1968

Effect of maze arm alternation on maze traversal latency : analysis of the aftereffects hypothesis

Ronald Seymour Johnson

EFFECT OF MAZE ARM ALTERNATION

ON MAZE TRAVERSAL LATENCY:

ANALYSIS OF THE AFTEREFFECTS HYPOTHESIS

by

RONALD SEYMOUR JOHNSON

Approved:

Richard L. Patten
Supervising Professor

Kenneth A. Blick
Chairman

EFFECT OF MAZE ARM ALTERNATION ON MAZE TRAVERSAL LATENCY: ANALYSIS OF THE AFTEREFFECTS HYPOTHESIS

A Thesis

Submitted to the Graduate Faculty of the
The University of Richmond
in partial fulfillment of the
requirements for the degree of
Master of Arts

in

The Department of Psychology

by
Ronald Seymour Johnson
B.A., Wake Forest University, 1966
August, 1968

Acknowledgments

The writer wishes to express sincere appreciation to his thesis adviser, Dr. Richard L. Patten, whose ideas, enthusiastic consultation and confidence made this study a valuable learning experience. The statistical advice of Dr. William H. Leftwich, who always made himself available throughout the data analysis, was invaluable in the completion of the manuscript. Genuine appreciation is also extended to thesis committee members, Dr. Kenneth A. Blick and Dr. L. James Tromater for their consultation and encouragement throughout the study.

The writer is deeply grateful to Mrs. Ann Schaefer who typed the entire manuscript and whose patience made errors less frustrating.

TABLE OF CONTENTS

TABLE OF FIGURES

FIGURE PAGE

Chapter I

INTRODUCTION

Clark Hull (1952, ch. 4) proposed that nonreinforced trials facilitate distinctive aftereffects and used this "aftereffect" theory to account for the PREE (the greater resistance to extinction of partially rewarded Ss as compared to continuously rewarded Ss). The theory proposed that stimulus traces of a nonrewarded trial (S^N) persist and are conditioned to the locomotor response (R_i) on trials which are reinforced and preceded by nonreinforced trials. If the $S^N \rightarrow R_i$ association has been established under partial reward conditions, and since S^N occurs during extinction, PREE is predicted.

Recent evidence for modified versions of the aftereffect hypothesis has involved straight runway studies. Studies by Capaldi, Hart, & Stanley (1963), Capaldi & Spivey (1963), and Spence, Platt & Matsumoto (1965) suggest that replacing S^N with noncontingent intertrial reinforcement (ITR) preceding the next rewarded occurance of R_i can eliminate PREE. Patterned running speeds appropriate to single alternating schedules of rewarded (R) and nonrewarded (N) trials have been obtained by Bloom & Capaldi (1961), and Capaldi & Stanley (1963) and have been interpreted as evidence for an aftereffect hypothesis of direct $S^N \rightarrow R_i$ association.

The straight runway evidence does not preclude a nonassociative interpretation of how S^N affects R_i. A nonassociative (e.g., r_g) interpretation of S^N effects can be used to account for the straight runway data above.

Patten, Tyson, & Johnson (1967) have provided what appears to be more convincing evidence of direct association between S^N and R_i by utilizing a selective learning situation (Y-maze) in which S^N was conditioned during training to the response of turning to one of the two alternatives. The Patten, Tyson & Johnson study employed two groups of Ss receiving partial (50%) reward in one arm of the Y-maze and continuous reward in the other arm. The sequence of N and R trials administered to the two groups of Ss is essentially that presented in Appendix B, Table I. With reference to Table I it can be seen that S^N was conditioned to the response of turning toward the partial reward arm in Group NRP, and to the response of turning toward the continuous reward arm in Group NRC.

The percentage choice data collected by Patten, Tyson & Johnson on test trials following N trials provided evidence for $S^N \rightarrow R_i$ association according to their design. However, the maze traversal latency data collected by Patten, Tyson & Johnson did not clearly support an aftereffects theory. More specifically, Ss in Group NRC exhibited faster running on R trials following N trials (TFN) in accordance with aftereffects theory; however, Ss in Group NRP did not run faster on TFN.

The present study is primarily concerned with evaluating a specific hypothesis regarding the different patterns of maze traversal latencies in Groups NRC and NRP. The hypothesis is stated as follows:

As indicated by a number of studies (Dember & Fowler, 1958; Douglas, 1966; Estes & Schoeffler, 1955; Walker, Dember, Earl & Karoly, 1955) rats receiving forced trial training in a selective learning situation exhibit a tendency to avoid the same alternative on two successive trials (i.e., they exhibit "spontaneous alternation"). Thus, the different maze traversal latency patterns exhibited by Groups NRC and NRP in the Patten, Tyson & Johnson study is due to the fact that on N-trials NRC Ss were forced to the same arm as the previous trial, while NRP Ss were forced to the different arm.

The design employed in the present investigation of the "spontaneous alternation" (SPA) hypothesis involved replicating the Patten, Tyson & Johnson study (Groups NRC and NRP) and comparing the obtained latency patterns with the latency patterns of two groups of Ss (RC and RP) for whom the N trials occur in both same and different arms. In addition, the latency pattern on same trials was compared with the latency pattern on different trials in groups RC and RP -- a within-Ss evaluation of the SPA hypothesis.

Chapter II

METHOD

Subjects and Apparatus

The Ss were 96 naive female albino rats of the Sprague Dawley strain, 90-100 days old at the start of experimental training. The Y-maze had an 18 in. stem, 10 in. arms, and 8 in. goalboxes set at 90 degree angles to the maze arms. Ss made a right turn to enter the right goalbox and a left turn to enter the left goalbox. Hinged sections of hardware cloth covered the top of the stem, arm, and goalbox sections of the maze. The entire maze was painted a flat black. A clear plexiglass sliding retrace door was located 1 in. from the beginning of each maze arm.

Photocells were placed 7 in. from the end of the stem, 1½ in. and 7 in. respectively from the beginning of each maze arm. Two Silent Hunter Klockounters were operated by the sequential interruption of the stem photobeam and the two goal-arm photobeams. The first Klockounter recorded stem traversal time over a 8½ in. section of the maze; the second Klockounter recorded arm traversal time over a 5½ in. section of the maze.

Preliminary Training

Ss were handled individually 2-5 min. each day for nine days. On Days 1-2, Ss were housed two per cage and received ad lib water and Purina food pellets. On Day 3, Ss were put in individual home cages,

each furnished with a 5 in. x 7 in. strip of cloth toweling, and placed on a 22½ hr. food deprivation schedule which was maintained throughout the experiment. Days 3-9 were alotted for Ss habituation to the deprivation schedule. Days 5-9 were alotted for Ss' habituation to the apparatus. Apparatus habituation trials consisted of permitting Ss to explore the unbaited maze in pairs for a 3-4 min. period each day. On Days 8 and 9 Ss were given approximately 9 gm. of wet mash in their home cages after maze habituation trials.

Experimental Training

On Day 10, Ss were randomly assigned to either Group NRC, Group NRP, Group RC, or Group RP, corresponding to four combinations of two bi-level experimental treatments. Ss received a 16 day series of acquisition training trials, followed by six free-choice extinction trials on Day 16. Table 1 (Appendix B) presents the schedule of training trials administered to Groups NRC and NRP. Table 2 (Appendix B) presents the schedule of training trials which were administered to Groups RC and RP.

With reference to Table 1, Group NRP Ss received continuous reward in one arm, followed by an NR sequence of partial reward in the other arm. This daily schedule of trials was repeated for each of 16 training days. A single free-choice nonrewarded test trial preceded the final rewarded trial on Day 2 and Day 9. Group NRC Ss received an RN sequence of trials in the partially rewarded arm. On Day 16, the nonrewarded trial in the partial reward arm (P-arm) was followed by six free-choice extinction trials. The Group NRP schedule of trials was designed to condition S^N to the response of turning toward the P-arm. The Group

NRC schedule of trials was designed to condition S^N to the response of turning toward the continuously rewarded arm (C-arm).

With reference to Table 2, the arm in which Group RC Ss and Group RP Ss received their first trial was determined as follows; the arm, left (L) or right (R), in which a given S was rewarded on the first trial on consecutive days was determined by a randomly determined (non replacement) sequence of four of the 4-day orders: LRLR, LLRR, LRRL, RRLL, RLLR, and RLRL. These 4 four-day first-trial acquisition sequences accounted for the sixteen days of acquisition training. For RC Ss S^N was conditioned to the response of turning toward C-arm. For RP Ss S^N was conditioned to the response of turning toward P-arm. Thus, for half the training days, within the RP and RC groups, Ss received their second trial in the same arm as they received the first trial; for the remaining half of the training days, the Ss were forced on the second trial to enter the opposite arm they entered on the first trial.

A random ½ of the Ss in each of the four groups received partial reward in the left maze arm; the remaining Ss received partial reward in the right maze arm. Training trials were forced by closing the appropriate retrace door. A trial began by placing S in the door of the maze stem. On rewarded trials Ss were permitted 15 sec. exposure to approx. 8 gm. of wet mash, which covered the bottom of a ½ in. high x 2 in. diameter metal food cup placed at the end of the goalbox. On nonrewarded trials Ss ran to an empty food cup and were removed from the goalbox 15 sec. after interrupting the terminal photobeam. After being removed from the goalbox Ss were placed in a waiting cage, of the type used as home cages, for a 30 sec. intertrial interval. Before each trial the stem, both maze arms and the choice point were wiped

with S's home cage rag to provide a measure of odor trail control. Running latencies were taken over the final three training days.

