INFORMATION TO USERS

This material was produced from a microfilm copy of the original document. While the most advanced technological means to photograph and reproduce this document have been used, the quality is heavily dependent upon the quality of the original submitted.

The following explanation of techniques is provided to help you understand markings or patterns which may appear on this reproduction.

1. The sign or "target" for pages apparently lacking from the document photographed is "Missing Page(s)". If it was possible to obtain the missing page(s) or section, they are spliced into the film along with adjacent pages. This may have necessitated cutting thru an image and duplicating adjacent pages to insure you complete continuity.

2. When an image on the film is obliterated with a large round black mark, it is an indication that the photographer suspected that the copy may have moved during exposure and thus cause a blurred image. You will find a good image of the page in the adjacent frame.

3. When a map, drawing or chart, etc., was part of the material being photographed the photographer followed a definite method in "sectioning" the material. It is customary to begin photoing at the upper left hand corner of a large sheet and to continue photoing from left to right in equal sections with a small overlap. If necessary, sectioning is continued again — beginning below the first row and continuing on until complete.

4. The majority of users indicate that the textual content is of greatest value, however, a somewhat higher quality reproduction could be made from "photographs" if essential to the understanding of the dissertation. Silver prints of "photographs" may be ordered at additional charge by writing the Order Department, giving the catalog number, title, author and specific pages you wish reproduced.

5. PLEASE NOTE: Some pages may have indistinct print. Filmed as received.

Xerox University Microfilms
300 North Zeeb Road
Ann Arbor, Michigan 48106

Downloaded from SHAREOK. Persistent Handle URL: https://hdl.handle.net/11244/4128

76-24,365

JOBE, Jared B., 1951-
EFFECT OF REWARD MAGNITUDE, NONREWARD CONFINEMENT DURATION, AND REINSTATEMENT OF RETRIEVAL CUES ON SINGLE ALTERNATION PATTERNING WITH A 24-HR ITI.

The University of Oklahoma, Ph.D., 1976
Psychology, experimental

Xerox University Microfilms, Ann Arbor, Michigan 48106

THE UNIVERSITY OF OKLAHOMA

GRADUATE COLLEGE

EFFECT OF REWARD MAGNITUDE, NONREWARD CONFINEMENT DURATION, AND REINSTATEMENT OF RETRIEVAL CUES ON SINGLE ALTERNATION PATTERNING WITH A 24-HR ITI

A DISSERTATION

SUBMITTED TO THE GRADUATE FACULTY

in partial fulfillment of the requirements for the

degree of

DOCTOR OF PHILOSOPHY

BY

JARED B. JOBE

Norman, Oklahoma

1976

EFFECT OF REWARD MAGNITUDE, NONREWARD CONFINEMENT DURATION, AND REINSTATEMENT OF RETRIEVAL CUES ON SINGLE ALTERNATION PATTERNING WITH A 24-HR ITI

APPROVED BY

Roger L. Mellgren

Larry E. Gottlieb

Eric Eich Kenrick

Roger L. Jones

R. E. Brown

ACKNOWLEDGEMENTS

I would like to express my sincere appreciation to Dr. Roger L. Mellgren for his guidance and help not only during the preparation of this dissertation, but also during the four years in which I was his student, when Dr. Mellgren taught me about animal learning, research, and writing. I would also like to thank Dr. N. Jack Kanak for his valuable instruction about human learning and verbal learning research. I wish to express my gratitude to the members of my committee for their help during the preparation of this dissertation. And, special thanks to Dr. Jeffrey A. Seybert for first arousing my interest in animal learning, and to Ray L. Littlejohn for his help in running subjects and analyzing the data.

I would like to express my thanks to my wife, Lynne, for her help and sacrifices so that I might complete my degree. In addition, I wish to thank my parents for their help and support throughout my education.

Finally, thanks to Richard A. Feinberg for the great egg rolls.

TABLE OF CONTENTS

Page

Manuscript to be submitted for publication

INTRODUCTION 1

METHOD 4

RESULTS 6

DISCUSSION 7

REFERENCES 12

APPENDIX A Literature Review 16

APPENDIX B Statistical Tests 46

Abstract

The hypothesis was tested that the necessary conditions for the observation of single alternation patterning at a 24-hr ITI are: 1) a large magnitude of reward (LMR): 2) a long nonreward confinement duration (NCD): and, 3) maximal reinstatement of retrieval cues by making the goal box, runway and start box as similar as possible. Four groups received 1 trial a day for 136 days. As predicted, only a group receiving all three of the above conditions patterned. A second group receiving small reward, a long NCD, and reinstatement, a third group receiving LMR, a short NCD, and reinstatement, and a fourth group receiving LMR, a long NCD, and nonreinstatement all failed to demonstrate any evidence of patterning. The results support the sequential theory notion that goal-box events regulate instrumental responding at long ITIs.

Effect of Reward Magnitude, Nonreward Confinement Duration, and Reinstatement of Retrieval Cues on Single Alternation Patterning with a 24-hr ITI

On an alternating schedule of reinforced (R) and nonreinforced (N) trials of RNRNRN, rats learn to run rapidly on R trials and slowly on N trials after a considerable period of training. The occurrence of single alternation (SA) patterning is a well-known phenomenon at massed trials (e.g., Capaldi, 1958; Franchina & Kaiser, 1971; Tyler, Wortz, & Bitterman, 1953). However, at spaced trials, the phenomenon is less well documented. Some studies have reported SA patterning with an intertrial interval (ITI) of up to 24 hr (e.g., Capaldi & Lynch, 1966), whereas other studies have failed to find SA patterning with a 24-hr ITI (Amsel, Hug, & Surridge, 1969; Surridge & Amsel, 1965; 1968).

Even at massed trials, the magnitude of SA patterning has been shown to be a function of the magnitude of reward and the nonreward confinement duration (NCD). That is, a large magnitude of reward and/or a long NCD results in more pronounced patterning (Bloom, 1967; Burt & Wike, 1963; Campbell, Crumbaugh, Rhodus, & Knouse, 1971). Apparently at spaced trials, the occurrence of patterning depends upon both a large magnitude of reward and a long NCD. Such an assumption is consistent with much of the literature.

As discussed by Capaldi and Spivey (1965), the failure of Surridge and Amsel (1965) to find patterning at a 24-hr ITI may be attributed to

the short NCD used (30-35 sec). Capaldi and Lynch (1966) found SA patterning with a 24-hr ITI using a 120-sec NCD but not using a 30-sec NCD. However, neither Surridge and Amsel (1968) nor Amsel, Hug, and Surridge (1969) observed patterning with a 24-hr ITI using a 120-sec NCD. Both of these studies, however, used an apparatus in which the brightness of the start and goal sections differed considerably (gray vs. black and white).

According to Capaldi (1970) when a goal event occurs in an external stimulus context X, and a similar but different stimulus context X' is later presented, then only a portion of the memory of nonreward (S^N) or the memory of reward (S^R) will be reinstated. The methodological importance of this assumption recently received considerable experimental support (Jobe & Mellgren, 1974; Jobe, Mellgren, Feinberg, Littlejohn, & Rigby, in press). At spaced trials, when the start and goal sections were of similar brightness, i.e. gray, sequential effects were observed, but when the start and goal sections differed in brightness, i.e. gray vs. black and white, sequential effects were not observed. The relevance of these studies to the failures of Surridge and Amsel (1968) and Amsel, Hug, and Surridge (1969) to find patterning is obvious: Even though the reward magnitude was relatively large (500 mg) and the NCD was 120 sec, S^N and S^R were not adequately reinstated for the observation of SA patterning.

According to the present hypothesis, in order to observe SA patterning with a 24-hr ITI, it is necessary to use a large magnitude of reward, a long NCD, and to adequately reinstate S^N and S^R. Such a prediction follows the deduction from the sequential hypothesis (e.g., Capaldi, 1967) that SA patterning occurs because the rat learns to run rapidly in the presence of S^N and slowly in the presence of S^R. It is thus apparent that these memories must be strong and that they must be maximally reinstated if

these memories are to regulate the running behavior of the rat at long ITIs. And, if the memory of an N and or an R trial is weak or is not fully reinstated, then it will be difficult if not impossible for the rat to use the memory of the last goal event as a predictor of the outcome of the current trial.

It was the purpose of the present experiment to demonstrate that SA patterning with a 24 hr ITI will occur only under conditions of a large reward, a long NCD, and maximal reinstatement. In order to test the above hypothesis, four groups were used. One group received a large magnitude of reward (22 pellets), a long NCD (120 sec), and maximal reinstatement of goal events (gray alley throughout). This group was predicted to show patterned running since S^N and S^R should be strong and maximally reinstated. A second group received large reward, a short NCD (30 sec), and maximal reinstatement. This group is similar to a group used by Surridge and Amsel (1965) and by Capaldi and Lynch (1966). No patterning was predicted since S^N should not be as salient or strong as the first group due to the short NCD. A third group received a small reward (2 pellets), a long NCD, and maximal reinstatement. This group was not predicted to pattern since S^R should not be as salient or strong as the first group due to the small reward used. A fourth group received a large reward, a long NCD, and less than maximal reinstatement of S^N and S^R (gray start and run sections with a black and white striped goal box). This group is similar to a group used by Surridge and Amsel (1968) and one used by Amsel, Hug, and Surridge (1969). Even though S^N and S^R are strong in this group, patterning was not predicted because S^N and S^R were not maximally reinstated.

