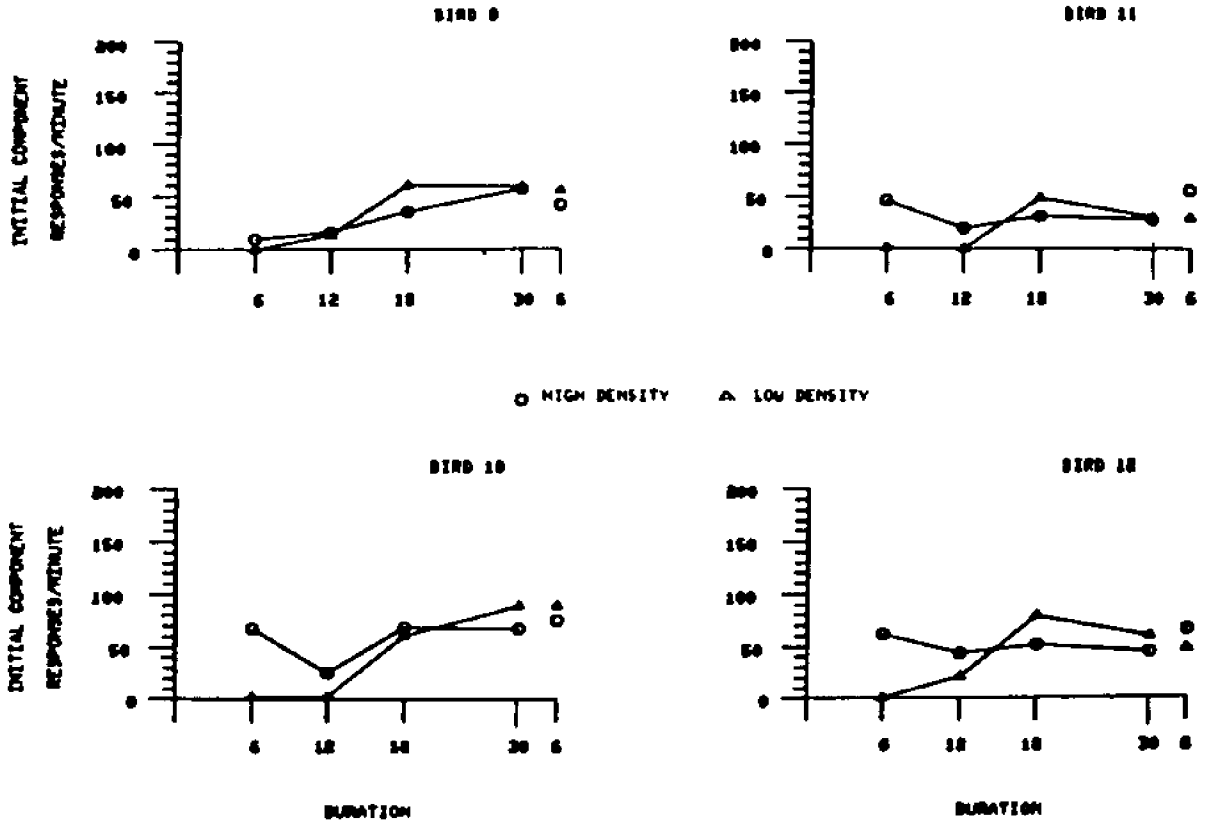
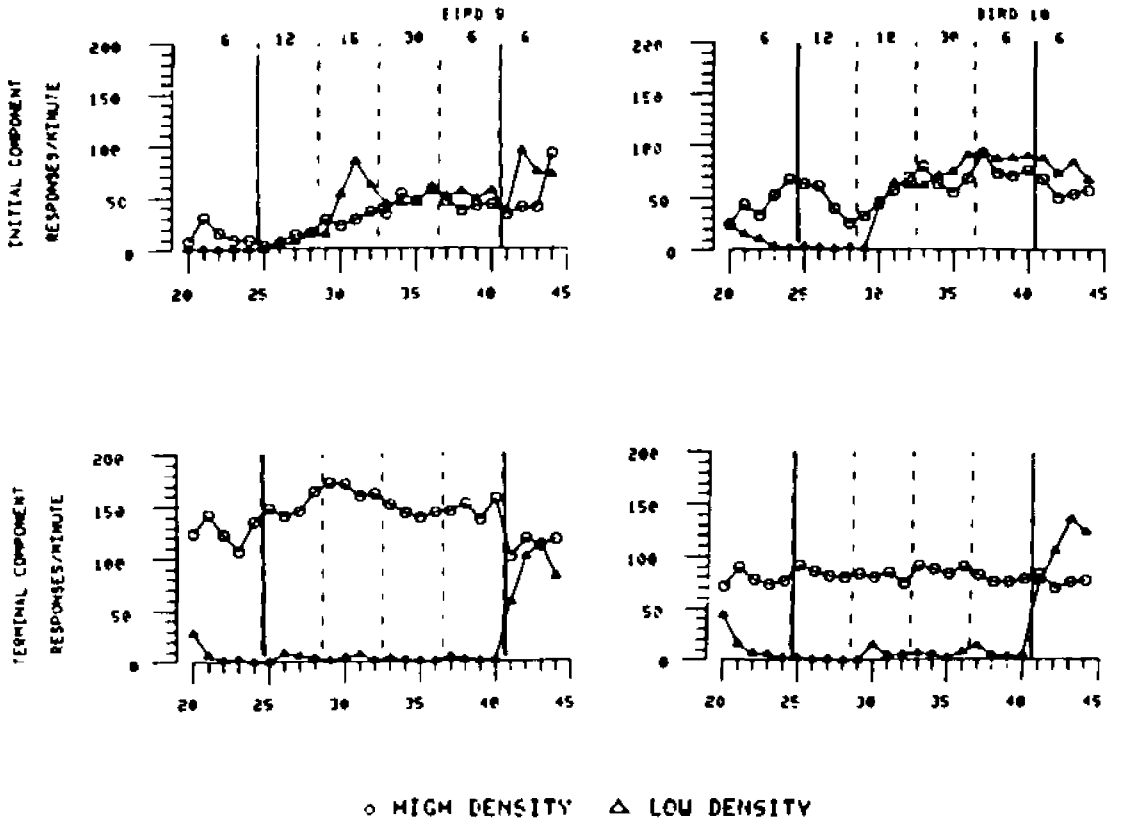
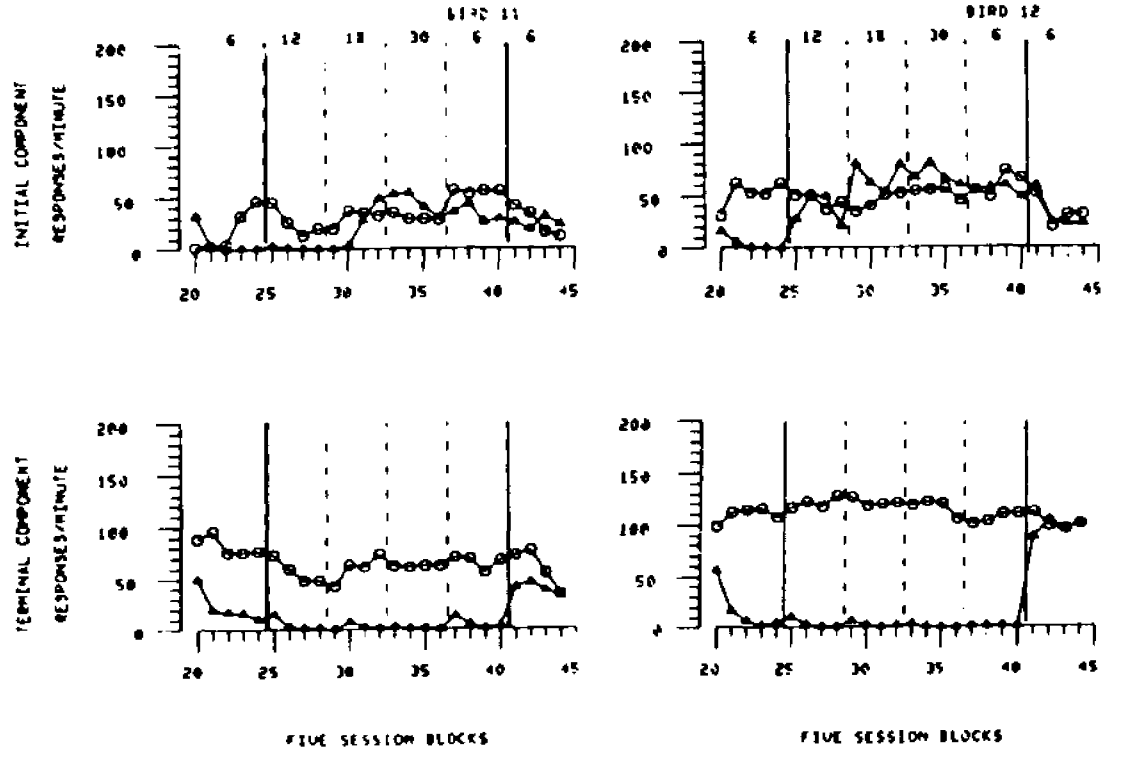