Analysis of Latency Data

The major question of this study involved the Groups x Trials interaction in traversal latency found by Patten, Tyson & Johnson. Group NRC Ss got the second (N) trial in the same arm they received the first (R) trial. Group NRP Ss got the second (N) trial in a different arm from the first (R) trial. This factor (Sequence) could have been responsible for the different speed patterns obtained.

The initial analysis of variance was concerned with possible between-Ss Sequence effects. The factors evaluated were: Sequence, with two levels (fixed vs. varied first trial arm), Association, with two levels corresponding to the association of S^N with either C-arm or P-arm choice, Replications, with four levels, and Trials, with two levels (daily trials 1-2). Thus a four-factor 2 x 2 x 4 x 2 ANOV was employed in the initial analysis.

Ignoring Replications, an Association x Sequence x Trials interaction would be consistent with the SPA hypothesis.

Since it was expected that the four treatment groups would have different trial 2 latencies, a 2 x 4 x 2 ANOV was applied seperately to Ss run under varied and fixed levels of Sequence. Both analyses were to provide replications of the Patten, Tyson & Johnson findings, in accordance with the SPA hypothesis.

The second, within-S, analysis of variance examined latency data from the varied level of the Sequence factor. The factors evaluated were Association, with two levels, Replications, with four levels, Repetition, with two levels (same arm vs. different arm trials), and

Trials, with two levels (Trial 1 vs. Trial 2). The last two factors were repeated measures factors. The only interaction predicted by the SPA hypothesis was between Repetition and Trials, with Trial 2 latencies increasing on same-arm trials and decreasing on different-arm trials. The 2 x 4 x 2 x 2 ANOV was also applied to the latency data from Trials 2 and 3. This analysis was to provide a replication of the Patten, Tyson & Johnson findings in accordance with the SPA hypothesis, i.e., an interaction between Association and Trials, with Group RC Ss exhibiting a significantly greater decrease in latency on Trial 3 than Group RP Ss.

Analysis of Percentage Choice Data

Acquisition. The Cochran Q Test (over the two acquisition test trials and the first extinction trial) was applied to Groups RP and NRP combined to determine if these Ss developed significant P-arm choice in accordance with the aftereffects hypothesis. A Cochran Q Test was also applied to the choice data from Groups RC and NRC combined to determine if these Ss developed significant C-arm choice. Between-S comparisons on each test trial employed t-tests (for differences in proportions) as in Patten, Tyson & Johnson, as well as the one-sample proportion t-test.

Extinction Data. Between-S comparisons on individual extinction trials two through six employed t-tests for differences in proportions and the one sample proportion t-test as in Patten, Tyson & Johnson.

Chapter III

RESULTS

Acquisition

Preceding any statistical analysis a constant of 1 was added to each S's latency on a given trial and the resulting data were transformed into 5-place logs. A constant of 1 was employed to avoid the possibility of negative logs. The data without the above transformation are presented along with each animal's acquisition training schedule in Tables 3-18 of Appendix B.

The pooling procedure for all analyses of variance in the present experiments was as follows: all replication factors and interactions with replications were treated as random sources of variance and thus were pooled with the appropriate within group sum of squares to form the experimental error term.

Combined Running Latency

The initial design for this experiment was concerned with possible between S Sequence effects. The performance of the four experimental groups was compared in a mixed analysis of variance. The results of this analysis (Appendix A, Table I) revealed a significant Association x Trials interaction, $F(1,104)=13.06$; $p < .01$. Analysis of simple effects indicated a significant Trials effect for C-arm Ss, $F(1,104)=41.43$; $p < .01$. C-arm Ss ran slower on Trial 2 than Trial 1. In addition, C-arm Ss ran slower on Trial 2 than P-arm Ss, $F(1,104)=41.35$;

$p < .01$. Mean transformed combined running latencies with reference to the Association x Trials interaction are presented in the left panel of Fig. 1.

Further analysis yielded a significant Sequence x Trials interaction, $F(1,104)=28.46$; $p < .01$. Analysis of simple effects revealed a significant Trials effect for Ss under the fixed-sequence treatment factor, $F(1,104)=58.57$; $p < .01$. Fixed-sequence Ss ran slower on Trial 2 than Trial 1. Further analysis of simple effects indicated that on Trial 2 running latencies for fixed-sequence Ss were slower than running latencies for varied-sequence Ss, $F(1,104)=47.82$; $p < .01$. Mean transformed combined running latencies with reference to the Sequence x Trials interaction are presented in the right panel of Fig. 1.

Stem Running Latency

The results of a mixed analysis of variance (Appendix A, Table II) yielded a significant Association x Trials interaction, $F(1,104)=27.14$; $p < .01$. Analysis of simple effects revealed a significant Trials effect for C-arm Ss, $F(1,104)=76.01$; $p < .01$. Stem running latencies on Trial 2 were slower than Trial 1. Analysis of simple effects further revealed that C-arm Ss ran slower on Tfial 2 than did P-arm Ss, $F(1,104)=84.89$; $p < .01$. Mean transformed stem running latencies with reference to the Association x Trials interaction are presented in the left panel of Fig. 2.

In addition, the results revealed a significant Sequence x Trials interaction, $F(1.104)=32.74$; $p < .01$. Analysis of simple effects revealed a significant Trials effect for fixed-sequence Ss, $F(1,104)=82.50$; $p < .01$. Fixed-sequence Ss ran slower on Trial 2 than Trial 1.

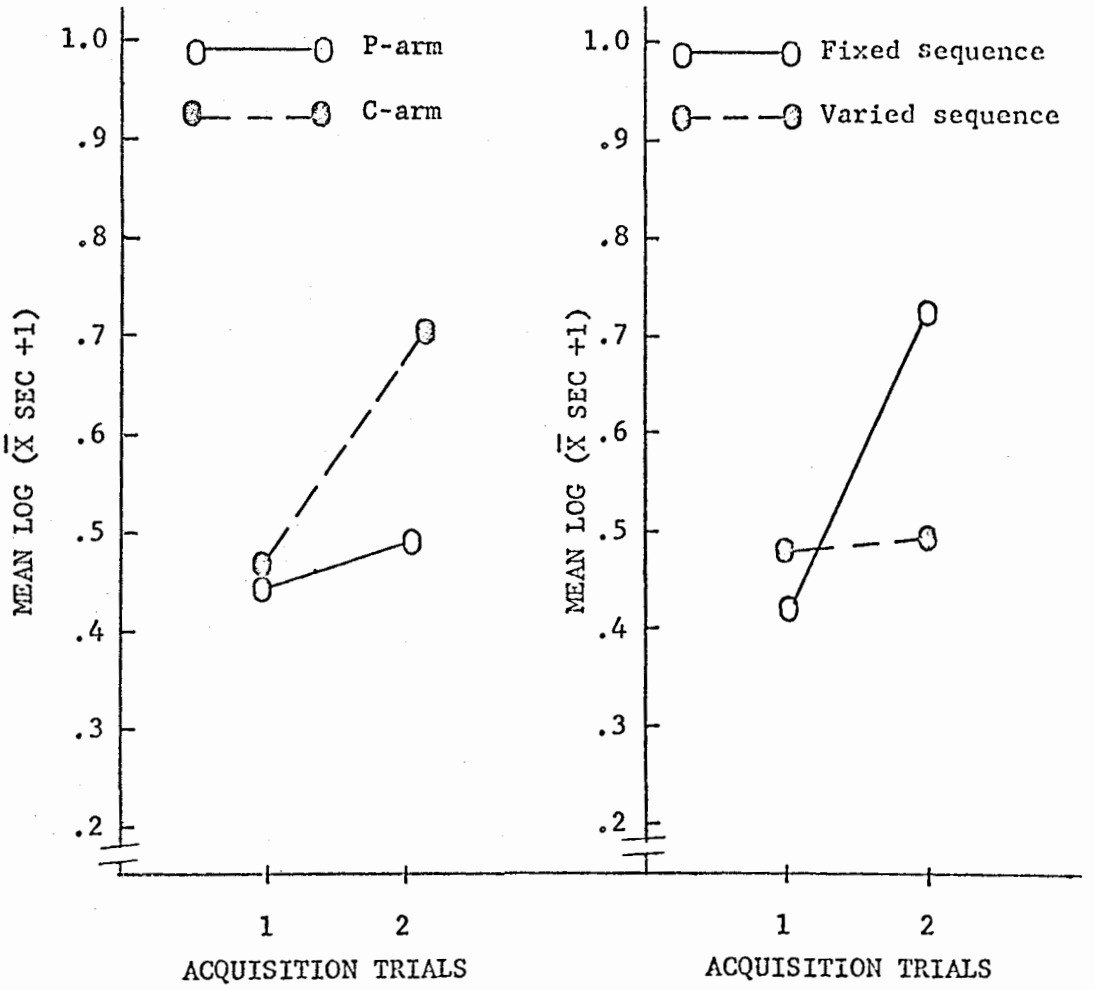

Fig. 1. Transformed combined running latencies for trial 1 and trial 2 of acquisition with reference to the association x trials interaction and the sequence x trials interaction for treatment groups differing in association and sequence.