Method

Subjects

The subjects were 40 naive male albino rats obtained from the Holtzman, Co., and were approximately 75 days old at the beginning of the experiment. They were housed individually and randomly assigned to one of four groups (N = 10/group).

Apparatus

The apparatus consisted of a wooden straight-alley runway painted flat gray with the exception of one of the two interchangeable goal boxes. The two goal boxes were identical with the exception that one was painted flat gray and the other was black and white vertical stripes 1.9 cm wide. The alley was divided into start, run, and goal sections, separated by two guillotine doors which were lowered behind the rat to prevent retracing. The start box was 30.4 cm long, the run section 114.3 cm long, and the goal boxes were 38.1 cm long. All sections were 15.2 cm wide X 17.7 cm high and were covered by a hinged hardware cloth top. Several metal baby-food caps mounted on small wooden blocks served as food cups, one of which was always used on N trials so that food odors or crumbs would not be present on such trials. Start, run, and goal times were recorded by three .01-sec Standard Electric Timers. The start time began when the start-box door was raised and stopped when the subject broke a photocell located 18.5 cm fron the start-box door. Run time began when the first photocell was interrupted and stopped when the subject broke a second photobeam 6.5 cm from the goal-box door, a distance of 91.5 cm. Goal time began when the second photocell was interrupted and stopped when the subject broke a third photocell located 9.5 cm inside the goal-box door, a distance of 16.0 cm. All partial measures as well as total were converted to reciprocals and the results are reported as 1/time.

Procedure

One week prior to the beginning of the experiment the subjects were placed on a 12-gm per day Purina Lab Chow deprivation schedule with water continuously available. On each of the three days prior to the beginning of the study, the rats were handled and given a small handful of 45-mg pellets in the home cage.

Four experimental groups were used in the design of the experiment. Group 22-120-R received 22 45-mg pellets on rewarded trials, a 120-sec NCD on nonrewarded trials, and reinstatement of retrieval cues (homogeneous gray alley). Group 22-30-R received 22 pellets, a 30-sec NCD, and reinstatement. Group 2-120-R received 2 pellets, a 120-sec NCD, and reinstatement; and Group 22-120-N received 22 pellets, a 120-sec NCD, and nonreinstatement of retrieval cues (gray runway with the black and white striped goal box).

The single alternation schedule (NRNRNRNR, etc.) consisted of one trial a day for 136 days with a 24-hr ITI. Group 22-120-R and Group 2-120-R began the single alternation schedule with a reinforced (R) trial and Group 22-30-R and Group 22-120-N began with a nonreinforced (N) trial. The order of running was randomized so that for each rat an R trial immediately followed an N trial of another rat 50% of the time and an R trial of another rat the other 50% of the time. The same thing was true on an N trial. This was done in order to control for any odor cues which might be present. In addition the goal box was wiped clean with a damp sponge after each trial. On an R trial the subject was removed from the goal box immediately after it had consummed the appropriate number of pellets and on an N trial the subject was removed when the appropriate NCD had elapsed.

Results

The total speeds for each group are presented in Figure 1 for the last 7 blocks of 4 trials each of N and R trials, i.e. the last 56 trials. As can be clearly observed in Figure 1 only Group 22-120-R patterned. Dependent t-tests were performed on the last block of N and R trial blocks of Groups 22-30-R, 2-120-R, and 22-120-N. None of these differences approached significance. No other analyses were performed on the data of these groups.

A separate analysis of variance was performed on the last 7 blocks of N vs. R trials for total speeds of Group 22-120-R, with N vs. R trials as a within-subjects factor, and blocks of trials nested within conditions (N vs. R trials). Reliable patterning occurred as evidenced by the significant main effect of conditions (N vs. R trials), F (1, 9) = 91.52, $p < .01$. The blocks nested within conditions effect was also significant, F (12, 108) = 8.14, $p < .01$. Of course this effect consists of both the blocks main effect and the Conditions X Blocks interaction. Since the major item of interest here is the development of patterning across blocks, Tukey comparisons (at the .01 level, corrected for the total number of means, 14) were performed between the N and R blocks of trials at each of the 7 trial blocks. Reliable patterning occurred on Blocks 4, 5, 6, and 7 as evidenced by the significant post hoc comparisons on these blocks.

In an attempt to further evaluate the development of patterning, separate analyses of variance were also performed on the last 7 blocks of trials for start, run, and goal speeds. Reliable patterning occurred in all three partial measures as evidenced by significant main effects of conditions (N vs. R trials), for start, F (1, 9) = 34.48, $p < .01$; for run, F (1, 9) = 103.99, p .01; and for goal, F (1, 9) = 61.96, $p < .01$.

The blocks nested within conditions factor was also significant in all three partial measures, in start, F (12, 108) = 8.05, p <.01; in run, F (12, 108) = 7.33, p <.01; and in goal, F (12, 108) = 2.49, p < .01.

As is typically found (e.g., Capaldi & Lynch, 1966) reliable patterning occurred initially in goal, next in run, and finally in start as can be clearly seen in Figure 2. In goal reliable patterning occurred on Blocks 2, 3, 4, 5, 6, and 7; in run on Blocks 4, 5, 6, and 7; and in start only on Block 7 as indicated by post hoc comparisons performed at the .01 level of significance, controlling for the total number of means tested (14 each).

Discussion

As predicted, reliable patterning occurred only in a group receiving a large magnitude of reward, a long NCD, and maximal reinstatement of retrieval cues (Group 22-120-R). There was no evidence of patterning for Groups 22-30-R, 2-120-R, and 22-120-N. The results confirmed the hypothesis that with an ITI as long as 24 hr, the memories of reward and nonreward events must be very strong and must be reinstated to a maximal degree for the observation of SA patterning. Or, to put it another way, N and R trials must be easily discriminable from each other.

These findings are consistent with the results of Capaldi and Spivey (1965) in demonstrating that the lack of patterning reported by Surridge and Amsel (1965) was probably due to the short NCD used. This experiment also supports the contention that the failures to observe patterning by Surridge and Amsel (1968) and by Amsel, Hug, and Surridge (1969) even with a relatively large reward and a long NCD were most likely attributable to the lack of reinstatement of S^N and S^R caused by goal and start sections of the apparatus which differed considerably in terms of brightness or

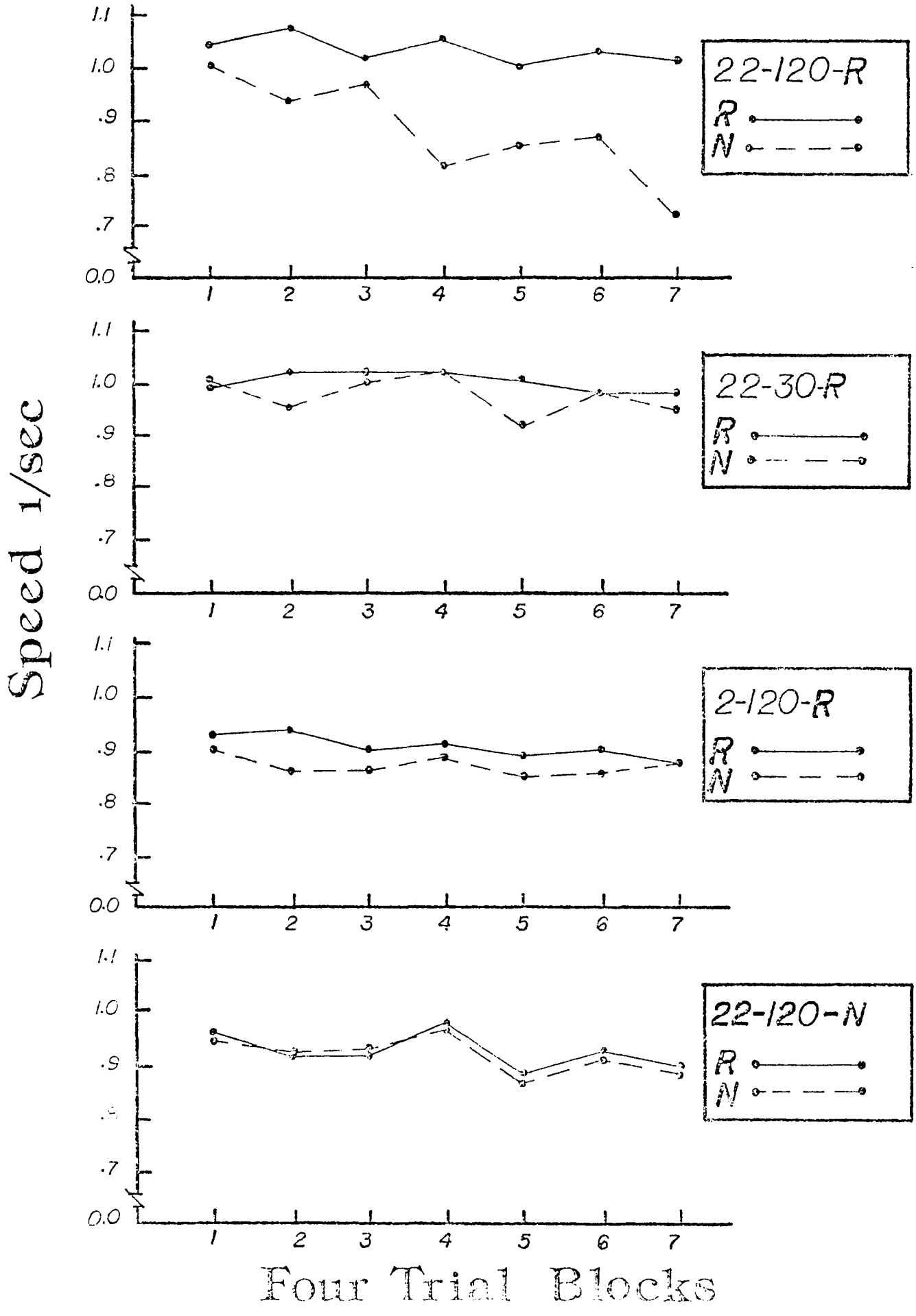
color. This present demonstration of the importance of the reinstatement of retrieval cues in finding SA patterning at a 24-hr ITI is consistent with an earlier study by Jobe and Mellgren (1974) which demonstrated the importance of reinstatement at long ITIs with respect to another sequential variable, number of successive nonreinforcements (N-length).