BIRD 8
BIRD 11
INITIAL COMPONENT
RESPONSES/MINUTE
200
150
100
50
0
6
12
18
30
6
○ HIGH DENSITY
△ LOW DENSITY
BIRD 10
BIRD 18
DURATION

Figure 9. Rates of responding for four birds during Phases VI, VII, and VIII of Experiment 3. Initial component rates during high- and low-density sequences are shown in the upper graphs, and the terminal component rates are shown in the lower graphs. Solid, vertical lines separate data from successive phases. Dashed, vertical lines separate successive manipulations of the initial component duration.



○ HIGH DENSITY △ LOW DENSITY



Discussion

The results of Experiment 3 taken together with those of Experiments 1 and 2 demonstrate that there are two factors which can account for the direction of the following density effect. The schedule of reinforcement operating in the initial component and the duration of the initial component appear to contribute to the type of following density effect obtained. In Experiment 1, with extinction schedules in the initial component and no differential stimuli in the terminal components, the magnitude of the following-high-density effect varied with the duration of the initial component. In Experiment 2, with a nonzero schedule of reinforcement in the initial component and no differential stimuli in the terminal components, the following-high-density effect was observed for only two birds when the 6 sec initial component was presented. However, only two of the four birds demonstrated the following-low-density effect at long durations. Finally, in Experiment 3, with a nonzero schedule of reinforcement in the initial component and differential stimuli in the terminal components, the following-high-density effect occurred at the 6 sec initial component, but the following-low-density effect was observed at longer durations.

The demonstration of the following-high-density effect at the short duration of the initial component, across Experiments 1, 2, and 3, is consistent with the data of Brown et al. (1982) and Marcucella (1981). Brown et al. and Marcucella both observed higher rates of responding during a target component which was followed by a component associated with a nonzero schedule of reinforcement than during a target component which was followed by a component associated with extinction. Whereas Brown et al. and Marcucella were able to demonstrate the replicability of the following-high-density effect, only in Experiment 1 was this effect able to be recovered at the return to 6 sec recovery point. However, only in Experiment 1 did the following-low-density effect fail to appear. Birds in Experiments 2 and 3 demonstrated the following-low-density effect at the extended durations, but most of these birds failed to demonstrate a return of the following-high-density effect when the initial component was returned to 6 sec. The difference between the following-high and -low-density effects, obtained at long durations as well as at the 6 sec recovery point, suggests that the presence of reinforcers in the initial component was an important determinant of the following-low-density effect.

General Discussion

Experiments 1, 2, and 3 present a systematic unravelling of the factors which were responsible for the type of following density effect obtained. The duration of the initial component and the schedule of reinforcement in the initial component appear to jointly determine the type of following density effect obtained.

The Following Density Effects

Across all three experiments, only the following-high-density effect was observed when the target component was initially 6 sec in duration. This effect evaluated in Phase VI, was statistically reliable for Experiments 1 and 3, as shown by separate t tests on the difference scores for response rate in the target components (Experiment 1 $t(3) = 3.20$, Experiment 2 $t(3) < 1.0$, and Experiment 3 $t(3) = 3.93$, $p < .05$). This sequential effect was demonstrated at the short duration, eventhough the type of reinforcement schedule in the target components and the presence versus the absence of differential stimuli in the terminal components were different among experiments. Brown et al. (1982), Marcucella (1981) and Williams (1979) also demonstrated the following-high-density effect with differences in procedures. Brown et al. and Marcucella observed the following-high-density effect when target components were associated with extinction and were short in

duration (e.g. 1.5 or 4 sec). Williams observed the following-high-density effect when all components were short but equal in duration, the target components contained nonzero schedules of reinforcement, and the terminal components were not differentially cued.

When the target components were increased in duration, the three experiments revealed differences in the behavior occurring in these components. Therefore, the mean response rates of the last ten sessions for each duration of the initial component during Phases VI and VII of Experiments 1, 2, and 3 were subjected to a duration x sequence x experiment analysis of variance. This analysis revealed a significant three-way interaction ($F(6,27) = 2.56$; $p < .05$). Among experiments, differential rates of responding in the initial component of the high- and low-density sequences differed reliably with the change in initial component duration. Figures 2, 5, and 8 demonstrate the differences in response rates in the initial component between sequences across the various durations of the initial component. However, as indicated in the results sections, different patterns of responding were reliable in Experiments 1 and 3 in their analyses of variance. While the data of Experiment 1 demonstrated the following-high-density effect and its diminution with the increase in component duration, the data of Experiment 3

demonstrated the diminution of the following-high-density effect and the appearance of the following-low-density effect with this increase in component duration. The following-low-density effect was also observed at the long durations for two birds of Experiment 2, but this effect never appeared in Experiment 1.