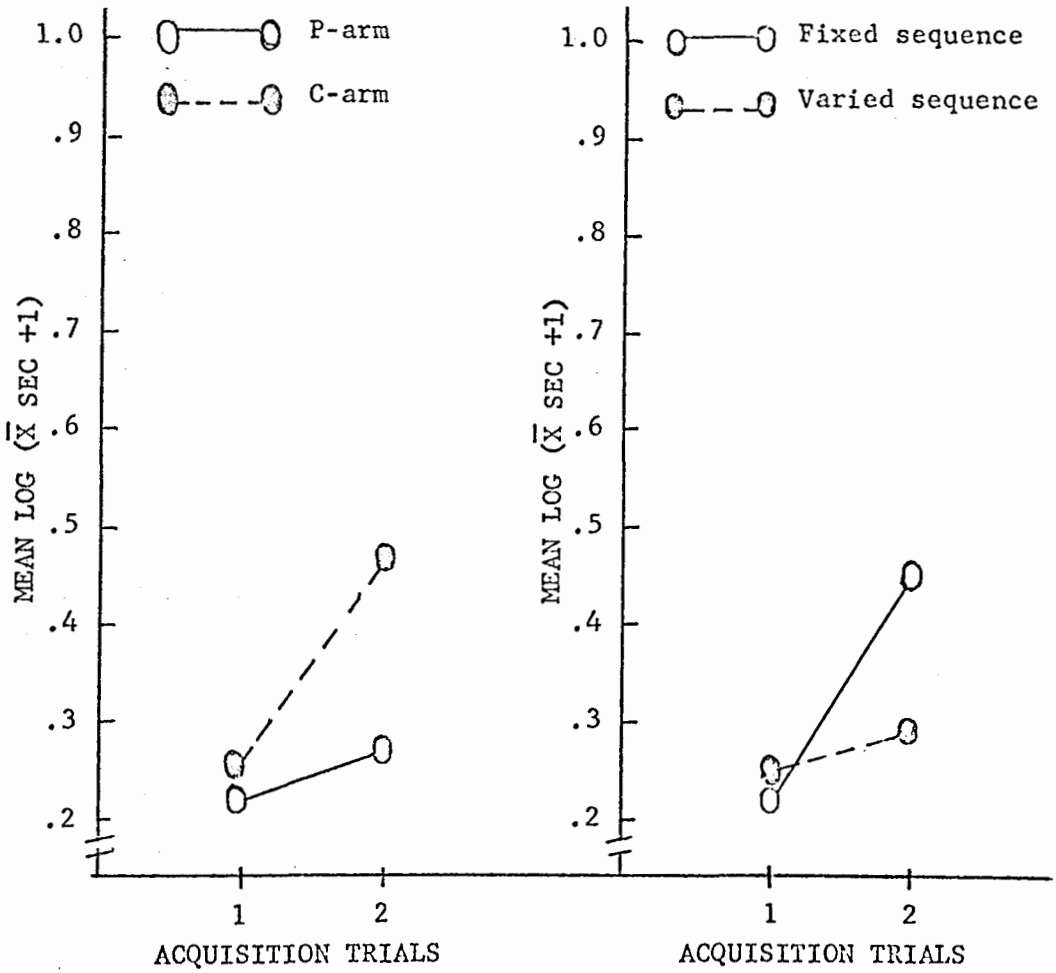

Fig. 2. Transformed stem running latencies for trial 1 and trial 2 of acquisition with respect to the association x trials interaction and the sequence x trials interaction for treatment groups differing in association and sequence.

Analysis of simple effects also revealed that fixed-sequence Ss ran slower on Trial 2 than varied-sequence Ss, $F(1,104)=48.48$; $p < .01$. Mean transformed stem running latencies with reference to the Sequence x Trials interaction are presented in the right panel of Fig. 2.

Arm Running Latency

The results of a mixed analysis of variance (Appendix A, Table III) revealed a significant Sequence x Trials interaction $F(1,104)=12.41$; $p < .01$. Analysis of simple effects indicated a significant Trials effect for fixed-sequence Ss, $F(1,104)=15.74$; $p < .01$. Fixed-sequence Ss ran slower on Trial 2 than Trial 1. Analysis of simple effects further revealed that Ss under the fixed-sequence condition ran slower on Trial 2 than varied-sequence Ss, $F(1,104)=20.38$; $p < .01$. Mean transformed arm running latencies with reference to the Sequence x Trials interaction are presented in Fig. 3.

Comparisons between C-arm Ss and P-arm Ss under the Varied Level of the Sequence Factor

Combined Running Latency

Mean transformed combined running latencies for C-arm and P-arm Ss over Trial 1 and Trial 2 of acquisition under the varied level of the sequence factor are presented in the upper panel of Fig. 4. The results of a mixed analysis of variance (Appendix A, Table IV) yielded a significant Association x Trials interaction, $F(1,52)=7.90$; $p < .01$. Statistical evaluation of simple effects indicated a significant Trials effect for C-arm Ss, $F(1,52)=4.17$; $p < .05$. C-arm Ss ran slower on Trial 2 than Trial 1. Further analysis revealed no significant difference in combined running latency between C-arm and P-arm Ss on Trial 2 ($p > .05$).

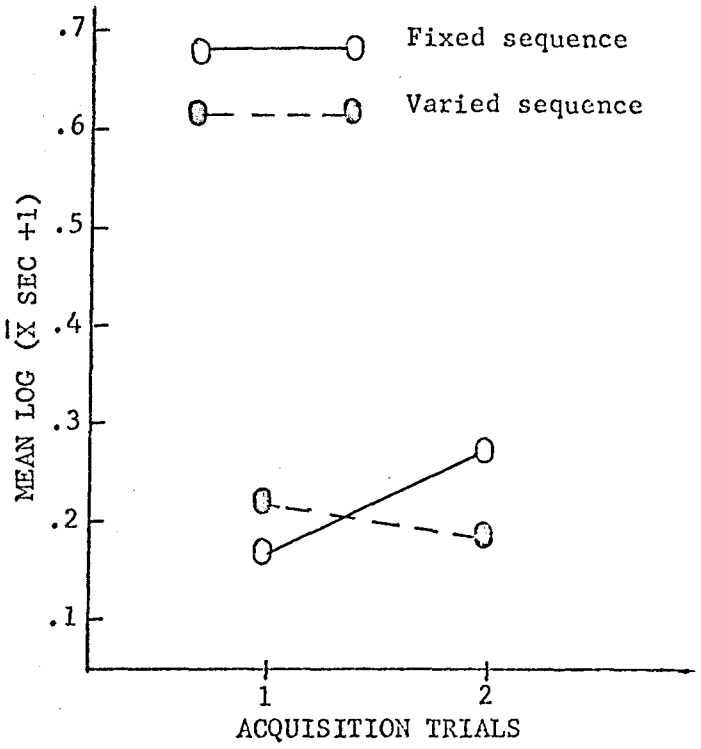

Fig. 3. Transformed arm running latencies for trial 1 and trial 2 of acquisition with respect to the sequence x trials interaction for treatment groups differing in association and sequence.