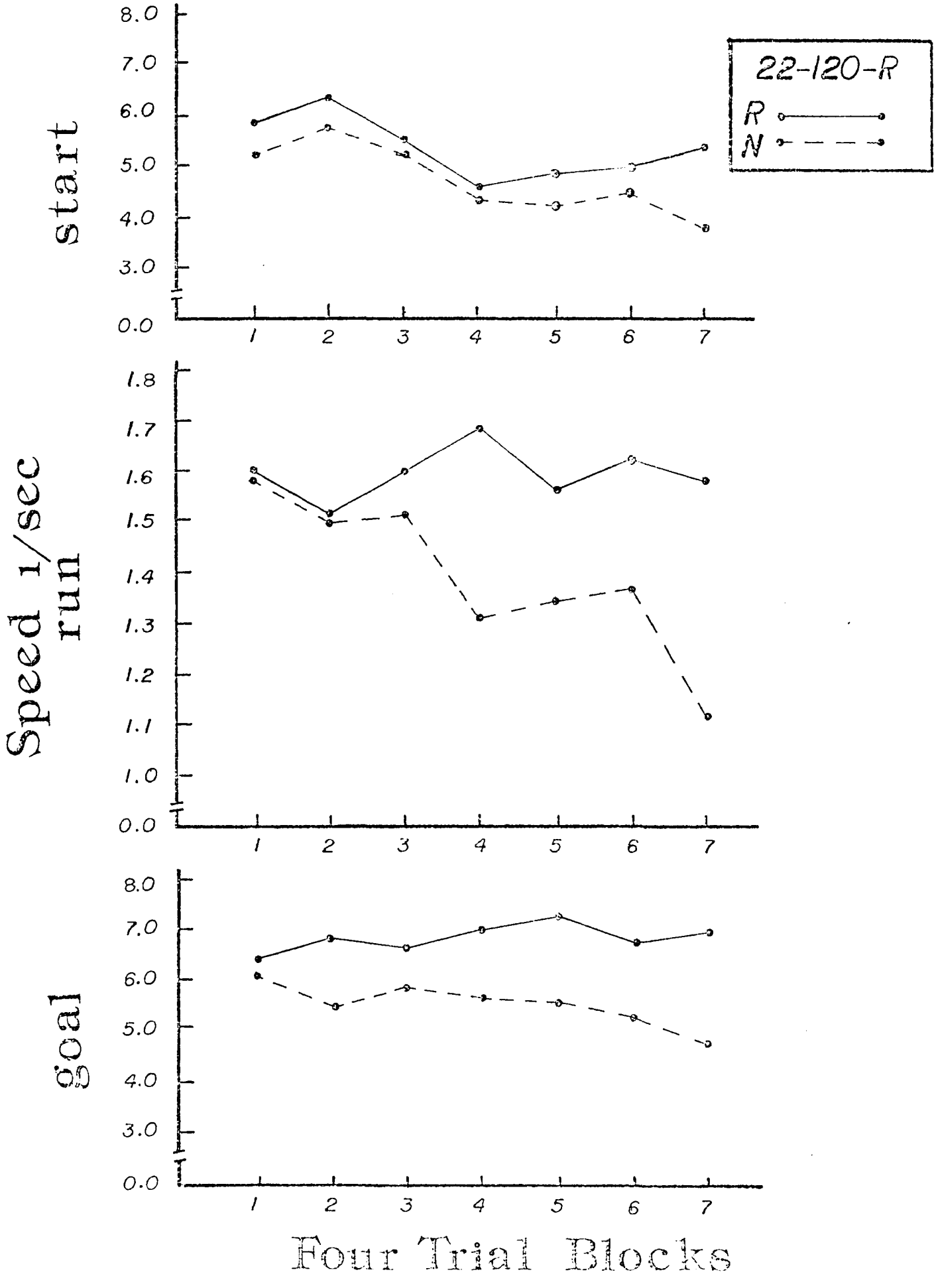
Finally, this experiment is consistent with other studies which support the notion that sequential variables are effective at ITIs as long as 24 hr (Capaldi & Capaldi, 1970; Capaldi & Spivey, 1965; Seybert, Mellgren, & Jobe, 1973), and are inconsistent with various hypotheses that sequential theory (e.g., Capaldi, 1967) can only account for massed trials data (Amsel, 1967; Gonzalez & Bitterman, 1969).

Figure Captions

Figure 1. Mean total speeds for the last 56 trials in blocks of 4 N and 4 R trials for all 4 groups.

Figure 2. Mean start, run, and goal speeds for the last 56 trials in blocks of 4 N and 4 R trials for Group 22-120-R.


Speed 1/sec
1.1
1.0
.9
.8
.7
0.0
1 2 3 4 5 6 7
22-120-R
R
N
22-30-R
R
N
2-120-R
R
N
22-120-N
R
N
Four Trial Blocks


22-120-R
R
N
start
8.0
7.0
6.0
5.0
4.0
3.0
0.0
1
2
3
4
5
6
7
Speed 1/sec
run
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.0
goal
Four Trial Blocks

References

Amsel, A. Partial reinforcement effects on vigor and persistence. In K. W. Spence & J. T. Spence (Eds.), The psychology of learning and motivation. Vol. 1. New York: Academic Press, 1967.

Amsel, A., Hug, J. J., & Surridge, C. T. Subject-to-subject trial sequence, odor trails, and patterning at a 24 hr ITI. Psychonomic Science, 1969, 15, 119-120.

Bloom, J. M. Early acquisition responding on trials following different rewards and nonrewards. Psychonomic Science, 1967, 7, 37-38.

Burt, D. H., & Wike, E. L. Effects of alternating partial reinforcement and alternating delay of reinforcement on a runway response. Psychological Reports, 1963, 13, 439-442.

Campbell, P. E., Crumbaugh, C. M., Rhodus, D. M., & Knouse, S. B. Magnitude of partial reward and amount of training in the rat: An hypothesis of sequential effects. Journal of Comparative and Physiological Psychology, 1971, 75, 120-128.

Capaldi, E. J. The effect of different amounts of training on the resistance to extinction of different patterns of partially reinforced responses. Journal of Comparative and Physiological Psychology, 1958, 51, 367-371.

Capaldi, E. J. A sequential hypothesis of instrumental learning. In K. W. Spence & J. T. Spence (Eds.), The Psychology of learning and motivation, Vol. 1. New York: Academic Press, 1967.

Capaldi, E. J. An analysis of the role of reward and reward magnitude in instrumental learning. In J. H. Reynierse (Ed.), Current issues in animal learning. Lincoln, Neb.: University of Nebraska Press, 1970.

Capaldi, E. J., & Capaldi, E. D. Magnitude of partial reward, irregular reward schedules, and a 24-hour ITI: A test of several hypotheses. Journal of Comparative and Physiological Psychology, 1970, 72, 203-209.

Capaldi, E. J., & Lynch, D. Patterning at a 24-hour ITI: Resolution of a discrepancy more apparent than real. Psychonomic Science, 1966, 6, 229-230.

Capaldi, E. J., & Spivey, J. E. Comment. Psychonomic Science, 1965, 3, 110.

Franchina, J. J., & Kaiser, P. Acquisition, transfer, and reacquisition of single-alternation responding in the rat. Journal of Comparative and Physiological Psychology, 1971, 76, 256-261.

Gonzalez, R. C., & Bitterman, M. E. Spaced-trials partial reinforcement effects as a function of contrast. Journal of Comparative and Physiological Psychology, 1969, 67, 94-103.

Jobe, J. B., & Mellgren, R. L. Successive nonreinforcements (N-length) and resistance to extinction at spaced trials. Journal of Experimental Psychology, 1974, 103, 652-657.

Seybert, J. A., Mellgren, R. L., & Jobe, J. B. Sequential effects on resistance to extinction at widely spaced trials. Journal of Experimental Psychology, 1973, 101, 151-154.

Surridge, C. T., & Amsel, A. Performance under a single alternation schedule of reinforcement at 24-hr intertrial interval. Psychonomic Science, 1965, 3, 131-132.

Surridge, C. T., & Amsel, A. Confinement duration on rewarded and nonrewarded trials and patterning at 24-hour ITI. Psychonomic Science, 1968, 10, 107-108.

Tyler, D. W., Wortz, E. C., & Bitterman, M. E. The effect of random and alternating partial reinforcement on resistance to extinction in the rat. American Journal of Psychology, 1953, 66, 57-65.