The appearance of the following-low-density effect in Experiments 2 and 3 but not in Experiment 1 suggests that the reinforcers earned in the target components played an important role in the following-low-density effect. At the extended durations (18 and 30 sec), birds made contact with the reinforcement schedule in the target components, and at the same time, rates of responding in the target components increased. Consistent with this finding, Williams (1979) also observed the following-low-density effect in target components which contained a nonzero schedule of reinforcement. When the target components were shortened to 6 sec in duration, rates of responding in these components did not consistently return to the response rates observed prior to the duration manipulation (Phase VI). Since target component response rates in Experiment 1 did demonstrate the return of the following-high-density effect and the target component response rates in Experiments 2 and 3 did not demonstrate a return of this effect, the increased exposure to the presence of reinforcers in the target components,

across durations, appears responsible for the maintenance of the following-low-density effect in Experiments 2 and 3. Further support for the role of reinforcers in the target component is also indicated when the S-SR contingency was removed in Phase VIII. Rates of responding in the target components in Experiments 2 and 3 did not return to baseline response rates observed prior to any manipulation, i.e. Phase III.

Implications of the Following Density Effects

The present results provide an opportunity to reconcile the different sequential effects observed in multiple schedule paradigms (e.g. Brown et al., 1982; Farley, 1980; Marcucella, 1981; Williams, 1979). The following-high-density effect reported by Brown et al. and Marcucella, was replicated by the present Experiment 1 and was demonstrated to be dependent upon the duration of the target component. Another moderator of the following-high-density effect appears to be the presence of reinforcers in the target components. This latter conclusion is supported by an examination of the pattern of results at the various exposures to the 6 sec duration of the target component when an S-SR contingency was present (i.e. Phases IV, VI, and VII).

Across experiments, either the following-high-density effect, or no effect was evident in the first two of these

phases. However, under the final condition (Phase VII), both the following-high-density effect and following-low-density effect were observed. It should be acknowledged that there were at least three factors which differentiated the final 6 sec condition from the preceding 6 sec conditions. First, between the two conditions birds in Experiments 2 and 3 acquired a history of exposure to an increased rate of reinforcement in the target components. Second, under the final 6 sec condition, there was a somewhat higher prevailing rate of earned reinforcement in the target components in Experiments 2 and 3 (see Tables G and H). Third, the following-low-density effect was observed, at extended durations of the target components, in Experiments 2 and 3 prior to the final 6 sec condition. This third factor suggests that the failure to recover the following-high-density effect, by some birds, reflects non-asymptotic performance. However, a review of the data suggests that this explanation is not by itself an adequate account. At the final 6 sec condition (Phase VII), birds in Experiment 1 did recover the following-high-density effect. Birds 5 and 6 in Experiment 2 and all birds in Experiment 3 appeared to demonstrate stable performance in the target components. Thus, it appears that the presence of earned reinforcers in the target component is implicated as a determining factor for the type of following density effect observed.

The pattern of results observed in the present investigation bears some similarity to the data presented by Woodruff et al. (1977). In their investigation, keypecking rate in a two-component multiple schedule was demonstrated to be sensitive to the manipulation of S-SR and R-SR relations. The differential effects of an S-SR relationship were influenced by the strength of an R-SR relationship, and vice versa. In the present investigation, the S-SR contingency effects diminished with the increase in target component duration. The S-SR contingency effects also were weakened by the presence of an R-SR contingency in the target components. That is, in the present study, with an S-SR contingency and no reinforcers present in short target components, the following-high-density effect was observed (e.g. Experiment 1). With an S-SR contingency and reinforcers present in short target components, no consistent effect was observed (e.g. Experiment 3). However, this analysis in terms of competition between S-SR and R-SR relations cannot explain all of the present data, notably the following-low-density effect.

Although there does not seem to be a satisfactory simple explanation for the following-low-density effect, the present investigation provides some important new information. The appearance of the following-low-density effect was dependent upon the presence of earned reinforcers

in the target components; this sequential effect was only observed in Experiments 2 and 3, not in Experiment 1. The following-low-density effect was also observed to be weakest when the effects of the S-SR contingency between the target component cues and the reinforcement schedule in the terminal components were demonstrated to be strongest, i.e. at short durations of the target component.

The above observations suggest that the sequential information provided by target component cues exercises separate and opposite effects on behavior in the target components. These following density effects varied as a function of both the rate of reinforcement in, and the duration of the target components. The sequential effect which occurs under a particular set of parameters may be understood as resulting from an interaction of these factors.

While the data of Experiment 2 appears to be somewhat anomalous, Birds 5 and 6 did respond similarly to birds in Experiment 3. Although the following components were uncued in Experiment 2, a correlation based on sequential cues was possible since there was strict alternation of sequences. Birds 5 and 6 appeared to be able to learn the alternation of high-density (RI) and low-density (Ext) reinforcement schedules in the following components, while the data of Birds 7 and 8 suggest that these birds were insensitive to

these sequential regularities. Target component response rates of Birds 7 and 8 were low and were not consistently related to the value of the following schedule. Birds 7 and 8 also displayed smaller differences in response rates in the terminal component of each sequence than other birds in comparable stimulus conditions (i.e. Experiments 1 and 2).

The Relative Delay Hypothesis: An Interpretation of the Following Density Effect

A plausible interpretation of the following-high-density effect was suggested by Brown et al. who stated that responding during the target component was dependent upon the relative delay to reinforcement signaled by each component cue, i.e. an S-SR contingency. Higher rates of responding were observed during the initial component which was associated with the shorter delay to food. Using choice procedures, Fantino (1977) has also shown that behavior during the initial links is dependent upon the reduction in delay to reinforcement associated with each choice alternative. Therefore, the relation between response rate and relative delay to reinforcement was also examined in the present investigation. The relative delay to reinforcement was calculated as in Brown et al.. That is, the time elapsed from the onset of an initial component and the next, single reinforcer occurrence, was determined for all presentations of each of the two initial components in a