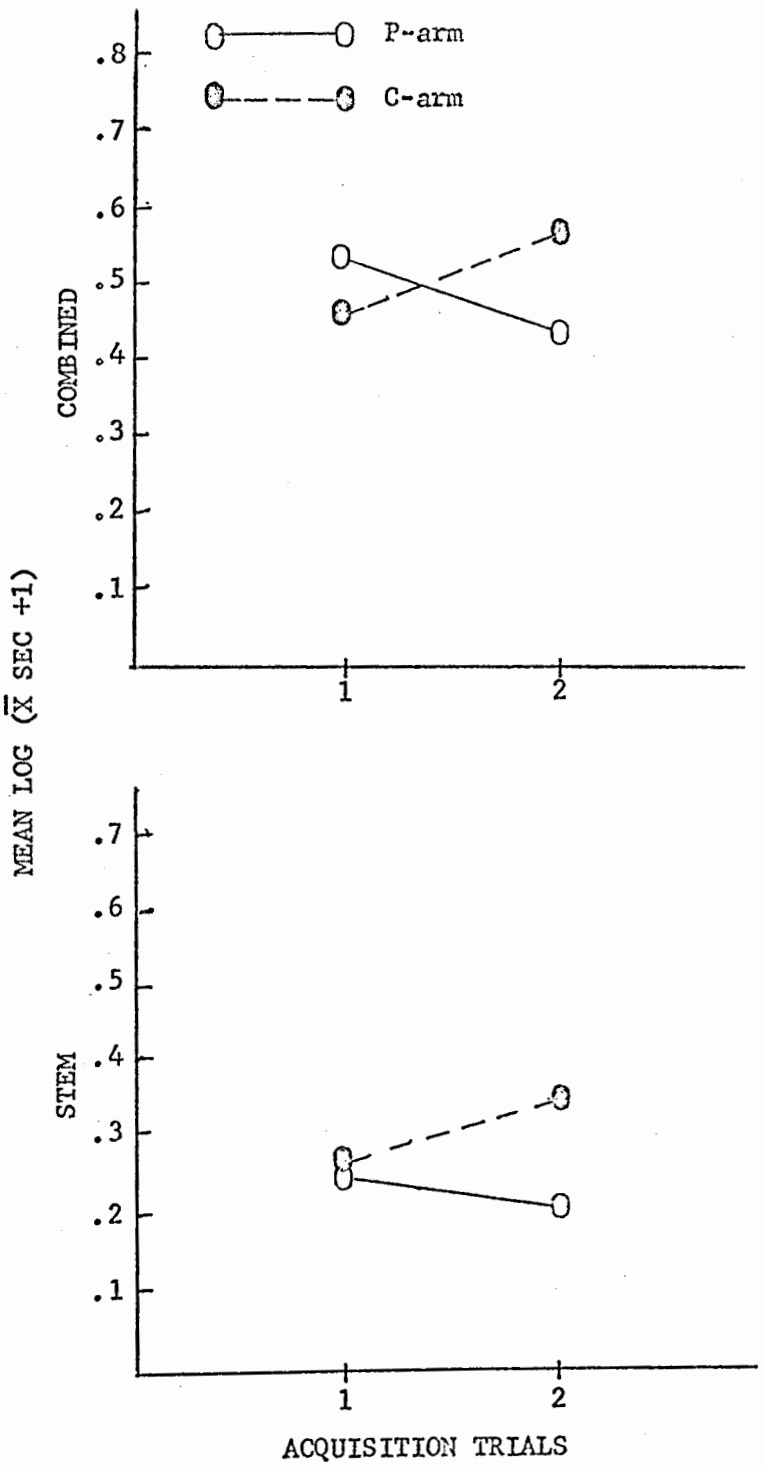

Fig. 4. Transformed combined latencies and stem latencies for trial 1 and trial 2 of acquisition for treatment groups differing in association under the varied level of the sequence factor.

Stem Running Latency

Mean transformed stem running latencies for C-arm and P-arm Ss over Trial 1 and Trial 2 of acquisition under the varied level of the sequence factor are presented in the lower panel of Fig. 4. Inspection of the lower panel of Fig. 4 indicated that C-arm Ss were running slower on Trial 2 than Trial 1. Statistical evaluation supported this observation: the results of a mixed analysis of variance (Appendix A, Table V) revealed a significant Association x Trials interaction, $F(1,52)=7.41$; $p < .01$. Analysis of simple effects revealed that while P-arm and C-arm Ss did not differ in Trial 2 latencies ($p > .05$), C-arm Ss ran slower on Trial 2 than Trial 1, $F(1.52)=7.62$; $p < .01$.

Arm Running Latency

The results of a mixed analysis of variance (Appendix A, Table VI) comparing the performance of C-arm Ss and P-arm Ss under the varied level of the sequence factor revealed no significant differences over Trial 1 and Trial 2 of acquisition ($p > .05$).

Comparisons between C-arm Ss and P-arm Ss under the Fixed Level of the Sequence Factor

Combined Running Latency

The results of a mixed analysis of variance (Appendix A, Table VII) revealed a significant Trials effect, $F(1,52)=9.27$; $p < .01$. C-arm Ss and P-arm Ss ran slower on Trial 2 than Trial 1 of acquisition. The results of the analysis failed to yield a reliable Association x Trials interaction ($p > .05$).

Stem Running Latency

A mixed analysis of variance comparing the two experimental groups (Appendix A, Table VIII) yielded a significant Trials effect, $F(1,52)=$

9.67; $p < .01$. The two groups ran slower on Trial 2 than Trial 1. The results of the analysis failed to reveal a reliable Association x Trials interaction ($p > .05$).

Arm Running Latency

The results of a mixed analysis of variance (Appendix A, Table IX) indicated a significant Trials effect, $F(1,52)=5.53$; $p < .05$. The two experimental groups ran slower on Trial 2 than Trial 1. A reliable Association x Trials interaction was not obtained ($p > .05$).

In summary: the significant Association x Trials interaction with combined and stem running latencies under the varied level of the sequence factor indicated a significant Trials effect over the first two acquisition trials of the present study. Group RC ran slower on Trial 2 than Trial 1 with no significant differences between Trial 1 and Trial 2 latencies for Group RP. In addition, Group RP and Group RC Ss did not differ reliable in Trial 2 latencies. Group NRP and Group NRC both ran slower on Trial 2 than Trial 1, but no reliable differences between groups in Trial 2 latencies were indicated.

Comparisons of Group RP and Group RC with Respect to Repetition over Trial 1 and Trial 2 of Acquisition

Combined Running Latency

Mean transformed combined running latencies for Group RP and Group RC over Trial 1 and Trial 2 of acquisition are presented in Fig. 5. Inspection of Fig. 5.indicated that Group RC ran slower on Trial 2 than Trial 1. Statistical evaluation confirmed this observation: the results of a mixed analysis of variance on treatment totals (Appendix A, Table X) revealed a significant Association x Trials interaction, $F(1,49)-8.92$; $p < .01$. Analysis of simple effects indicated a

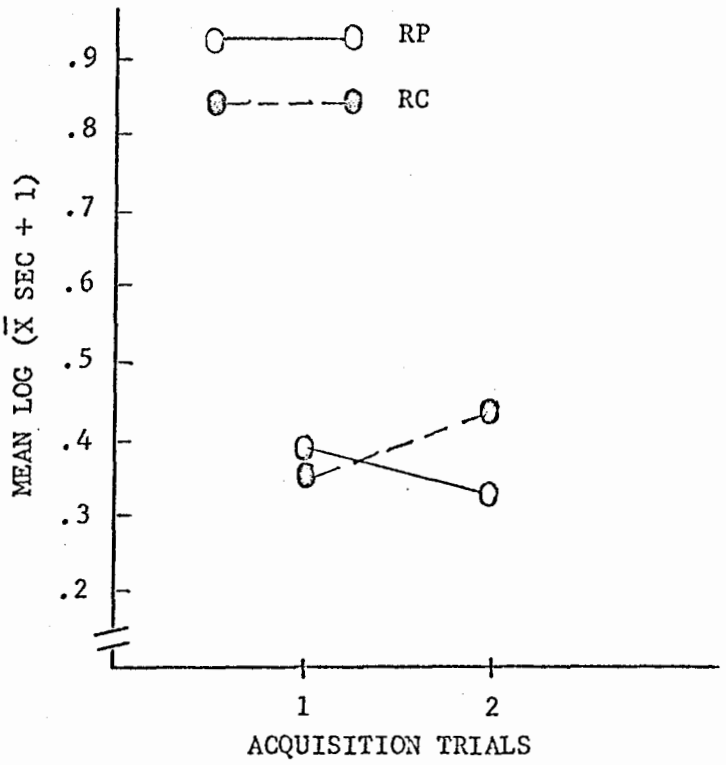

Fig. 5. Transformed combined latencies for trial 1 and trial 2 of acquisition for treatment groups differing in association from the varied level of the sequence factor.

significant Trials effect for Group RC, $F(1,49)=5.67$; $p < .05$. Comparison of Trial 2 latencies between Group RP and Group RC did not indicate a reliable difference ($p > .05$). In addition, the results of the analysis failed to yield a reliable Repetition x Trials interaction ($p > .05$).

Stem Running Latency

Mean transformed stem running latencies for Group RP and Group RC over Trial 1 and Trial 2 of acquisition are presented in Fig. 6. A mixed analysis of variance on treatment totals (Appendix A, Table XI) indicated a significant Association x Trials interaction, $F(1,49)=5.81$; $p < .05$. Analysis of simple effects revealed a significant Trials effect for Group RC, $F(1,49)=6.81$; $p < .05$. Group RC showed slower stem running latencies on Trial 2 than on Trial 1 of acquisition. Comparison of Trial 2 latencies between Group RP and Group RC did not indicate a reliable difference ($p > .05$). In addition, the results of the analysis failed to yield a reliable Repetition x Trials interaction ($p > .05$).

Further analysis revealed a significant Association x Repetition x Trials interaction, $F(1,49)=5.21$; $p < .05$. Mean transformed Trial 2 stem running latencies for Group RP and Group RC over same arm trials and different arm trials are presented in Fig. 7. Subsequent analysis of simple effects revealed a significant Repetition effect for Group RP, $F(1,49)=21.24$; $p < .01$. Group RP showed slower stem running latencies on different arm trials than same arm trials.

Arm Running Latency

Mean transformed arm running latencies for Group RP and Group RC over Trial 1 and Trial 2 of acquisition are presented in Fig. 8.