APPENDIX A

LITERATURE REIVEW

LITERATURE REVIEW

This literature review will attempt to discuss as well as account for discrepancies in the data of studies investigating patterned performance. Patterned performance can be defined as the rat's ability to respond rapidly on a reinforced trial and slowly on a nonreinforced trial, although patterning has also been investigated using delay of reinforcement. Several different types of patterning schedules will be discussed, such as, single alternation, double alternation, and other regular schedules of reinforcement.

Simultaneous differential contrast and successive discrimination, both of which might be termed patterning investigations in the broadest sense of the term, will not be discussed.

Both runway studies and discrete-trial and free-response lever pressing will be investigated, as well as both appetitive and escape conditioning situations.

Single Alternation Patterning

Single alternation (SA) patterning involves a schedule of trials in which a single reinforced (R) trial is followed by a single nonreinforced (N) trial, i.e. RNRNRN, etc. Typically, the rat responds rapidly following R trials and slowly following N trials early in acquisition, a result termed reverse patterning. Following this early period of reverse patterning, the rat responds equally fast following both R and N trials, and finally, after considerable training, the rat responds slowly on N trials and rapidly on R trials. SA patterning usually occurs initially in the goal measure, next in the run measure, and finally in the start measure. The magnitude of the patterning effect usually improves from start through goal, i.e. the largest difference between N and R trials is in goal, next in run, and least in start.

Several variables have been investigated which have been shown to affect the magnitude or occurrence of SA patterning, among them are magnitude of reward, nonreward confinement duration, intertrial interval, and reinstatement of retrieval cues. These variables and their important theoretical implications will be discussed.

Of those theories which attempt to explain and predict the occurrence of SA patterning, the most well-known are the Hull-Sheffield hypothesis (e.g., Sheffield, 1949) and the sequential hypothesis (e.g., Capaldi, 1967). According to the Hull-Sheffield hypothesis, SA patterning occurs because responses in the presence of the aftereffects of reinforcement are never reinforced, whereas responses in the absence of the aftereffects of reinforcement or in the presence of nonreinforcement aftereffects are always reinforced. The rat will therefore learn to run rapidly in the absence of reinforcement aftereffects and slowly in the presence of reinforcement aftereffects. The Hull-Sheffield hypothesis also theorizes that the aftereffects of reinforcement and nonreinforcement dissipate quite rapidly and therefore patterning is not predicted at long intertrial intervals.

E. J. Capaldi's sequential hypothesis (e.g., Capaldi, 1967), sometimes referred to as a modified version of the Hull-Sheffield hypothesis, assumes that the stimulus consequences of N and R trials are not dissipating aftereffects, but are memories. These memories are inactive between trials and reinstated by the experimental situation. Patterning at long intertrial intervals may be more difficult to obtain, but still can be observed if the stimulus consequences of reward and nonreward are strong and are adequately reinstated by the experimental situation. Therefore, the larger the reward magnitude, the stronger will be the memory of reinforcement

(S^R) and the longer the nonreward confinement duration, the stronger will be the memory of nonreinforcement (S^N). And finally, the more retrieval cues present on a trial, which were present on the previous trial, the more S^N and S^R will be reinstated (Capaldi, 1971).

In extinction rats receiving a SA schedule should be less resistant to extinction than rats receiving longer N-lengths (number of successive nonreinforcements followed by a reinforcement), since, according to sequential theory, after extensive acquisition training longer N-lengths result in greater generalization of habit strength in the continuous nonreward of extinction.

SA-patterning studies at massed trials. The first report of SA-patterning was by Tyler, Wortz, and Bitterman (1953). One group received a SA schedule of R and N trials and a second group received a 50% random partial reinforcement schedule. Reinforcement was 10-sec access to wet mash and the nonreward confinement duration (NCD) was 10 sec. Acquisition consisted of 10 trials per day for 12 days and extinction consisted of 10 trials per day for 6 days with an intertrial interval (ITI) of 20 sec. Early in training the SA rats tended to run faster on nonreinforced trials, i.e. fast following R trials and slow following N trials. In the intermediate stage of training, running was equally fast following both N and R trials. Finally, on Trial 65 patterning appeared and remained consistent over the remaining 55 trials. In extinction the alternating group extinguished more rapidly than the random group.

Capaldi (1958) investigated the effects of different amounts of training and different patterns of partial reinforcement. Acquisition consisted of either 14 or 7 days at 10 trials per day with an ITI of 20 sec. Reinforcement was 20 sec of wet mash and the NCD was 20 sec. Group

A-7 received a single alternation of N and R trials for seven days. Group A-14 received single alternation of N and R for 14 days. Group R-7 received a 50% random partial reinforcement schedule of N and R for seven days, and Group R-14 random 50% partial reinforcement for 14 days. Group A-14 exhibited patterned running on the final day acquisition, but Group A-7 did not show any evidence of patterning. In extinction Group A-14 was significantly inferior to the other three groups which did not differ among themselves.

Cogan and Capaldi (1961) also found SA patterning at massed trials. Each rat received 10 trials a day for 20 days with an ITI of 20 sec. Reinforcement was 20-sec access to wet mash and the NCD was 20 sec. Reverse patterning occurred initially and patterning began by Day 6 and was quite large by Day 8. Similar results were reported by Bloom and Capaldi (1961). Acquisition consisted of 12 trials a day for 24 days with a 10-sec ITI. The NCD was 20 sec and reinforcement was 20 sec of wet mash. Again, reverse patterning occurred early in training, followed by equal responding on R and N trials, with patterning occurring on Day 7. In extinction, the SA rats were less resistant to extinction than a group which received longer N-lengths.

Harris and Thomas (1966) demonstrated SA patterning at massed trials without handling the rats between trials and without odor cues. The apparatus was a triangular-shaped alley consisting of three runways arranged so that the rat could go from the goal box of one alley directly to the start box of the next alley without being handled. Reinforcement was 5 45-mg pellets and the NCD was 20 sec. The ITI was 20-30 sec. For the first 4 days 7 trials a day were given and for the last 18 days 13 trials a day were given. Patterning appeared on Day 7 and increased in magnitude throughout the rest

of training. Consistent results were obtained by Hanford and Zimmerman (1969) using an automated runway. SA patterning occurred without contamination due to handling, odor cues, or cues generating from a manually-operated runway. Inconsistent with most other studies, the strongest measure was start time.

Franchina and Kaiser (1971) also found considerable patterning with a 20-sec ITI. Reinforcement was 20-sec access to wet mash and the NCD was 20 sec. Reverse patterning, as usual, was found early in training, followed by equal responding, followed by patterning.

Capaldi and Stanley (1963) varied the ITI and found patterning at all 4 ITIs. Eight trials a day for 23 days were given with ITIs of either 15 sec, 2 min, 10 min, or 20 min. On the initial days of training all groups showed reverse patterning, and by Days 17 and 18 all 4 groups were patterning. Patterning was better for the 15-sec and 20-min groups than for the 2-min and 10-min groups.

Several studies have investigated the effects of reward magnitude and NCD on SA patterning. Bloom (1967) using a 20-sec ITI gave 18 days of training, 3 trials a day, to investigate performance on trials following reinforcement (TFR) and on trials following nonreinforcement (TFN) early in training. Group RnR received 60-sec reward, followed by 10-sec nonreward followed by 60-sec reward. Group rNr received 10-sec reward, followed by 60-sec nonreward, followed by 10-sec reward. Group RNR received 60-sec R, 60-sec N, and 60-sec R; and Group rnr received 10-sec R, 10-sec N, and 10-sec R. Through 36 trials running was faster on TFR than on TFN. However on Trials 37-54 the n groups continued to run slow on TFN and fast on TFR, while N groups ran fast on TFN and slow on TFR. Thus, the N groups demonstrated patterning, and whereas the n groups did not

pattern. Learning was far from complete as only 54 trials were given. In addition, running was fastest following large reward, slower following small reward, slower still following short nonreward, and slowest following long nonreward. These results indicated that different amounts of nonreward and reward produce distinctive stimulus aftereffects or memories which are conditionable on a succeeding trial. Burt and Wike (1963) varied the NCD at massed trials (20-sec ITI). The NCD used was either 20, 80, or 120 sec. The rats received 10-trials per day for 20 days. All three groups patterned although patterning occurred earlier and was of greater magnitude with the 80 and 120-sec NCD.

Campbell, Crumbaugh, Rhodus, and Knouse (1971) investigated the effect of magnitude of reward, NCD, and level of training on SA patterning at massed trials (20-sec ITI). Reward was either 2 or 20 45-mg pellets. Training was 6 trials per day for either 5 or 30 days in Experiment 1, and for 25 days in Experiment 2. The NCD as 20 sec in Experiment 1 and 60 sec in Experiment 2. In Experiment 1 only the extensive-acquisition large-reward group patterned. In Experiment 2 both large-reward and small-reward groups patterned. Patterning occurred much sooner and was of greater magnitude when large reward was used and when a longer NCD was used.

SA-patterning studies at spaced trials. As previously discussed, Capaldi and Stanley (1963) obtained SA patterning with ITIs of 15 sec, 2 min, 10 min, and 20 min. These results suggested that S^N and S^R do not dissipate at least for 20 min, and are inconsistent with the Hull-Sheffield hypothesis. Consistent results were demonstrated by Flaherty and Davenport (1972) with a 16-min ITI. Reward was 10 45-mg pellets and the NCD was 45 sec. The entire apparatus was gray. The rats received 6 trials per day for 36 days. Patterning occurred in run and goal sections

on about Day 16 and increased in magnitude over days. In start patterning was small and increased over days, occurring on about Day 18.