session. The relative delay was calculated as the mean delay from the initial component in the sequence designated as high-density in Phases VI and VII, divided by the sum of the mean delays from both initial components. Any reinforcers earned subsequent to the first in a component were ignored. The relative rate of responding was computed as the response rate in the initial component of the high-density sequence divided by the sum of the response rates in the initial component of each sequence. Both measures were calculated for the last ten sessions of each duration of the initial component (see Tables A, B, and C, in Appendix). As observed by Brown et al., differential responding during the 6 sec initial component between sequences was related to the relative delay to reinforcement (see Tables A, B, and C in Appendix). In Phase VI, higher rates of responding were observed in the initial component associated with the shorter delay to food. When the initial component duration was increased in the present study, the S-SR contingency expressed in terms of relative delay to reinforcement does not provide a satisfactory explanation of the present data. An examination of Tables A, B, and C in the Appendix illustrate only small and inconsistent changes in the relative delay to reinforcement associated with the initial component cue of the high-density sequence as the initial component increased in duration. Moreover, there

was no consistent relation between the relative delays to reinforcement and the relative response rates. At long durations, the relative delays to reinforcement in Experiments 2 and 3 were consistently below .5 (Tables B and C). According to the relative delay model, the following-high-density effect would be expected to be maintained at long durations. However, at longer component durations birds make contact with the reinforcement schedule in the target component and a competition between following density effects may occur. Although differential responding during the target components can be discussed in terms of the relative delays to reinforcement signaled by each component cue, how this S-SR contingency operates across the different experimental paradigms remains unclear.

Conclusion

The present investigation demonstrated that the duration of the target components and the schedule of reinforcement in the target components were important determinants of the type of following density effect obtained. This investigation further suggests that analyses of sequential effects must consider the interaction of these factors.

APPENDIX

Table A

Relative Response Rates, Absolute Delays, and Relative Delays for Experiment 1

Subject	Phase	Relative Rate	DelayH	DelayL	DelayR
1	III(6sec)	.50	37.6	40.7	.48
	VI(6sec)	.96	56.8	90.3	.39
	VII(12sec)	.95	70.1	110.7	.39
	(18sec)	.99	95.7	142.3	.40
	(30sec)	.94	124.2	182.6	.41
	(6sec)	.99	64.9	99.3	.40
2	III(6sec)	.50	37.4	39.3	.49
	VI(6sec)	.97	56.3	90.3	.38
	VII(12sec)	.93	79.4	121.9	.39
	(18sec)	.96	88.2	133.4	.40
	(30sec)	.93	107.2	165.8	.39
	(6sec)	.98	60.2	94.7	.39
3	III(6sec)	.48	37.2	34.8	.52
	VI(6sec)	.71	62.6	96.0	.39
	VII(12sec)	.99	70.1	110.9	.39
	(18sec)	.99	82.5	128.9	.39
	(30sec)	.95	101.4	158.5	.39
	(6sec)	.99	58.2	92.7	.39
4	III(6sec)	.39	40.7	38.8	.51
	VI(6sec)	1.0	58.3	92.5	.39
	VII(12sec)	1.0	71.7	113.3	.39
	(18sec)	1.0	91.0	118.9	.43
	(30sec)	.99	117.4	180.7	.39
	(6sec)	00	58.7	93.3	.39

DelayH = absolute delay in the high-density sequence
DelayL = absolute delay in the low-density sequence
DelayR = relative delay in the high-density sequence

Table B

Relative Response Rates, Absolute Delays, and Relative Delays for Experiment 2

Subject	Phase	Relative Rate	DelayH	DelayL	DelayR
5	III(6sec)	.44	40.6	40.2	.50
	VI(6sec)	.81	62.1	96.2	.39
	VII(12sec)	.04	58.8	90.5	.39
	(18sec)	.23	79.9	107.0	.43
	(30sec)	.22	78.8	116.5	.40
	(6sec)	.31	53.3	84.7	.39
6	III(6sec)	.46	35.2	36.3	.49
	VI(6sec)	.57	61.3	95.5	.39
	VII(12sec)	.22	60.1	86.5	.41
	(18sec)	.37	75.3	110.3	.41
	(30sec)	.41	79.1	116.3	.41
	(6sec)	.44	49.8	80.3	.38
7	III(6sec)	.56	35.8	35.3	.50
	VI(6sec)	.99	64.0	97.8	.40
	VII(12sec)	.91	75.7	113.3	.40
	(18sec)	1.0	102.7	156.4	.40
	(30sec)	.99	97.6	156.3	.38
	(6sec)	1.0	55.8	89.5	.38
8	III(6sec)	.50	34.7	34.7	.50
	VI(6sec)	.99	69.7	103.9	.40
	VII(12sec)	.96	78.6	122.2	.39
	(18sec)	.80	102.8	150.0	.41
	(30sec)	.74	116.1	173.9	.40
	(6sec)	.95	64.3	97.3	.40

DelayH = absolute delay in the high-density sequence
DelayL = absolute delay in the low-density sequence
DelayR = relative delay in the high-density sequence

Table C

Relative Response Rates, Absolute Delays, and Relative Delays for Experiment 3

Subject	Phase	Response Rate	DelayH	DelayL	DelayR
9	III(6sec)	.42	35.3	35.6	.50
	VI(6sec)	.98	53.0	87.4	.38
	VII(12sec)	.62	66.1	99.3	.40
	(18sec)	.31	63.3	100.7	.39
	(30sec)	.48	81.3	116.6	.41
	(6sec)	.44	56.9	89.1	.39
10	III(6sec)	.57	30.8	33.7	.48
	VI(6sec)	.96	52.7	88.0	.37
	VII(12sec)	.95	75.8	121.4	.38
	(18sec)	.50	65.2	103.1	.39
	(30sec)	.43	86.4	113.0	.43
	(6sec)	.47	56.0	87.6	.39
11	III(6sec)	.45	40.0	41.8	.49
	VI(6sec)	.98	56.0	89.9	.38
	VII(12sec)	.92	74.3	114.0	.39
	(18sec)	.47	78.5	115.5	.41
	(30sec)	.45	84.3	122.1	.41
	(6sec)	.73	63.6	96.2	.40
12	III(6sec)	.63	40.1	41.2	.50
	VI(6sec)	.99	56.5	90.8	.38
	VII(12sec)	.54	67.1	104.0	.39
	(18sec)	.44	72.5	106.7	.41
	(30sec)	.44	84.2	118.5	.42
	(6sec)	.58	67.8	94.7	.42

DelayH = absolute delay in the high-density sequence
DelayL = absolute delay in the low-density sequence
DelayR = relative delay in the high-density sequence

Table D

Mean Response Rate Across Subjects During the Initial Component of the High- and Low-Density Sequences of Experiment 1

Duration	High-Density Sequence		Low-Density Sequence	
	Mean	S.D.	Mean	S.D.
6 sec	25.90	19.25	.91	.87
12 sec	15.09	12.62	.79	1.10
18 sec	8.12	9.33	.24	.46
30 sec	5.89	7.06	.41	.55
6 sec	18.10	13.11	.17	.13

Table E

Mean Response Rate Across Subjects During the Initial Component of the High- and Low-Density Sequences of Experiment 2