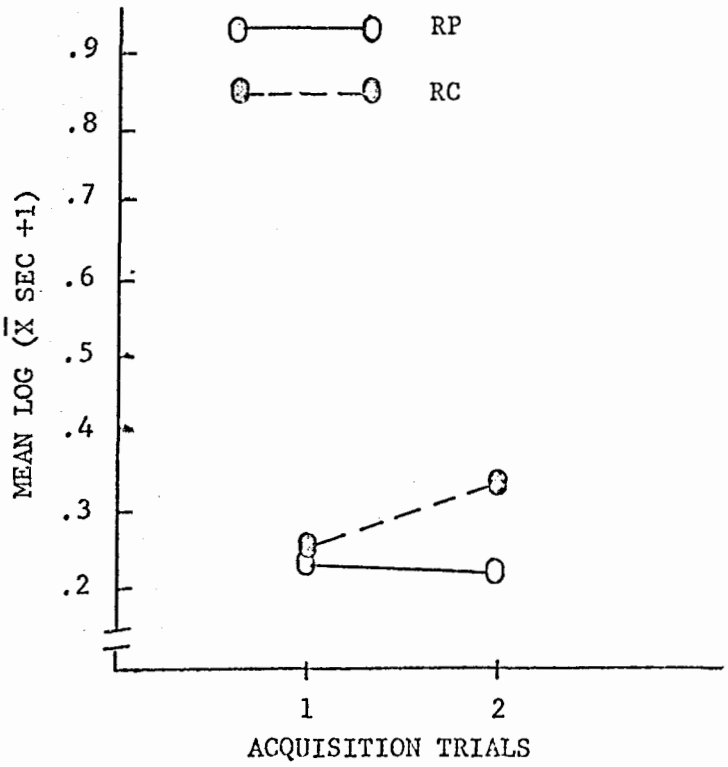

Fig. 6. Transformed stem latencies for trial 1 and trial 2 of acquisition for treatment groups differing in association from the varied level of the sequence factor.

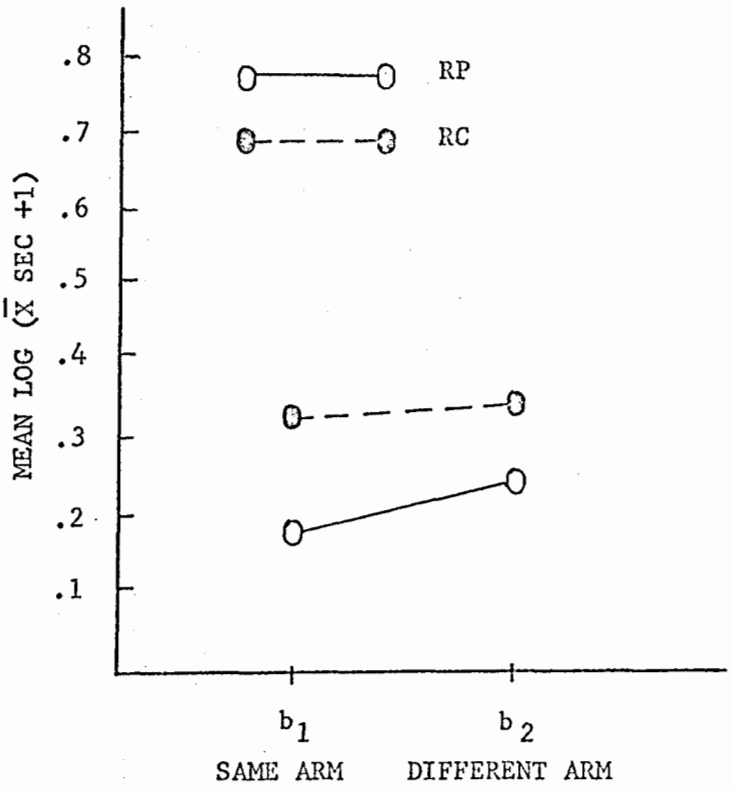

Fig. 7. Transformed trial 2 stem latencies for same arm trials and different arm trials for treatment groups differing in association.

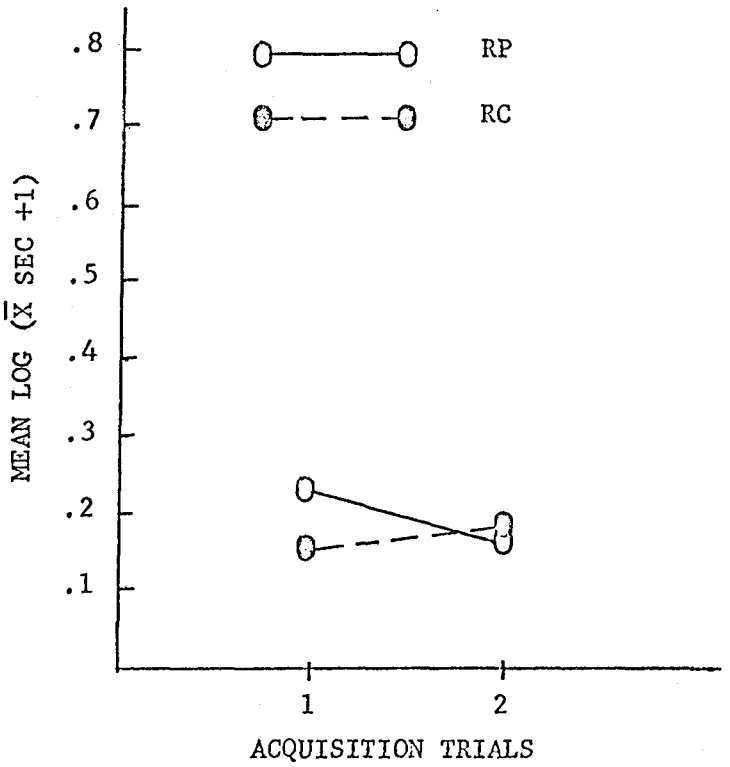

Fig. 8. Transformed arm latencies for trial 1 and trial 2 of acquisition for treatment groups differing in association from the varied level of the sequence factor.

Inspection of Fig. 8 suggested that Group RP ran faster on Trial 2 than Trial 1. Statistical evaluation confirmed this observation: the results of a mixed analysis of variance on treatment totals (Appendix A, Table XII) revealed a significant Association x Trials interaction, $F(1,49)=7.33$; $p < .01$. Subsequent analysis of simple effects indicated a significant Trials effect for Group RP, $F(1,49)=10.54$; $p < .01$. Further statistical evaluation failed to reveal differences between Group RP and Group RC with respect to Trial 2 latencies ($p > .05$). In addition, the results of the analysis failed to indicate a reliable Repetition x Trials interaction ($p > .05$).

Comparisons of Group RP and Group RC with Respect to Repetition over Trial 2 and Trial 3 of Acquisition

Combined Running Latency

Mean transformed combined running latencies for Group RP and Group RC over Trial 2 and Trial 3 of acquisition are presented in Fig. 9. A mixed analysis of variance on treatment totals (Appendix A, Table XIII) indicated a significant Association x Trials interaction, $F(1,49)=4.23$; $p < .05$. Analysis of simple effects revealed a significant Trials effect for Group RC, $F(1,49)=11.52$; $p < .01$. Group RC ran faster on Trial 3 than Trial 2. Comparison of Trial 3 latencies between the two experimental groups failed to reveal a reliable difference ($p > .05$).

Stem Running Latency

Mean transformed stem running latencies for the two experimental groups over Trial 2 and Trial 3 of acquisition are presented in Fig. 10. A mixed analysis of variance on treatment totals (Appendix A, Table XIV) indicated a significant Association x Trials interaction, $F(1,49)=4.44$; $p < .05$. Subsequent analysis of simple effects revealed a significant

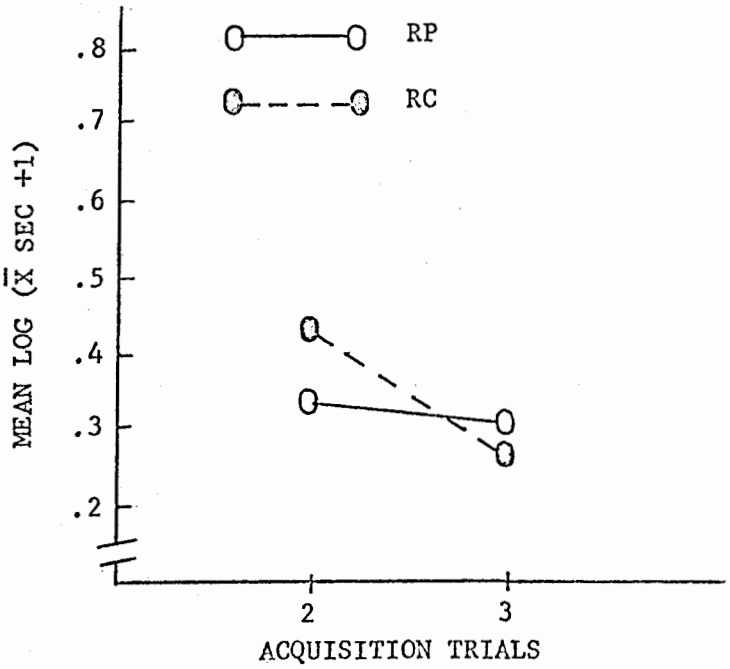

Fig. 9. Transformed combined running latencies over trial 2 and trial 3 of acquisition for groups differing in association from the varied level of sequence.