Bloom and Malone (1968) demonstrated patterning at spaced trials (1-hr ITI) without contamination due to odor cues. Reinforcement was a 30-sec access to 97 mg pellets and the NCD was 60 sec. Patterning was most pronounced in the goal section, less in run, and least in start, although significant in all three measures. Running was initially slower on TFN and faster on TFR, and patterning first appeared on Block 5 (100 trials).

Thus, with ITIs of up to 1 hr SA patterning has been consistently demonstrated, suggesting that S^N and S^R are memories and not aftereffects, since it would be difficult to think of aftereffects as persisting for 1 hr.

With ITIs of 24 hr, SA patterning has not been demonstrated consistently, and those variables (reward magnitude and NCD) which affect the magnitude of patterning with shorter ITIs apparently affect the occurrence of patterning using a 24-hr ITI. Also, it appears that reinstatement of S^N and S^R is of importance in spaced-trials patterning studies. As discussed by Capaldi (1970, 1971) when a goal-box event occurs in the presence certain external cues, the memory of that goal-box event will be better reinstated as more of the cues which were present in the goal box are present in the start box on a subsequent trial. Thus, if the start and goal sections of the apparatus are of different brightness, then S^R and S^N can not be reinstated to a maximal degree and patterning will be not observed.

Capaldi and Spivey (1964) gave rats one trial a day for 126 days, with reinforcement consisting of 60-sec access to wet mash and with a 120-sec NCD. Early in training, as other studies have demonstrated, running

was faster on N trials than on R trials. This tendency reversed itself first in the goal section, then in the run, and lastly in the start section. Patterning occurred in all three sections by the end of training, with differences being the greatest in the goal section.

Capaldi and Spivey's (1964) results are inconsistent with those of Surridge and Amsel (1966), who failed to find any patterning with a 24-hr ITI. Rats were run for 192 days at one trial a day. Group SA received a single alternation schedule, Group R received 50% random alternation, and Group C received CRF. Confinement on N trials was 30-35 sec and reinforcement was one 500-mg pellet. No patterning was observed for Group SA in either start, run, or goal measures. In extinction, Group R was slightly superior to Group SA, and both groups were superior to Group C in terms of resistance to extinction. Surridge and Amsel claimed that Capaldi and Spivey's results were due to food odors present on R trials leading to olfactory discrimination. A more likely explanation offered by Capaldi and Spivey (1965) is that the NCD (30-35 sec) in Surridge and Amsel's study was not long enough for patterning to occur at a 24-hr ITI, since the results of Burt and Wike (1963) showed that patterning was more pronounced the longer the goal confinement on N trials.

Capaldi and Lynch (1966) confirmed the view that the NCD is a most important variable in the occurrence or nonoccurrence of patterning using a 24-hr ITI. A group receiving 30-sec confinement, that used by Surridge and Amsel (1966), failed to pattern, whereas a group receiving a 120-sec confinement, that used by Capaldi and Spivey (1964), patterned. Group 30 received a 30 sec NCD, and Group 120 received a 120 sec NCD. Both groups received 30 sec of access to wet mash on R trials and 110 trials. Group 30 failed to show any evidence of patterning in either start, run,

or goal, but Group 120 patterned on about Trial 50, and patterning improved from start to goal. Capaldi and Lynch (1966) suggested that the previous results of Capaldi and Spivey could not be due to differential smell, since in their present study a similar group, Group 120, patterned, and another group, Group 30, did not. If Ss were discriminating on the basis of odors, then both groups would have patterned.

Both Surridge and Amsel (1968) and Amsel, Hug, and Surridge (1969) failed to find any evidence of patterning on the basis of memory even with a long NCD using a 24-hr ITI. Surridge and Amsel varied confinement time on both N and R trials. Group NC30-RC30 was confined to the goal box on both N and R trials for 30 sec; Group NC120-RC30 was confined for 120 sec on N trials and 30 sec on R trials; and Group NC30-RC120 was confined for 30 sec on N trials and 120 sec on R trials. All three groups received one trial per day for 134 days with reward being 1 500-mg pellet. Only Group NC120-RC30 should have showed patterning since that was the only group to receive a 120-sec NCD. None of the three groups showed any evidence of patterning. The failure to find patterning even with a 120-sec NCD was most likely due to the fact that the apparatus consisted of gray start and entry boxes and black and white run and goal sections, resulting in less than maximal reinstatement of S^N and S^R. The same apparatus was used by Amsel, Hug, and Surridge who found patterning via odor cues but not via memory. Rats received 168 trials single alternation, reward consisting of 1 500-mg pellet, and nonreward a 120-sec confinement. In Phase I (Trials 1-72) rat 1 ran first and rats 2-10 ran in a random order with R on odd days and N on even days. Patterning reliably occurred only in the goal measure. In Phase II (Trials 73-112) half of the rats received R on each day and half N after either a 6 or 7 day interval. Thus, in this phase,

odor trials could not be used as a source of discrimination. Patterning did not occur in any measure (start, run, goal). In Phase III (Days 113-168) the procedure was that used in Phase I. Patterning was restored although it was not as pronounced in the goal measure as in Phase I. These results suggested that rats do lay down differential odors which other rats can use as cues in responding. Again, however, the failure to find patterning on the basis of memory was probably attributable to the lack of reinstatement of retrieval cues.

Thus, at massed trials the magnitude of SA patterning is increased by a large magnitude of reward and a long NCD, whereas at spaced trials (24-hr ITI) a large magnitude of reward and a long NCD in addition to maximal reinstatement of retrieval cues are necessary for the observation of SA patterning.

Effect of liquid reinforcers on SA patterning. Using sucrose solutions as reinforcement, patterning effects appear to be more difficult to obtain, especially at longer ITIs. Katz (1959) observed differential responding earlier and of a greater magnitude with an ITI of 35 sec compared to an ITI of 25 min. Katz, Woods, and Carrithers (1966) investigated SA responding with ITIs of 25 sec, 2 min, 20 min, and 24 hr (the latter being based on all subjects). Nine trials per day were given for 30 days and the first trial of the day also alternated singlely between R and N. Reinforcement consisted of 15-sec access to a solution of 10 gm of sucrose to every 90 ml of water. The NCD was 15 sec and the apparatus was completely gray. Patterning occurred only for the rats run at a 25-sec ITI.

Franchina and Sparling (1973) gave SA training with R trials consisting of either 32% or 4% sucrose solutions and N trials consisting of a dry tube or for half of the rats in the 32% group, plain water. The alley

was completely black. The ITI was 20 sec and the NCD was 20 sec. On Days 1 and 2, 6 trials were given and thereafter 12 trials for a total of 216 trials. Reversed patterning occurred initially and all groups showed faster running on R trials, but only the 32% group patterned reliably, regardless of the type of N trial. The magnitude of the patterning was much less than that obtained by Franchina and Kaiser (1971) in the same alley using solid food. Apparently S^R is much less strong or discriminable when liquid reinforcers are used, which would result in effects similar to those obtained when a small magnitude of reward is used. Such an explanation would be consistent with the failure to obtain patterning at spaced trials with sucrose reinforcers, although short NCDs were used in most cases.

Single alternation of immediate and delayed-reinforcement trials. According to sequential theory (Capaldi, 1967) delayed reinforcement is somewhat similar to nonreward, and the longer the delay interval, the more delayed reinforcement is like nonreward. Patterning should occur in this situation for similar reasons, i.e. the memory of delay, S^D, is conditioned to responding whereas S^R is never conditioned to responding. If the delay interval is short, however, S^D and S^R may not be discriminably different enough for the rat to use them to predict goal-box outcomes. Thus SA patterning should only occur with longer delay intervals.

Wike, Kintsch, and Gutekunst (1959) first attempted to find patterned running with a SA schedule of immediate and delayed reinforcement. The ITI was 20 sec. Reinforcement consisted of 20-sec access to wet mash and the delay on delayed trials was 20 sec. Ten trials per day were given for 11 days. A second group received random patterns of delay. The SA group failed to show patterning and the two groups did not differ in terms

of resistance to extinction. Likewise, Cogan and Capaldi (1961) failed to obtain SA patterning using a short delay interval. A delay group and a usual SA of N and R trials group were used. The delay interval for Group D was 20 sec and reward was 20-sec access to wet mash. For Group P the NCD was 20 sec and reward was also 20-sec access to wet mash. Each group was given 10 trials per day for 20 days with an ITI of 20 sec. Eight days of extinction with 10 trials per day followed acquisition. For Group P running was initially faster following reinforced trials and slower following nonreinforced trials. By Day 6 Group P evidenced patterning which became marked by Day 8 and continued marked throughout acquisition. For Group D running was equally rapid on both delayed and immediately reinforced trials although at a rate below the R trials of Group P.

The results of Cogan and Capaldi (1961) were replicated and extended by Burt and Wike (1963) using a longer period of delay. Group LD received 20 sec mash reinforcements alternated with 20 sec delay prior to feeding, and Group LP received 20 sec mash reinforcement alternated with 20 sec confinement without food as in Cogan and Capaldi's study. The medium (MD) and high delay (HD) groups received 60 and 100 sec of delay on odd numbered trials, and the medium (MP) and high partial (HP) received 80 and 120 sec of confinement on nonreward trials. Ss received 10 trials per day for 20 days with a 20 sec ITI, and eight days of extinction. The results indicated that: 1) patterned running was demonstrated by both the partial and delay groups when longer delays were imposed, 2) patterning was observed earlier with the longer confinement times, 3) as in the Cogan and Capaldi study the low delay group did not pattern, but the low partial group did pattern, and 4) in extinction the partial groups were more resistant than their respective delay group.