Duration	High-Density Sequence		Low-Density Sequence	
	Mean	S.D.	Mean	S.D.
6 sec	5.67	4.93	.30	.44
12 sec	2.32	2.32	16.81	32.67
18 sec	20.01	26.15	28.19	38.16
30 sec	23.87	28.57	30.75	38.04
6 sec	24.27	24.86	41.62	51.78

Table F

Mean Response Rate Across Subjects During the Initial Component of the High- and Low-Density Sequences of Experiment 3

Duration	High-Density Sequence		Low-Density Sequence	
	Mean	S.D.	Mean	S.D.
6 sec	41.54	23.54	1.07	1.18
12 sec	26.68	11.68	11.86	16.20
18 sec	44.63	14.60	59.18	15.18
30 sec	49.23	10.62	57.15	21.81
6 sec	59.68	15.80	55.04	25.08

Table G

Number of Reinforcers Earned in the Target Component of each Sequence in the Last Five Sessions of each Phase in Experiment 2

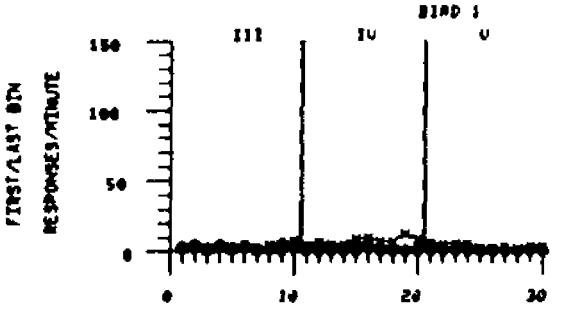
	Birds			
Phases	5	6	7	8
III				
High-density	1	1	0	0
High-density	2	1	1	0
IV				
High-density	6	6	1	2
Low-density	3	0	0	0
V				
High-density	2	5	1	2
High-density	9	6	5	0
VI				
High-density	6	5	2	1
Low-density	1	0	0	0
VII(12 sec)				
High-density	9	4	1	0
Low-density	21	9	0	0
VII(18 sec)				
High-density	20	20	1	0
Low-density	25	23	0	0
VII(30 sec)				
High-density	27	26	15	1
Low-density	17	18	0	1
VII(6 sec)				
High-density	7	4	0	0
Low-density	6	5	0	0
VIII				
High-density	5	7	1	0
High-density	8	8	9	0

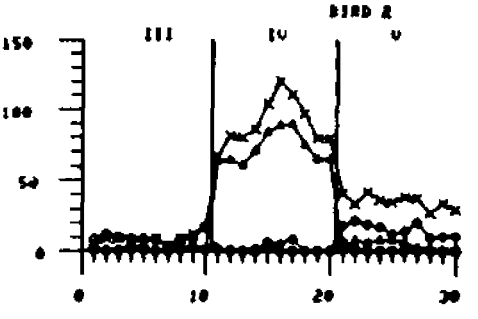
Table H

Number of Reinforcers in the Target Components of each Sequence for the Last Five Sessions of each Phase in Experiment 3

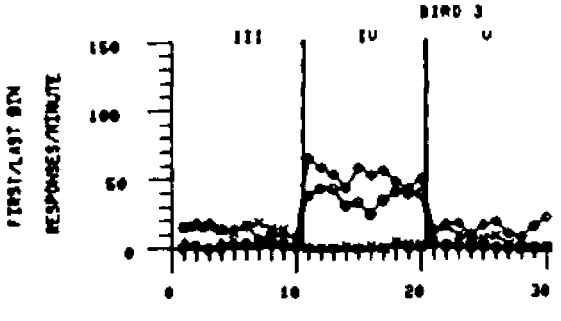
	Birds			
Phases	9	10	11	12
III				
High-density	0	1	2	0
High-density	1	3	2	1
IV				
High-density	8	9	4	5
Low-density	0	0	0	0
V				
High-density	1	2	4	5
High-density	6	7	9	8
VI				
High-density	8	8	4	5
Low-density	0	0	1	0
VII(12 sec)				
High-density	6	6	3	3
Low-density	6	0	0	4
VII(18 sec)				
High-density	25	27	12	14
Low-density	11	13	14	15
VII(30 sec)				
High-density	32	31	34	33
Low-density	32	33	21	22
VII(6 sec)				
High-density	2	2	2	3
Low-density	7	8	9	12
VIII				
High-density	4	5	1	3
High-density	4	4	1	4

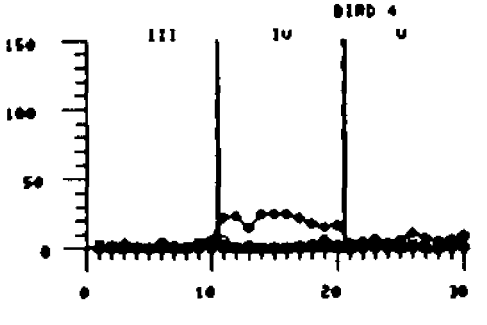
Figure 10. Rates of responding for four birds in the first 3 sec bin and the last 3 sec bin of the initial component of each sequence for the last ten sessions of Phases III, IV, and V of Experiment 1. Solid, vertical lines separate data from successive phases.





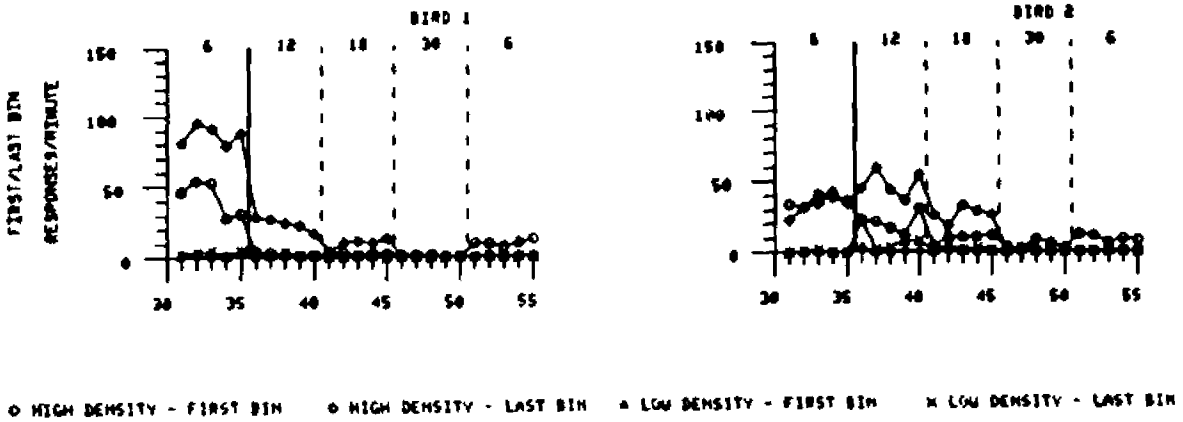
○ LOW DENSITY - FIRST BIN ○ LOW DENSITY - LAST BIN ▲ HIGH DENSITY - FIRST BIN × HIGH DENSITY - LAST BIN





○ HIGH DENSITY - FIRST BIN ○ HIGH DENSITY - LAST BIN ▲ LOW DENSITY - FIRST BIN × LOW DENSITY - LAST BIN

Figure 11. Rates of responding for four birds in the first 3 sec bin and the last 3 sec bin of the initial component of each sequence for the last five sessions of Phases VI and VII of Experiment 1. Solid, vertical lines separate data from successive phases. Dashed, vertical lines separate successive manipulations of the initial component duration.