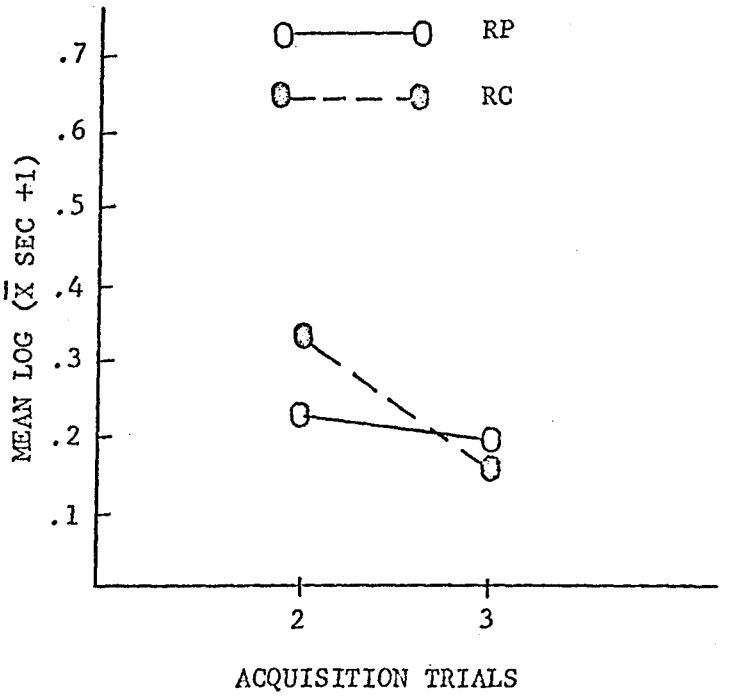

Fig. 10. Transformed stem running latencies over trial 2 and trial 3 of acquisition for groups differing in association from the varied level of sequence.

Trials effect for Group RC, $F(1,49)=14.13$; $p < .01$. Group RC ran faster on Trial 3 than Trial 2. Further analysis failed to yield a reliable difference between Group RP and Group RC Trial 3 latencies ($p > .05$).

Arm Running Latency

Mean transformed arm running latencies for Group RP and Group RC over Trial 2 and Trial 3 of acquisition are presented in Fig. 11. Inspection of Fig. 11 suggested that Group RC ran faster on Trial 3 than Trial 2. Statistical evaluation confirmed this observation: the results of a mixed analysis of variance on treatment totals (Appendix A, Table XV) indicated a significant Association x Trials interaction, $F(1,49)=4.06$; $p < .05$. Subsequent analysis of simple effects revealed a reliable Trials effect for Group RC, $F(1,49)=8.05$; $p < .01$.

Percentage Choice Data

The obtained choice data represented in terms of percentage of C-arm choice for the four experimental groups are presented in Fig. 12. The Cochran Q test over the two acquisition test trials and the first extinction trial applied to Groups NRP and RP combined indicated that P-arm Ss developed significant P-arm choice, $Q(2)=20.74$; $p < .001$. The same test applied to Groups NRC and RC combined did not indicate significant differences in C-arm choice over the three trials, $Q(2)=2.17$; $p > .05$.

Group NRC and Group RC Ss chose the C-arm significantly beyond the chance (.50) baseline on the first acquisition test trial, $t(23)=3.24$; $p < .001$, $t(23)=4.12$; $p < .001$, respectively. In addition, Group NRC and Group RC Ss chose the C-arm significantly beyond the

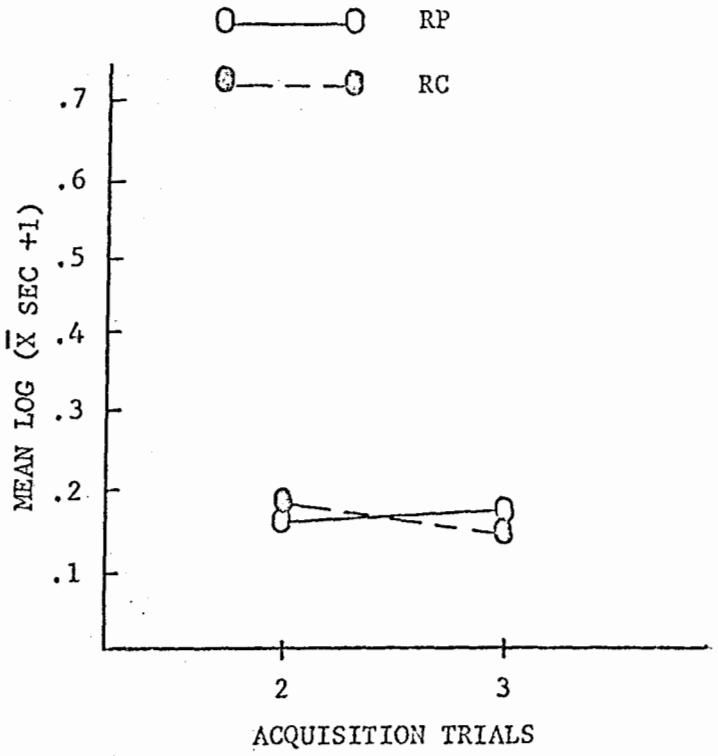

Fig. 11. Transformed arm running latencies over trial 2 and trial 3 of acquisition for groups differing in association from the varied level of sequence.

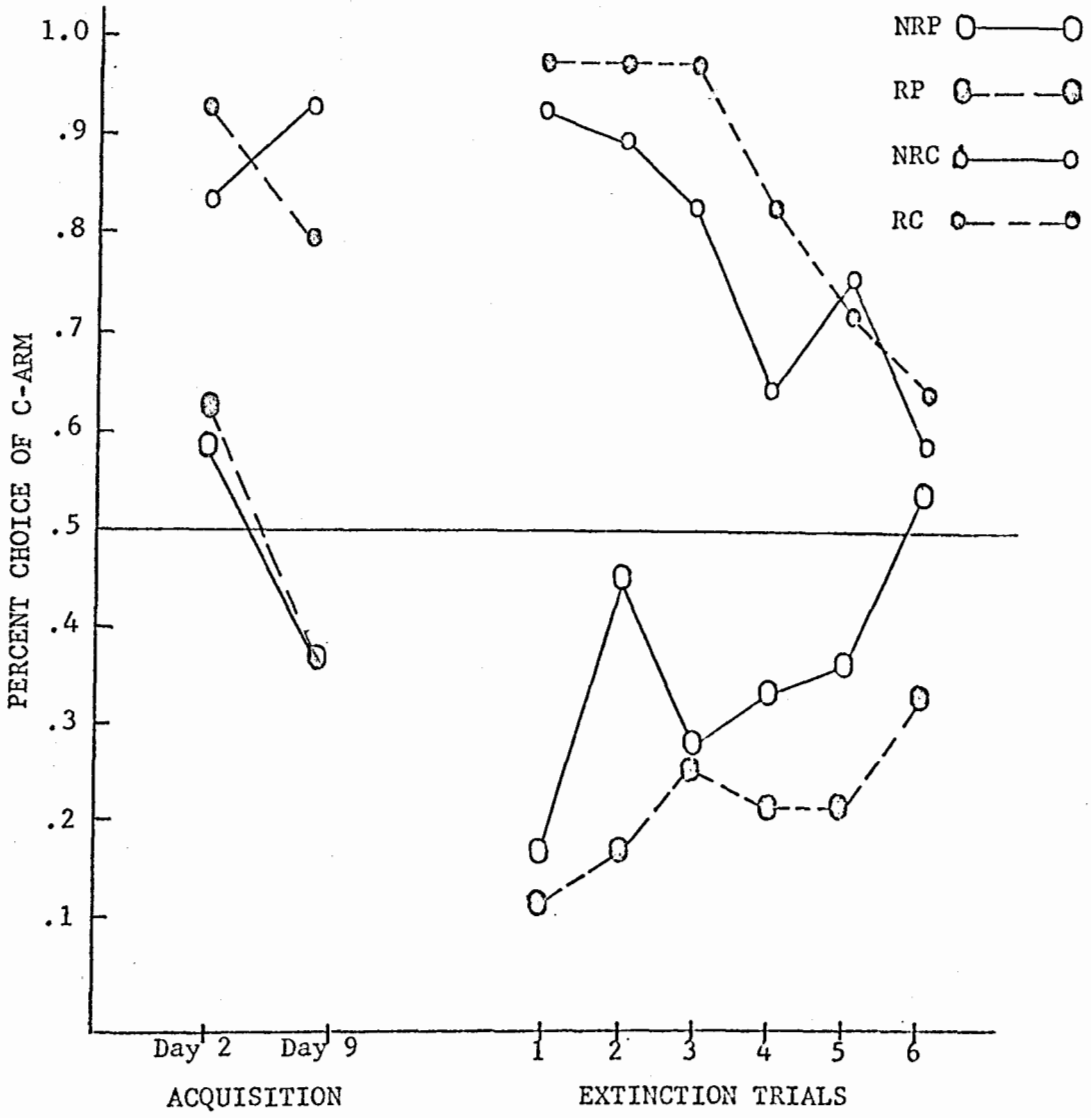

Fig. 12. Percent choice of the C-arm for the four experimental groups over the two acquisition test trials and the six free choice trials comprising extinction.

chance baseline on the second acquisition test trial, $t(23)=4.12$; $p < .001$, $t(23)=2.84$; $p < .01$, respectively. Both Group NRP and RP Ss failed to choose the P-arm beyond the chance baseline on the first acquisition test trial, $t(23)=.78$; $p > .05$, $t(23)=1.18$; $p > .05$, respectively, as well as the second acquisition test trial, $t(23)=1.27$; $p > .05$, $t(23)=1.27$; $p > .05$, respectively.