SA patterning in escape conditioning. Patterning on the basis of single alternation of intermittent shock (shock and nonshock trials) in escape training was reported by Franchina and Snyder (1970). The apparatus was a white start box and black safe box separated by a guillotine door and a hurdle. On a shock trial, the guillotine door activated a 50-v shock which the rat escaped by jumping the hurdle. On nonshock trials, the shock was omitted. Training was 16 trials a day for 10 days. Reliable patterning was observed beginning with Block 21 (84 trials) and remained pronounced throughout training. These results, however, were not analogous to the appetitive data, since Ss were continuously reinforced--on shock trials by shock offset, and on nonshock trials by the reduction of fear conditioned to start box cues by shock. The results of Franchina and Snyder may have been due to the conditioning of slow and fast responding to the memory of stimuli of shock and nonshock trials.

A more analogous procedure to the appetitive situation in instrumental escape conditioning for the demonstration of patterning was done by Seybert, Mellgren, Jobe, and Eckert (1974). Unlike the Franchina and Snyder (1970) study, primary motivation was present on nonshock trials as well as on shock trials. A rewarded trial consisted of shock in the start and run sections of the alley (.5 ma) and reduced level in the goal section (.1 ma). A nonreward trial consisted of shock in all sections of the runway. When rats were given 4 trials per day with a 5-6 min ITI, patterning was not observed with a single alternation group. With a 45-sec ITI and 8 trials per day, the single alternation group patterned by Day 4 (32 trials).

Seybert (1974) also observed single alternation patterning in escape conditioning with a 24-hr ITI, using a procedure identical to that used by Seybert et al. (1974).

Transfer of SA patterning. Franchina and Kaiser (1971) investigated acquisition, transfer, and reacquisition of a SA schedule at massed trials (20-sec ITI). Phase 1 lasted 16 days, Phase 2 lasted 7 days, and Phase 3 11 days. Days 1 and 2 consisted of 6 trials per day and all other days 12 trials per day. Group SA received only SA in all phases. Groups SA-Rm-SA and SA-100-SA received SA in Phases 1 and 3 and random (Rm) or continuous (100%) reinforcement in Phase 2. Groups Rm-Rm-SA and 100-100-SA received random and 100% reinforcement in Phases 1 and 2 and SA in Phase 3. An R trial consisted of 20-sec access to wet mash and the NCD was 20 sec. In Phase 1 for SA rats reverse patterning occurred initially followed by a period of equal responding, followed by patterning on about Trial 48. In Phase 2 the SA-Rm-SA group ran faster on TFN than on TFR, but Group SA ran slower on TFR than Group SA-Rm-SA and there were no differences between the groups on TFN. Group SA-100-SA ran slower in Phase 2 than Group 100-100-SA. In Phase 3 on the first block of 6 trials all groups patterned except the 100-100-SA group which reverse patterned. SA learning occurred sooner following Phase 1 training under SA than under 100% or Rm and also occurred faster following 100% than following Rn training. Capaldi and Senko (1962) after training on a schedule of NNR for 14 days, during which time the rats ran slowly on the first N trial after Day 7, transferred rats to a SA schedule. Immediate and pronounced patterning occurred.

Bloom and Capaldi (1961) following SA and DA training and extinction, gave the DA group SA training, and gave the SA group DA training after 3 days of SA reacquisition. The DA group acquired the SA schedule in a manner largely indistinguishable from the SA group. During DA training training the SA group ran significantly faster on TFN than on TFR and this difference did not diminish through 144 trials.

The results of transfer studies support considerably the notion that SA patterning occurs because of 100% reinforcement in the presence of the memory of nonreward and 0% reinforcement in the presence of the memory of reward. After learning a SA schedule, rats transferred to a new schedule will continue to run rapidly on TFN and slowly on TFR even after 144 trials in some cases. And, training on another schedule of reinforcement prior to SA training can either facilitate, inhibit, or have no effect upon subsequent SA patterning.

Effect of brain lesions on SA patterning. Several studies have investigated the effects of various brain lesions on SA patterning. Barker and Thomas (1965) reported that rats with cingulate-cortex lesions failed to pattern on a SA schedule, but that neocortically-lesioned rats, sham-operated rats, and normal controls all patterned on the SA schedule. Failure to learn a SA schedule with anterior dorsal limbic lesions has also been demonstrated (Barker & Thomas, 1966), and also with septal lesions (Thomas, Hostetter, & Barker, 1968). Franchina and Brown (1970) found that rats with hippocampal lesions showed no SA behavior, but cortically-damaged rats and sham-operated controls showed SA behavior.

Those lesions which result in the elimination of patterning are involved in the limbic system, identified with memory and discrimination, whereas lesions not eliminating patterning are not part of the limbic system.

Double Alternation and Other Schedules

A double alternation (DA) schedule occurs when two R trials and two N trials are alternated, i.e. RRNNRRNN, etc. Whereas with a SA schedule each R and N trial is 100% predictable as to the outcome of the next trial, with a DA schedule each trial is only 50% predictable. Thus, patterning effects should be much more difficult to obtain under these conditions.

Bloom and Capaldi (1961) gave rats a schedule of DA, 12 trials a day for 24 days with a 10-sec ITI. There was no evidence of patterning. Ludvigson and Sytsma (1967) found DA patterning only when differential odor trials were present. No patterning occurred when odors were controlled. Eight trials a day were given for a total of 104 trials.

Seybert et al. (1974) using escape conditioning also failed to find DA patterning either with 4 trials a day for 120 trials and a 5-6 min ITI or with 8 trials a day for 96 trials and a 45-sec ITI.

Capaldi (1971) found that DA patterning could occur provided the situation was 100% predictable. To accomplish this Capaldi gave one group, the alternating group, a DA sequence of trials and a SA sequence of runway brightness, i.e. black, white, black, white, etc. Thus R and N occurred equally often in the black and white alleys. Therefore, if the rat is placed in the black alley on an N trial, the memory of R in the black alley two trials ago will be reinstated and R in the black alley reliably predicts 100% of the time an N trial in the black alley, so the rat should pattern. A second group received an irregular sequence of black and white alleys. Acquisition consisted of 12 trials a day, DA, for 42 days with an ITI of 2 min. Only the alternating group showed reliable patterning, confirming Capaldi's hypothesis.

Limited patterning has been reported using other regular schedules of reinforcement. Capaldi and Senko (1962) gave rats 12 trials a day with a schedule of NNR for 14 days. After Day 7 running was slow on the first N trial of the sequence and equally fast on the next two trials. Similarly, Capaldi (1967, p. 129) gave rats 10 trials a day, using a sequence of NNR with the first trial rewarded. Again, running was slow on the first N trial by Day 11 and equally fast on the second N trial and the R trial.

McHose (1967) used a schedule of RNN and reported a similar pattern of behavior. The rats received 3 trials a day for 3 days and 6 trials a day thereafter. Animals run without contamination due to odor cues ran fast, slow, fast on the 3-trial sequence. Animals given odor cues ran fast, slow, slow. Finally, Pschirrer (1972) gave rats a 3-trial sequence of milk, pellets, nonreward or pellets, milk, nonreward and found that running speed was slow on N trials in both groups.

The one consistent finding of the studies reported here is that behavior was appropriate (i.e., slow on N trials, fast on R trials) only when an external (odor) or internal (memory) cue was 100% reliable in terms of predicting the outcome of a given trial. DA patterning occurred only when odor cues were present or when the alley sequence was such that 100% predictability occurred. Patterning on schedules of RNN or NNR occurred only following R trials because an R trial always preceded an N trial. N trials predicted R trials only 50% of the time and no patterning occurred following N trials.

Patterning via ITI, Odor Cues, and Experimenter Cues

Bowen and Strickert (1966) found patterning on the basis of the ITI. All of the rats received 50% partial reward, and half of the ITIs were 5 min and half were 15 sec. For half of the rats in Group E, if any trial were N, the next trial was R if the ITI were 15 sec, and N if the ITI were 5 min. For the other half of Group E the contingencies were reversed. For Group C the goal event could not be reliably predicted. After 120 trials Group E ran faster on R trials than on N trials at both ITIs, although discrimination was poor at the long ITI even after 240 trials. Thus, rats can discriminate different ITIs and use this information in running.

As previously mentioned, several studies have found patterning on the basis of odor cues. Amsel, Hug, and Surridge (1969) found SA patterning on the basis of odor cues but not memory at a 24-hr ITI. Patterning via memory was not found probably due to differential goal box-start box brightness, as previously discussed. Also, Ludvigson and Sytsma (1967) found DA patterning on the basis of odor cues but not via memory. Finally, McHose (1967) found that rats ran fast, slow, slow on a schedule of RNN when odor cues were present, but ran fast, slow, fast when odor cues were not present. The procedures used in the above three studies were very similar. An R trial for an animal followed an R trial of another rat, and an N trial followed an N trial of another rat. The previous subject therefore laid down a differential odor on each trial which was a reliable predictor of the outcome of the present trial for the following subject.