BIRD 1
BIRD 2
FIRST/LAST BIN RESPONSES/MINUTE
6
12
18
30
6
150
100
50
0
30
35
40
45
50
55
○ HIGH DENSITY - FIRST BIN
● HIGH DENSITY - LAST BIN
▲ LOW DENSITY - FIRST BIN
× LOW DENSITY - LAST BIN

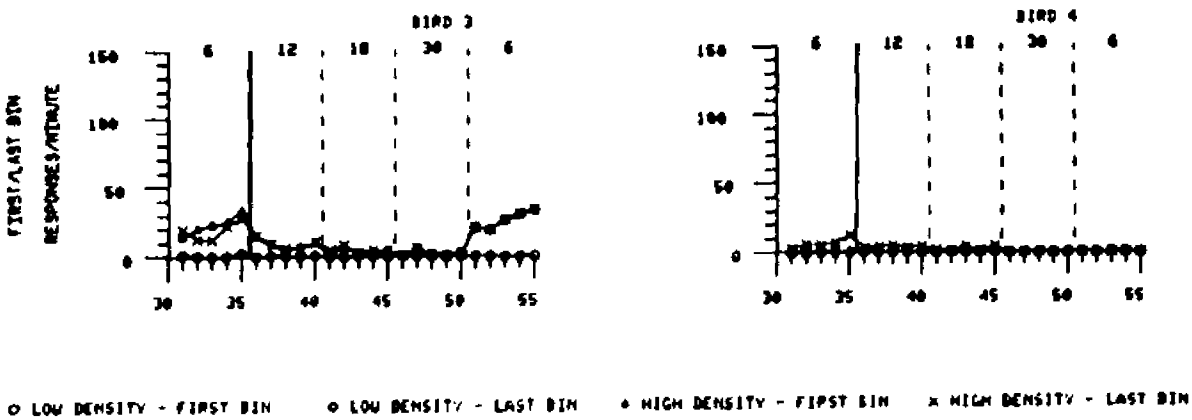
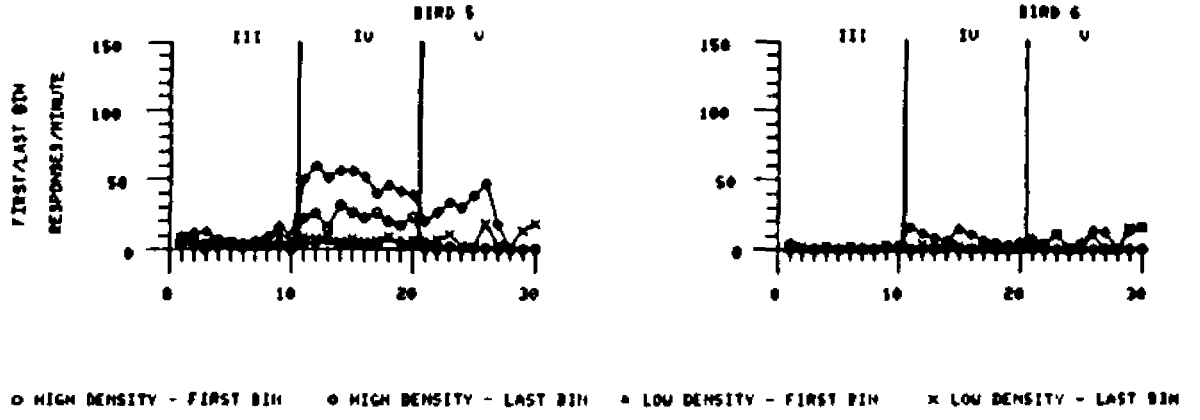

BIRD 3
BIRD 4
FIRST/LAST BIN RESPONSES/MINUTE
6
12
18
30
6
150
100
50
0
30
35
40
45
50
55
○ LOW DENSITY - FIRST BIN
● LOW DENSITY - LAST BIN
▲ HIGH DENSITY - FIRST BIN
× HIGH DENSITY - LAST BIN

Figure 12. Rates of responding for four birds in the first 3 sec bin and the last 3 sec bin of the initial component of each sequence for the last ten sessions of Phases III, IV, and V of Experiment 2. Solid, vertical lines separate data from successive phases.


BIRD 5
BIRD 6
III
IV
V
150
100
50
0
10
20
30
FIRST/LAST BIN
RESPONSES/MINUTE
o HIGH DENSITY - FIRST BIN
• HIGH DENSITY - LAST BIN
▲ LOW DENSITY - FIRST BIN
× LOW DENSITY - LAST BIN