A significant difference $t(94)=3.02$; $p < .01$, was associated with a greater percent choice of the C-arm by C-arm Ss on the first acquisition test trial. In addition, C-arm Ss chose the C-arm to a larger extent than P-arm Ss on the second acquisition test trial, $t(94)=4.73$; $p < .001$.

Nonparametric Trend Analysis

In order to accomodate this statistical procedure, the choice data from acquisition and extinction were collapsed into four blocks of two trials. The dependent variable was number of correct responses (responses predicted by the aftereffects hypothesis, i.e., $S \xrightarrow{N} R_i$) rather than percentage C-arm choice.

A. W. Still (1967) has suggested a nonparametric approach to the analysis of trend to circumvent the problem of interaction in data which do not meet the assumptions on which parametric tests are based. The choice data obtained in the present study precluded the use of the parametric analysis of variance approach since the distributions of the treatment populations could not be assumed to approximate normality and homogeneity of error variance between treatments was questionable. The procedure employed by Still (1967) enabled comparisons to be made between groups across trial-blocks with respect to number of correct responses. The hypothesis tested was whether or not the four groups

(RP, RC, NRP and NRC) were different with respect to the slope of their respective trends. The test of the significance of the difference between the slopes of the groups (Factor A) by trial-blocks (Factor B) profiles involved using the Kruskal-Wallis One-Way Analysis of Variance by Ranks (Siegel, 1956). Thus a significant Kruskal-Wallis H value would indicate global differences in trend among the AB profiles.

With k-1=3 degrees of freedom, the Kruskal-Wallis test indicated significant differences in the slopes of the linear trends of the four groups, $H=18.31$, $p < .001$. The results of a priori comparisons employing the Mann-Whitney U test indicated that Group RC chose the C-arm a larger number of times than Group RP chose the P-arm across the four blocks of trials, $U=151$; $p=.0023$. In addition, Group NRC chose the C-arm a larger number of times than Group NRP chose the P-arm, $U=173.5$; $p=.0091$.

EXTINCTION

First Extinction Trial

Group NRP and Group RP Ss chose the P-arm to a significant extent, $t(23)=3.24$; $p < .01$, $t(23)=3.73$; $p < .01$, respectively. In addition, Group NRC and Group RC Ss chose the C-arm to a significant extent, $t(23)=4.12$; $p < .001$, $t(23)=4.51$; $p < .001$, respectively. Further analysis revealed a significant difference associated with greater percent choice of the C-arm by C-arm Ss, $t(94)=5.02$; $p < .001$.

Extinction Trials Combined

Reference to Fig. 12 suggested a diminution of percentage P-arm choice by Group NRP Ss. Statistical evaluation confirmed this

observation: Group NRP Ss failed to choose the P-arm significantly beyond the chance baseline for all extinction trials combined, $t(23)=1.37$; $p > .05$. Group RP Ss chose the P-arm to a significant extent, $t(23)=2.75$; $p < .01$. In addition, Group NRC and RC Ss chose the C-arm to a significant extent, $t(23)=2.55$; $p < .01$, $t(23)=3.33$; $p < .01$, respectively.

Chapter IV

DISCUSSION

The obtained findings in the initial between-S analysis of Sequence provided a partial replication of the Patten, Tyson & Johnson (1967) study. C-arm Ss ran slower on Trial 2 than Trial 1 with combined and stem latency measures. In addition, C-arm Ss ran slower on Trial 2 than P-arm Ss. The slower Trial 2 latencies of NRP and NRC (fixed sequence) Ss obtained with combined, stem and arm latency measures indicated that Sequence was a factor. This finding suggests that the influence of an arm alternation on Trial 2 (Groups RP and RC) precludes the slower latencies which would be expected on nonrewarded trials.

Comparisons of Group RP with Group RC indicated patterned running only for Group RC Ss. This finding suggests that even when C-arm Ss received half their second (N) trials in a different arm from that traversed on the first (R) trial, Trial 2 latencies remained slower than Trial 1 latencies with combined and stem running latency measures. Arm latency measures failed to differentiate between the two groups. If arm alternation on the second (N) trial was a factor in determining the lack of-patterning behavior in Group NRP of the Patten, Tyson & Johnson (1967) study, the present findings do not offer conclusive evidence of its (arm alternation) generality as an explanation.

Group NRP and Group NRC both showed patterned latencies with combined, stem and arm latency measures. This finding constitutes a discrepancy with Group NRP performance in the Patten, Tyson & Johnson (1967) study. Group NRP in that study did not show patterning behavior, i.e., Trial 2 latencies did not differ significantly from Trial 1 latencies.

The Within-S analysis evaluating same-arm vs. different-arm Trial 2 latencies within Groups RP and RC indicated that repetition was a factor in the determination of Trial 2 latencies, at least for RP Ss. The obtained finding of a Repetition effect for Group RP Ss suggested that stem latencies on different-arm trials were slower than stem latencies on same-arm trials. This tendency to run faster on same-arm trials than different-arm trials was consistent with the findings of a recent study by Naef & Johnson (1968). Two of their experimental groups (RRR and RLL; where R = right maze arm, L = left maze arm) were forced on Trial 3 to the same arm visited on Trial 2 with all three trials rewarded. The Trial 3 latencies of these two groups were faster than those of two experimental groups (RLR and RRL) allowed to alternate arms on Trial 3. If Repetition was a factor that influenced Trial 3 latencies in the Naef & Johnson study and Trial 2 latencies in the present study, its influence was in the opposite direction of that predicted by the SPA hypothesis. According to the SPA hypothesis Trial 2 latencies should increase on same-arm trials and decrease on different-arm trials.

The finding that Group RC Ss ran slower on Trial 2 than Trial 1 is consistent with single alternation schedules (one R-N transition) of reward. The slower Trial 2 latencies for Group RC could have been

due in part to S^N associated with the second (N) trial (Capaldi, 1967) and in part to repetition of the same arm as that traversed on Trial 1 during half the acquisition trials.

Comparisons of Trial 2 and Trial 3 latencies between Groups RP and RC revealed a consistent Trials effect for RC Ss. RC Ss had faster Trial 3 latencies than Trial 2 latencies. This was consistent with the Patten, Tyson & Johnson (1967) findings in accordance with the SPA hypothesis. RC Ss were running to a rewarded trial in a different arm from that visited on Trial 2.

Choice data obtained in the present study indicated that P-arm Ss did not choose the C-arm to a significant extent on the first and second acquisition test trials. This is discrepant with the Day 3 test trial findings of Patten, Tyson & Johnson (1967). C-arm Ss in the present study chose the C-arm to a significant extent on acquisition test trials as in Patten, Tyson & Johnson (1967). This initial tendency to choose the C-arm (although not significant with P-arm Ss) is consistent with the findings of studies utilizing a random sequence of N and R trials in a partial reward arm (Spear, 1964; Spear & Pavlik, 1966; Spear & Spitzner, 1967 a, b).

The increment in P-arm choice by RP and NRP Ss from the first acquisition test trial to the first extinction trial is an indicant that the C-arm choice tendency in P-arm Ss was a strong factor early in acquisition only. P-arm Ss chose the P-arm to a significant extent on the first extinction trial. These latter findings along with the fact that C-arm Ss (Groups NRC and RC) chose the C-arm to a significant extent on the first extinction trial indicate the determination of choice behavior by S^N. The tendency to choose the continuous reward

arm was reflected in the finding that with acquisition and extinction test trials (nonparametric analysis of trend) C-arm Ss chose the C-arm to a greater extent than P-arm Ss chose the P-arm. In addition, the extinction data in the present study reflected a less rapid diminution of S^N control (with the exception of NRP Ss) than the Patten, Tyson & Johnson (1967) data.

In general, the findings of the present study do not imply any definite conclusions concerning the influence of an arm alternation on nonrewarded trial latencies. The results do indicate that the effects of arm alternation in the selective learning situation cannot be overlooked when looking for patterning behavior within the framework of an aftereffects interpretation. Although not ubiquitous, the obtained findings are consistent with a revised aftereffects interpretation (Capaldi, 1967).

Chapter V

SUMMARY

A recent study by Patten, Tyson & Johnson (1967) indicated that the pattern of partial reward in one arm of a Y-maze affected the pattern of running latencies on rewarded and nonrewarded trials in a manner which suggested the operation of an arm repetition vs. arm alternation factor. Research using the straight runway has indicated that when reward and nonreward are alternated, Ss run rapidly on rewarded trials and slowly on nonrewarded trials (Capaldi, 1958; Tyler et al., 1953). Patten, Tyson & Johnson failed to obtain this running speed pattern in one group of Ss conditioned by aftereffects (S^N) to choose a partially rewarded arm on free-choice trials. Their Group NRP latency measures did not indicate a significant increase in latency on nonrewarded trials, although Group NRC exhibited the expected patterning behavior. Group NRP Ss ran to a different arm on nonrewarded trials while Group NRC Ss ran to the same arm on nonrewarded trials as that visited on the first (R) trial. Thus the arm alternation between first (R) and second (N) trials for Group NRP in the Patten, Tyson & Johnson (1967) study could account for the faster latencies on the second (N) trial.

The findings of the present study relevant to this specific problem as well as to the overall findings of Patten, Tyson & Johnson (1967) were as follows:

(1) a consistent tendency for C-arm Ss to run slower on Trial 2 (nonrewarded trial) than Trial 1.