Surridge and Amsel (1965) found patterning on the basis of experimenter cues. Rats received 4 trials per day for 24 days with the schedules: RNRN, NRNR, RNNR, and NRRN. The experimenter engaged in differential activity following R and N trials, such as brushing out the goal box following R trials, which resulted in significantly faster running on R trials as compared to N trials. The ITI following R trials was 15 min and the ITI following N trials was 27 min. The possibility that the rats discriminated R and N trials on the basis of differential ITI was rejected since the patterning on the first trial of the day was as large as the patterning on the subsequent trials of the day.

These studies again indicate that the rat can use either internal (memory) of external (odor trials) cues to respond appropriately if they are 100% predictable.

Patterning Effects in a Lever-Press Situation

Patterning effects have also been shown to occur in lever-press situations. Heise, Keller, Khavari, and Laughlin (1969) demonstrated both SA and DA patterning in a discrete-trials lever-press situation. SA rats received ITIs of 5, 10, 20, 40, 80, or 160 sec and DA rats received ITIs of 10, 20, 40, or 80 sec. A trial was defined as 10 presses. Each session consisted of 480 trials; DA rats received 18 sessions and SA rats received 5 sessions. As the ITI increased, the rate of learning to pattern decreased, but both SA and DA rats learned to respond appropriately. For some SA rats the ITI was increased from 5 to 10 sec, then from 10 to 20 sec, and finally from 20 to 40 sec. Each shift temporarily disrupted patterning but recovery was rapid.

Gonzalez, Bainbridge, and Bitterman (1966) also used a discrete-trials lever-press situation to investigate SA patterning. Each rat received 20 trials per day for 24 days with an ITI 15 sec. Reinforcement was 1 45-mg pellet. For one group a trial was defined as one bar press, but for a second group a trial was defined as 10 presses. For the 1-press group patterning was of a small magnitude, but for the 10-press group patterning was of a very large magnitude. A second experiment used a 6 45-mg pellet reward with 1 press being a trial. The procedure was identical to the previous experiment. Patterning was of a much greater magnitude than that obtained in the previous experiment.

Bloom, Williams, and Metze (1973) found in a discrete-trials situation that patterning occurred sooner and was of larger magnitude when 5 and 0 45-mg pellets were alternated than when 5 and 1 45-mg pellets were alternated. Latency of pressing was equally rapid on 5-pellet trials

for both groups and the differences occurred on the 0 pellet vs. 1 pellet trials with the latency of pressing being slower on 0-pellet trials

Bloom and Smith (1965) found SA patterning in a free-response bar-press situation. After one day of pretraining, reinforcement occurred to responses to a stimulus light which came on for 10 sec with 10 sec between each "trial". This occurred for one day for 30 min. For the next 20 days a SA pattern occurred, i.e. bar presses were reinforced only during every other light period. Therefore, each 10-sec light-on period was a trial with a 10-sec ITI. For the next 10 days half remained on SA and half transferred to DA. Consistent with results of runway studies, more bar presses occurred on TFN than on TFR. And, similar to results of Bloom and Capaldi (1961) in the transfer phase, DA rats pressed more on TFN than on TFR at a rate not unlike the rats continuing on SA.

Wall and Goodrich (1964) not only found SA patterning in a bar press situation, but also more complex patterning. Rats were initially trained under free-operant CRF and then under discrete trial CRF for 300 trials. They then received 3 schedules of PRF: A period of NR (SA) training for 1980 trials, NNR for 1000 trials, and finally NNNR for 1000 trials. Other rats received the 3 periods in the order NNR, NR, NNNR for 1980, 1000, and 1000 trials, respectively. Appropriate patterning occurred under all 3 schedules.

Apparently, patterning on schedules other than SA can reliably occur in lever-press situations, even when 100% predictability is not present. Patterning occurs on schedules of DA, NNNR, NNR, as well as SA. Many more trials are run in this situation, however, which may account for the differences in the results of runway and lever-press studies using more complex schedules of reinforcement.

Trained Alternation

Several studies have investigated a type of patterning called trained alternation which consists of a rat learning to singly alternate responses in a T-maze. In other words the rats are allowed free choices in a T-maze but differentially rewarded for alternating responses. When long ITIs are employed, the term delayed alternation is used. The underlying process for this type of alternation is assumed to be similar to the process used in SA patterning, i.e. the memory of the previous trial is used as a cue for the response on the present trial. An internal cue rather than an external cue such as position or brightness operates.

Ladieu (1944) gave 2 trials a day with the first trial rewarded no matter which side was chosen, but with the second trial rewarded only if the side not selected on the first trial was chosen. The ITI initially was 30 sec but was gradually increased to 30 min. With all ITIs 70-80% alternation was obtained. In a second experiment, intervals of 0, 5, 15, 30, 60, and 120 min were used and arranged in a random order. Alternation slightly decreased as the interval increased.

Petrinovich and Bolles (1954) gave 3 trials per day and again the first trial of the day was rewarded on either side with alternating responses only rewarded on the other 2 trials. The ITI was 15 min and some rats were food deprived and others water deprived with the appropriate reward (food or water) given. Both food and water deprived rats alternated with the water-deprived rats making more errors than the food-deprived rats. Bolles and Petrinovich (1959) also found alternation with a 15-min ITI. Again 3 trials a day were given, with the first trial rewarded.

Petrinovich and Bolles (1957) used an identical procedure and used a 15-min ITI for the first 24 days (Phase I). Using a criterion of 10/12

correct responses on test trials, 12 of 16 rats were advanced to Phase II. In Phase II delay intervals (ITIs) were $\frac{1}{2}$, 1, $1\frac{1}{2}$, 2, $2\frac{1}{2}$, 3, $3\frac{1}{2}$, 4, $4\frac{1}{2}$, 5, and $5\frac{1}{2}$ hrs. The initial ITI was 30 min and if a rat reached a criterion of 5 of 6 correct responses, the ITI was increased by 30 min, and so forth until either the longest ITI was reached or until the rat failed to reach the criterion. Only 1 of 12 rats failed to reach the criterion. In other words 11 out of 12 rats learned to alternate responses even with a $5\frac{1}{2}$-hr ITI.

These studies support the findings of spaced-trials SA patterning studies in that response-produced interval stimuli (memory) are useful as cues for responding on a given trial even when the interval between trials is long.

Summary

The present literature review attempted to survey and discuss patterned performance on the basis of internal stimuli (memory). SA patterning studies were reviewed and the effects of important independent variables were examined. It was determined that SA patterning increased in magnitude with a large magnitude of reward, a long NCD, and a short ITI. At spaced trials, apparently SA patterning only occurs using a large reward, a long NCD, and reinstatement of retrieval cues.

Using liquid reinforcers, SA patterning is of much less magnitude than that found with food reinforcers and does not occur at all if the ITI is long. SA patterning also occurs if immediate and delayed trials are alternated, provided the delay interval is long enough. In instrumental escape conditioning, SA patterning also occurs, both at short and at long ITIs.

Depending upon the schedules used, transfer from a SA schedule can have various effects. Studies which have investigated the effects of brain lesions on SA patterning indicate that lesions in the limbic system, which is associated with memory and discrimination, disrupt SA patterning as would be expected. Other lesions have no effect on SA patterning.

Using DA and other schedules of reinforcement, patterning only appears to occur when an N or R trial is 100% predictive concerning the outcome of the following trial.

Patterning also is found when the ITI is a discriminative stimulus. And, in situations where internal stimuli are not reliable, patterning has been observed on the basis of differential odor trails and experimenter cues when they are 100% predictive.

Patterning effects have occurred in a lever-press situation even on schedules other than SA, although many more trials were used than typically occur in a runway situation.

Finally, patterning has been reported in trained alternation in a T-maze even with long ITIs.

The results of these studies indicate that the rat can use memory as an effective cue if a given goal event (N or R trial, for example) is a reliable predictor with respect to the goal event of the next trial, even at long ITIs.

REFERENCES

Amsel, A., Hug, J. J., & Surridge, C. T. Subject-to-subject trial sequence, odor trails, and patterning at 24-hr ITI. Psychonomic Science, 1969, 15, 119-120.

Barker, D. J., & Thomas, G. J. Ablation of cingulate cortex in rats impairs alternation learning and retention. Journal of Comparative and Physiological Psychology, 1965, 60, 353-359.

Barker, D. J., & Thomas, G. T. Effects of regional ablation of midline cortex on alternation learning by rats. Physiology and Behavior, 1966, 1, 313-317.

Bloom, J. M. Early acquisition responding on trials following different rewards and nonrewards. Psychonomic Science, 1967, 7, 37-38.

Bloom, J. M., & Capaldi, E. J. The behavior of rats in relation to complex patterns of partial reinforcement. Journal of Comparative and Physiological Psychology, 1961, 54, 261-265.

Bloom, J. M., & Malone, P. Single alternation patterning without a trace for blame. Psychonomic Science, 1968, 11, 335-336.

Bloom, J. M., & Smith, N. F. Stimulus aftereffects of bar pressing. Psychonomic Science, 1965, 3, 23-24.

Bloom, J. M., Williams, D. T., & Metze, L. P. Effects of varied and partial reward on discrete trial patterning of rats. Animal Learning and Behavior, 1973, 1, 167-170.

Bolles, R. C., & Petrinovich, L. Body weight changes and behavioral attributes. Journal of Comparative and Physiological Psychology, 1956, 49, 177-180.

Bowen, J., & Strickert, D. Discrimination learning as a function of internal stimuli. Psychonomic Science, 1966, 5, 297.