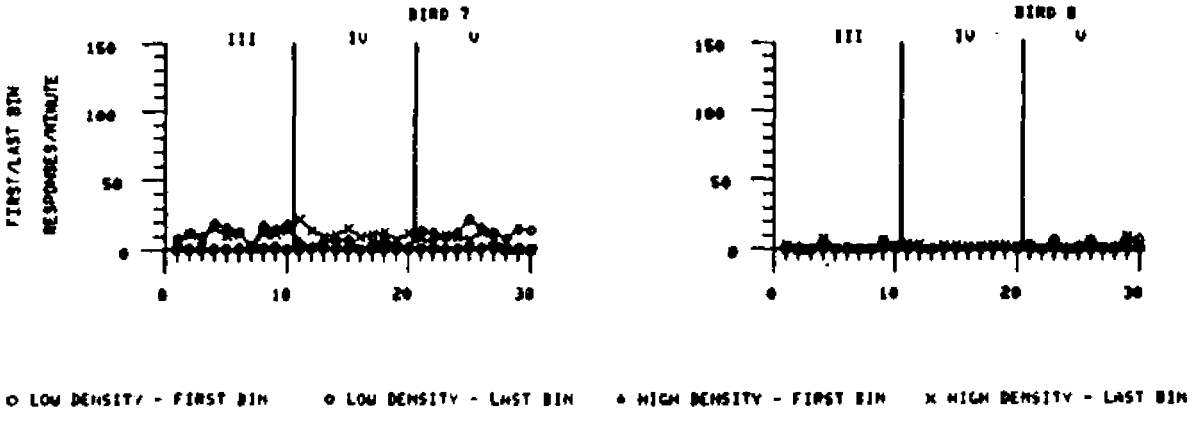
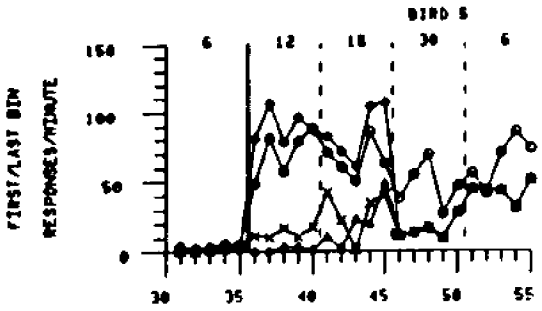
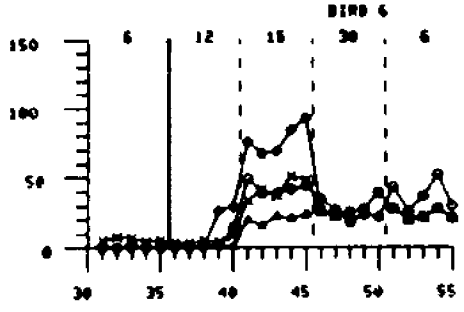
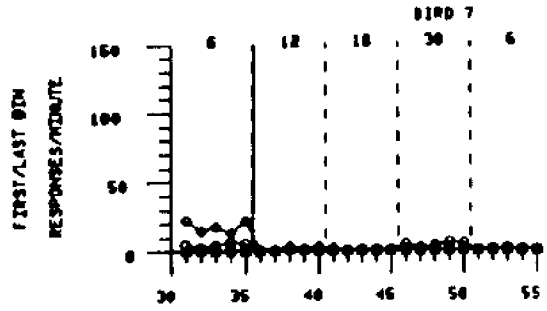

BIRD 7
BIRD 8
III
IV
V
150
100
50
0
10
20
30
FIRST/LAST BIN
RESPONSES/MINUTE
o LOW DENSITY - FIRST BIN
• LOW DENSITY - LAST BIN
▲ HIGH DENSITY - FIRST BIN
× HIGH DENSITY - LAST BIN

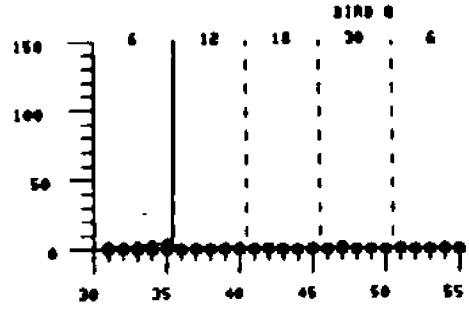
Figure 13. Rates of responding for four birds in the first 3 sec bin and the last 3 sec bin of the initial component of each sequence for the last five sessions of Phases VI and VII of Experiment 2. Solid, vertical lines separate data from successive phases. Dashed, vertical lines separate successive manipulations of the initial component duration.





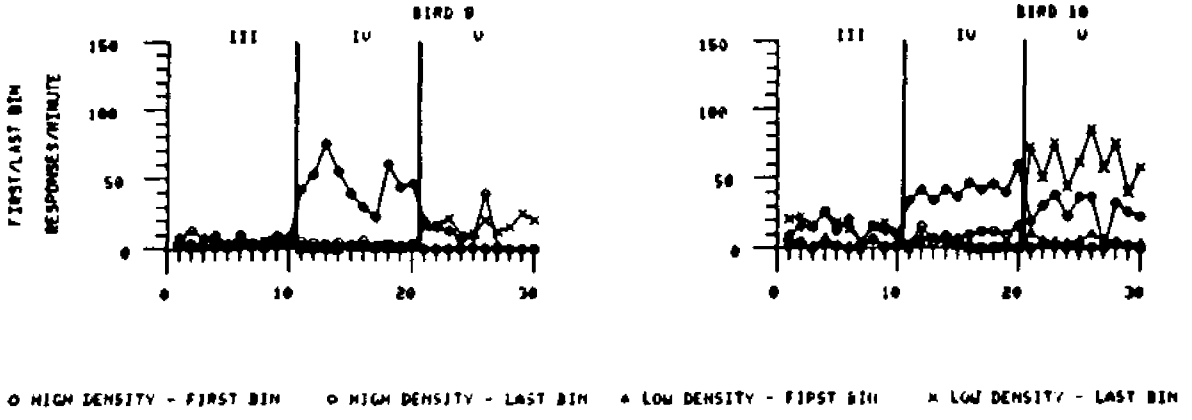
○ HIGH DENSITY - FIRST BIN ○ HIGH DENSITY - LAST BIN ▲ LOW DENSITY - FIRST BIN × LOW DENSITY - LAST BIN





○ HIGH DENSITY - FIRST BIN ○ HIGH DENSITY - LAST BIN ▲ LOW DENSITY - FIRST BIN × LOW DENSITY - LAST BIN

Figure 14. Rates of responding for four birds in the first 3 sec bin and the last 3 sec bin of the initial component of each sequence for the last ten sessions of Phases III, IV, and V of Experiment 3. Solid, vertical lines separate data from successive phases.


BIRD 9
BIRD 10
III
IV
V
FIRST/LAST BIN RESPONSES/MINUTE
150
100
50
0
0
10
20
30
O HIGH DENSITY - FIRST BIN
O HIGH DENSITY - LAST BIN
A LOW DENSITY - FIRST BIN
X LOW DENSITY - LAST BIN