Burt, D. H., & Wike, E. L. Effects of alternating partial reinforcement and alternating delay of reinforcement on a runway response. Psychological Reports, 1963, 13, 439-442.

Campbell, P. E., Crumbaugh, C. M., Rhodus, D. M., & Knouse, S. B. Magnitude of partial reward and amount of training in the rat: An hypothesis of sequential effects. Journal of Comparative and Physiological Psychology, 1971, 75, 120-128.

Capaldi, E. J. The effect of different amounts of training on the resistance to extinction of different patterns of partially reinforced responses. Journal of Comparative and Physiological Psychology, 1958, 51, 367-371.

Capaldi, E. J. A sequential hypothesis of instrumental learning. In K. W. Spence & J. T. Spence (Eds.), The psychology of learning and motivation. Vol. 1. New York: Academic Press, 1967.

Capaldi, E. J. An analysis of the role of reward and reward magnitude in instrumental learning. In J. H. Reynierse (Ed.), Current issues in animal learning. Lincoln, Neb.: University of Nebraska Press, 1970.

Capaldi, E. J. Memory and learning: A sequential viewpoint. In W. R. Honig & P. H. R. James (Eds.), Animal memory. New York: Academic Press, 1971.

Capaldi, E. J., & Lynch, D. Patterning at a 24-hour ITI: Resolution of a discrepancy more apparent than real. Psychonomic Science, 1966, 6, 229-230.

Capaldi, E. J., & Senko, M. G. Acquisition and transfer in partial reinforcement. Journal of Experimental Psychology, 1967, 63, 155-159.

Capaldi, E. J., & Spivey, J. E. Stimulus consequences of reinforcement and nonreinforcement: Stimulus traces or memory. Psychonomic Science, 1964, 1, 403-404.

Capaldi, E. J., & Spivey, J. E. Comment. Psychonomic Science, 1965, 3, 110 & 132.

Capaldi, E. J., & Stanley, L. R. Temporal properties of reinforcement aftereffects. Journal of Experimental Psychology, 1963, 65, 169-175.

Cogan, D., & Capaldi, E. J. Relative effects of delayed reinforcement and partial reinforcement on acquisition and extinction. Psychological Reports, 1961, 9, 7-13.

Flaherty, C. F., & Davenport, J. W. Successive brightness discrimination in rats following regular versus random intermittent reinforcement. Journal of Experimental Psychology, 1972, 96, 1-9.

Franchina, J. J., & Brown, T. S. Response patterning and extinction in rats with hippocampal lesions. Journal of Comparative and Physiological Psychology, 1970, 70, 66-72.

Franchina, J. J., & Kaiser, P. Acquisition, transfer, and reacquisition of single-alternation responding in the rat. Journal of Comparative and Physiological Psychology, 1971, 76, 256-261.

Franchina, J. J., & Snyder, C. R. Effect of patterns of shock and nonshock training trials on response alternation and extinction in escape training. Psychonomic Science, 1970, 21, 177-179.

Franchina, J. J., & Sparling, D. L. Effects of sucrose concentrations on single alternation runway responding in rats. Learning and Motivation, 1973, 4, 471-479.

Gonzalez, R. C., Bainbridge, P., & Bitterman, M. E. Discrete-trials lever pressing in the rat as a function of pattern of reinforcement, effortfulness

of response, and amount of reward. Journal of Comparative and Physiological Psychology, 1966, 61, 110-112.

Hanford, P. V., & Zimmerman, J. Differential running in rats under an alternating (FR2) schedule in an automated runway. Psychonomic Science, 1969, 14, 107-108.

Harris, J. H., & Thomas, G. J. Learning single alternation of running speeds in a runway without handling between trials. Psychonomic Science, 1966, 6, 329-330.

Heise, G. A., Keller, C., Khavari, K., & Laughlin, N. Discrete-trial alternation in the rat. Journal of the Experimental Analysis of Behavior, 1969, 12, 609-622.

Katz, S. The effect of intertrial interval on the discrimination of single-alternation intermittent-reinforcement schedules. American Psychologist, 1959, 14, 421. (Abstract)

Katz, S., Woods, G. T., & Caruthers, J. H. Reinforcement aftereffects and intertrial interval. Journal of Experimental Psychology, 1966, 72, 624-626.

Ladieu, G. The effect of length of delay interval upon delayed alternation in the albino rat. Journal of Comparative Psychology, 1944, 37, 273-286.

Ludvigson, H. W., & Sytsma, D. The sweet smell of success: Apparent double alternation in the rat. Psychonomic Science, 1967, 9, 283-284.

McHose, J. H. Patterned running as a function of the sequence of trial administration. Psychonomic Science, 1967, 9, 281-282.

Petrinovich, L., & Bolles, R. C. Deprivation states and behavioral attributes. Journal of Comparative and Physiological Psychology, 1954, 47, 450-453.

Petrinovich, L., & Bolles, R. Delayed alternation: Evidence for symbolic processes in the rat. Journal of Comparative and Physiological Psychology, 1957, 50, 363-365.

Pschirrer, M. Goal events as discriminative stimuli over extended intertrial intervals. Journal of Experimental Psychology, 1972, 96, 425-432.

Seybert, J. A. Spaced trial instrumental escape conditioning: Effects of sequential variables. University of Oklahoma, unpublished doctoral dissertation, 1974.

Seybert, J. A., Mellgren, R. L., Jobe, J. B., & Eckert, E. Sequential effects in instrumental escape conditioning. Journal of Experimental Psychology, 1974, 102, 473-483.

Sheffield, V. F. Extinction as a function of partial reinforcement and distribution of trials. Journal of Experimental Psychology, 1949, 39, 511-526.

Surridge, C. T., & Amsel, A. A "patterning" effect that seems unrelated to aftereffects from reward and nonreward. Psychonomic Science, 1965, 3, 373-374.

Surridge, C. T., & Amsel, A. Acquisition and extinction under single alternation and random partial-reinforcement conditions with a 24 hour intertrial interval. Journal of Experimental Psychology 1966, 72, 361-368.

Surridge, C. T., & Amsel, A. Confinement duration on rewarded and nonrewarded trials and patterning at 24-hr ITI. Psychonomic Science, 1968, 10, 107-108.

Thomas, G. J., Hostetter, G., & Barker, D. J. Behavioral functions of the limbic system. In E. Stellar & J. M. Sprague (Eds.), Progress in physiological psychology. Vol. 2. New York: Academic Press, 1968.

Tyler, D. W., Wortz, E. C., & Bitterman, M. E. The effect of random and alternating partial reinforcement on resistance to extinction in the rat. American Journal of Psychology, 1953, 66, 57-65.

Wall, A. M., & Goodrich, K. P. Differential responding on reinforcement and nonreinforcement trials occurring in fixed repeating patterns. Psychonomic Science, 1964, 1, 193-194.

Wike, E. L., Kintsch, W., & Gutekunst, R. Patterning effects in partially delayed reinforcement. Journal of Comparative and Physiological Psychology, 1959, 52, 411-414.

APPENDIX B

STATISTICAL TESTS

SUMMARY TABLE FOR 2(N vs. R TRIALS) X 7 (BLOCKS)
ANALYSIS OF VARIANCE WITH BLOCKS OF TRIALS NESTED
WITHIN N AND R TRIALS FOR MEAN START SPEEDS
FOR GROUP 22-120-R

Source	SS	df	MS	F
Total	158.085	139	27.652	
A/B(Subjects/Conditions)	14.321	1	14.321	34.48*
C/B(Blocks/Conditions)	5.501	12	4.585	8.05*
AC/B(Subjects Blocks/Conditions)	61.570	108	.570	

* $p < .001$

SUMMARY TABLE FOR 2(N vs. R TRIALS) X 7 (BLOCKS)
ANALYSIS OF VARIANCE WITH BLOCKS OF TRIALS NESTED
WITHIN N AND R TRIALS FOR MEAN RUN SPEEDS
FOR GROUP 22-120-R

Source	SS	df	MS	F
Total	5.624	139	1.973	
A/B (Subjects/Conditions)	1.484	1	1.484	104.00*
C/B (Blocks/Conditions)	1.158	12	.097	7.34**
AC/B (Subjects Blocks/Conditions)	1.420	108	.013	

* $p < .001$

** $p < .01$

SUMMARY TABLE FOR 2(N vs. R TRIALS) X 7 (BLOCKS)
ANALYSIS OF VARIANCE WITH BLOCKS OF TRIALS NESTED
WITHIN N AND R TRIALS FOR MEAN GOAL SPEEDS
FOR GROUP 22-120-R

Source	SS	df	MS	F
Total	192.632	139	72.446	
A/B (Subjects/Conditions)	61.969	1	61.969	74.19*
C/B (Blocks/Conditions)	14.473	12	1.206	2.49**
AC/B (Subjects Blocks/Conditions)	52.284	108	.484	

* $p < .001$

** $p < .01$

SUMMARY TABLE FOR 2(Nvs. R TRIALS) X 7 (BLOCKS)
ANALYSIS OF VARIANCE WITH BLOCKS OF TRIALS NESTED
WITHIN N AND R TRIALS FOR MEAN TOTAL SPEEDS
FOR GROUP 22-120-R

Source	SS	df	MS	F
Total	2.743	139	1.058	
A/B	,882	1	.882	91.52*
C/B	.611	12	.051	8.14*
AC/B	.675	108	.006	

* $p < .001$