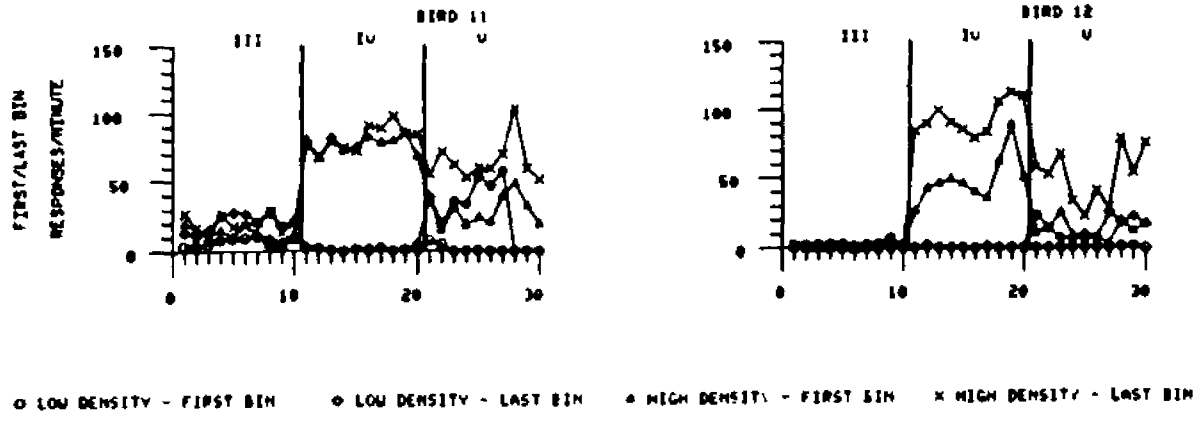
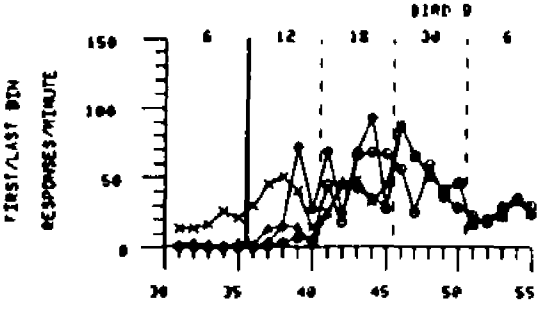
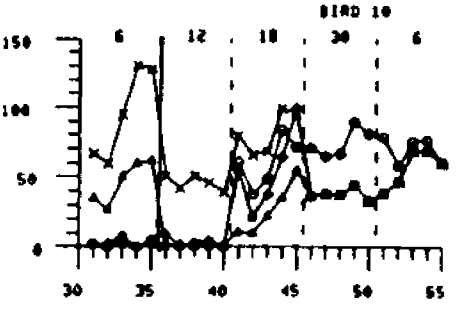
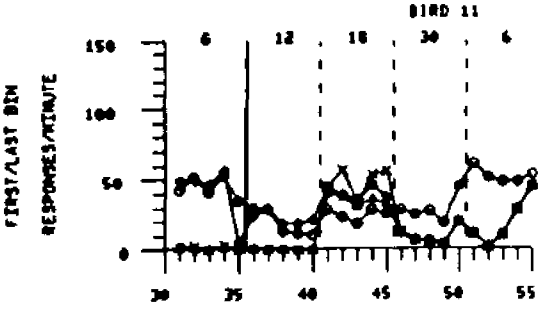

BIRD 11
BIRD 12
III
IV
V
FIRST/LAST BIN RESPONSES/MINUTE
150
100
50
0
0
10
20
30
O LOW DENSITY - FIRST BIN
O LOW DENSITY - LAST BIN
A HIGH DENSITY - FIRST BIN
X HIGH DENSITY - LAST BIN

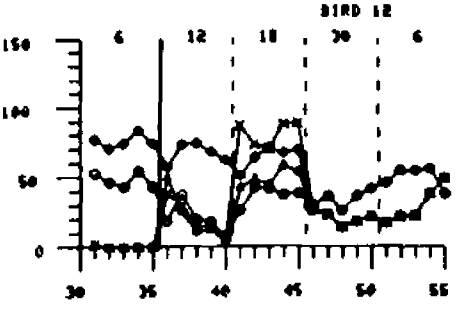
Figure 15. Rates of responding for four birds in the first 3 sec bin and the last 3 sec bin of the initial component of each sequence for the last five sessions of Phases VI and VII of Experiment 3. Solid, vertical lines separate data from successive phases. Dashed, vertical lines separate successive manipulations of the initial component duration.





○ LOW DENSITY - FIRST BIN ● LOW DENSITY - LAST BIN ▲ HIGH DENSITY - FIRST BIN × HIGH DENSITY - LAST BIN





○ HIGH DENSITY - FIRST BIN ● HIGH DENSITY - LAST BIN ▲ LOW DENSITY - FIRST BIN × LOW DENSITY - LAST BIN

REFERENCES

Brown, B.L., Hemmes, N.S., Coleman, D.A., Hassin, A., and Goldhammer, E. Specification of the stimulus-reinforcer relation in multiple schedules: Delay and probability of reinforcement. Animal Learning & Behavior, 1982, 10, 365-376.

Fantino, E. Conditioned reinforcement: Choice and information. In W.K. Honig and J.E.R. Staddon (Eds.), Handbook of operant behavior. New York: Prentice-Hall, 1977.

Farley, J. Automaintenance, contrast, and contingencies: Effects of local vs. overall and prior vs. impending reinforcement context. Learning and Motivation, 1980, 11, 19-48.

Herrnstein, R.J. On the law of effect. Journal of the Experimental Analysis of Behavior, 1970, 13, 243-266.

Marcucella, H. Stimulus control of respondent and operant keypecking: A single key procedure. Journal of the Experimental Analysis of Behavior, 1981, 36, 51-60.

Rachlin, H.C. Contrast and matching. Psychology Review, 1973, 80, 217-234.

Reynolds, G.S. Behavioral contrast. Journal of the Experimental Analysis of Behavior, 1961, 4, 57-71. (a)

Reynolds, G.S. An analysis of interactions in a multiple schedule. Journal of the Experimental Analysis of Behavior, 1961, 4, 107. (b)

Reynolds, G.S. Some limitations on behavioral contrast and induction during successive discrimination. Journal of the Experimental Analysis of Behavior, 1963, 6, 131-139.

Schwartz, B. and Gamzu, E. Pavlovian control of operant behavior: An analysis of autoshaping and its implications for operant conditioning. In W.K. Honig and J.E.R. Staddon (Eds.), Handbook of operant behavior. New York: Prentice-Hall, 1977.

Spealman, R.D. Interactions in multiple schedules: The role of the stimulus-reinforcer contingency. Journal of the Experimental Analysis of Behavior, 1976, 26, 79-93.

Terrace, H.S. Discrimination learning with and without "errors". Journal of the Experimental Analysis of

Behavior, 1963, 6, 1-29.

Williams, B.A. Contrast, component duration, and the following schedule of reinforcement. Journal of Experimental Psychology: Animal Behavior Processes, 1979, 5, 379-396.

Williams, B.A. The following schedule of reinforcement as a fundamental determinant of steady state contrast in multiple schedules. Journal of the Experimental Analysis of Behavior, 1981, 35, 293-310.

Williams, B.A. Another look at contrast in multiple schedules. Journal of the Experimental Analysis of Behavior, 1983, 39, 345-384.

Wilton, R.N. and Gay, R.A. Behavioral contrast in one component of a multiple schedule as a function of the reinforcement conditions operating in the following component. Journal of the Experimental Analysis of Behavior, 1969, 12, 239-246.

Woodruff, G., Conner, N., Gamzu, E., and Williams, D.R. Associative interaction: Joint control of keypecking by stimulus-reinforcer and response-reinforcer relationships. Journal of the Experimental Analysis of Behavior, 1977, 28, 133-144.