(2) slower second trial (N) latencies for fixed-sequence Ss (Group NRP and Group NRC).

(3) slower latencies on different-arm trials than same-arm trials for Group RP Ss.

(4) faster latencies on the third (R) trial than the second (N) trial for Group RC Ss.

(5) a tendency to choose the arm associated with continuous reward over that associated with partial reward.

(6) the development of associative control over choice behavior by the aftereffects of nonreward.

BIBLIOGRAPHY

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.

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 Spence, K. W. & Spence, J. T. (Ed.), The psychology of learning and motivation, New York: Academic Press, 1967, pp. 67-156.

Capaldi, E. J., Hart, D., & Stanley, L. R. Effect of intertrial reinforcement on the aftereffect of nonreinforcement and resistance to extinction. Journal of Experimental Psychology, 1963, 65, 70-74.

Capaldi, E. J., & Spivey, J. E. Effect of goal-box similarity on the aftereffect of nonreinforcement and resistance to extinction. Journal of Experimental Psychology, 1963, 66, 461-465.

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

Dember, W. N., & Fowler, H. Spontaneous alternation behavior. Psychological Bulletin, 1958, 55, 412-428.

Douglas, R. J. Cues for spontaneous alternation. Journal of Comparative and Physiological Psychology, 1966, 62, 171-183.

Estes, W. K. & Schoeffler, M. S. Analysis of variables influencing alternation after forced trials. Journal of Comparative and Physiological Psychology, 1955, 48, 357-362.

Hull, C. L. A behavior system. New Haven: Yale University Press, 1952.

Naef, Regula & Johnson, R. S. An additional parameter in elutriating reasons for alternation behavior. Unpublished manuscript, University of Richmond, 1968.

Patten, R. L., Tyson, G. M. & Johnson, R. S. Conditioning the after-effects of non-reward to a specific response. Unpublished manuscript, University of Richmond, 1967.

Siegel, S. Nonparametric statistics. New York: McGraw-Hill, 1956.

Spear, N. E. Choice between magnitude and percentage of reinforcement. Journal of Experimental Psychology, 1964, 68, 44-52.

Spear, N. E. & Pavlik, W. B. Percentage of reinforcement and reward Magnitude effects in a T-maze: Between and within subjects. Journal of Experimental Psychology, 1966, 71, 521-528.

Spear, N. E., & Spitzner, J. H. PRE within Ss: Conventional effect on differential speeds, reverse effect on choices. Psychonomic Science, 1967a, 7, 99-100.

_____. PRE in a T-maze brightness discrimination within and between subjects. Journal of Experimental Psychology, 1967b, 73, 320-322.

Spence, K. W., Platt, J. R., & Matsumoto, R. Intertrial reinforcement and the partial reinforcement effect as a function of number of training trials. Psychonomic Science, 1965, 3, 205-206.

Still, A. W. Use of orthogonal polynomials with nonparametric tests. Psychological Bulletin, 1967, 68 (5), 327-329.

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, 37-65.

Walker, E. L., Dember, W. N., Earl, R. W., & Karoly, A. J. Choice alternation: I. Stimulus vs. place vs. response. Journal of Comparative and Physiological Psychology, 1955, 48, 19-23.

APPENDIX A

Summary Tables of Analysis of Variance

Table I Summary Table of Analysis of Variance of Log Transformed Combined Latencies for Trial 1 and Trial 2 of Acquisition for Treatment Groups Differing in Association and Sequence.

Source	df	ms	F	P
Between	107			
Association (A)	1	.60431	8.81175	<.01
Sequence (S)	1	.30211	4.40522	<.05
A x S	1	.24923	3.63415	
Pooled Error	104	.06858		
Within	108			
Trials (T)	1	1.17882	30.12574	<.01
A x T	1	.51117	13.06338	<.01
S x T	1	1.11351	28.45668	<.01
A x S x T	1	.02463		
Pooled Error	104	.03913		

Table II Summary Table of Analysis of Variance of Log Transformed Stem Latencies for Trial 1 and Trial 2 of Acquisition for Treatment Groups Differing in Association and Sequence.

Source	df	ms	F	P
Between	107			
Association (A)	1	.62259	18.96984	<.01
Sequence (S)	1	.14069	4.28672	<.05
A x S	1	.08834	2.69165	
Pooler Error	104	.03282		
Within	108			
Trials (T)	1	.74997	50.84542	<.01
A x T	1	.40036	27.14305	<.01
S x T	1	.48295	32.74237	<.01
A x S x T	1	.04013	2.72068	
Pooled Error	104	.01475		

Table III Summary Table of Analysis of Variance of Log Transformed Arm Latencies for Trial 1 and Trial 2 of Acquisition for Treatment Groups Differing in Association and Sequence.

Source	df	ms	F	P
Between	107			
Association (A)	1	.00025		
Sequence (S)	1	.02768	1.63400	
A x S	1	.04522	2.66942	
Pooled Error	104	.01694		
Within	108			
Trials (T)	1	.04673	4.35914	<.05
A x T	1	.00758	.70709	
S x T	1	.13305	12.41138	<.01
A x S x T	1	.00340		
Pooled Error	104	.01072		

Table IV Summary Table of Analysis of Variance of Log Transformed Combined Latencies for Trial 1 and Trial 2 of Acquisition for Treatment Groups Differing in Association under the Varied Level of the Sequence Factor.

Source	df	ms	F	P
Between	53			
Association (A)	1	.03477		
Pooled Error	52	1.39047		
Within	54			
Trials (T)	1	.00013		
A x T	1	.16386	7.89687	<.01
Pooled Error	52	.02075		

Table V Summary Table of Analysis of Variance of Log Transformed Stem Latencies for Trial 1 and Trial 2 of Acquisition for Treatment Groups Differing in Association under the Varied Level of the Sequence Factor.

Source	df	ms	F	P
Between	53			
Association (A)	1	.12821		
Pooled Error	52	.47849		
Within	54			
Trials (T)	1	.01604	1.39721	
A x T	1	.08510	7.41289	<.01
Pooled Error	52	.01148		

Table VI Summary Table of Analysis of Variance of Log Transformed Arm Latencies for Trial 1 and Trial 2 of Acquisition for Treatment Groups Differing in Association under the Varied Level of the Sequence Factor.

Source	df	ms	F	P
Between	53			
Association (A)	1	.02605		
Pooled Error	52	.24713		
Within	54			
Trials (T)	1	.01104	2.25306	
A x T	1	.01058	2.15918	
Pooled Error	52	.00490		

Table VII Summary Table of Analysis of Variance of Log Transformed Combined Latencies for Trial 1 and Trial 2 of Acquisition for Treatment Groups Differing in Association under the Fixed Level of the Sequence Factor.

Source	df	ms	F	P
Between	53			
Association (A)	1	.81486		
Pooled Error	52	1.89854		
Within	54			
Trial (T)	1	2.29187	9.26869	<.01
A x T	1	.38010	1.53719	
Pooled Error	52	.24727		

Table VIII Summary Table of Analysis of Variance of Log Transformed Stem Latencies for Trial 1 and Trial 2 of Acquisition for Treatment Groups Differing in Association under the Fixed Level of the Sequence Factor.

Source	df	ms	F	P
Between	53			
Association (A)	1	.58271		
Pooled Error	52	.69423		
Within	54			
Trials (T)	1	1.21688	9.67006	<.01
A x T	1	.35538	2.82406	
Pooled Error	52	.12584		

Table IX Summary Table of Analysis of Variance of Log Transformed Arm Latencies for Trial 1 and Trial 2 of Acquisition for Treatment Groups Differing in Association under the Fixed Level of the Sequence Factor.

Source	df	ms	F	P
Between	53			
Association (A)	1	.01942		
Pooled Error	52	.31457		
Within	54			
Trials (T)	1	.16874	5.52883	<.05
A x T	1	.00041		
Pooled Error	52	.03052		

Table X Summary Table of Analysis of Variance of Log Transformed Combined Latencies for Trial 1 and Trial 2 of Acquisition for Treatment Groups Differing in Association from the Varied Level of the Sequence Factor.

Source	df	ms	F	P
Between	53			
Association (A)	1	.02703		
Pooled Error	52	1.66016		
Within	162			
Repetition (B)	1	.00713		
A x B	1	.01100		
Pooled Error	49	.01309		
Trials (T)	1	.00325		
A x T	1	.20173	8.92216	<.01
Pooled Error	49	.02261		
B x T	1	.01174		
A x B x T	1	.04793		
Pooled Error	58	1.27752		

Table XI Summary Table of Analysis of Variance of Log Transformed Stem Latencies for Trial 1 and Trial 2 of Acquisition for Treatment Groups Differing in Association from the Varied Level of the Sequence Factor.

Source	df	ms	F	P
Between	53			
Association (A)	1	.13557		
Pooled Error	52	.81898		
Within	162			
Repetition (B)	1	.00842	6.28358	<.05
A x B	1	.00391	2.91791	
Pooled Error	49	.00134		
Trials (T)	1	.03633	1.64092	
A x T	1	.12854	5.80578	<.05
Pooled Error	49	.02214		
B x T	1	.01128	1.44061	
A x B x T	1	.04078	5.20817	<.05
Pooled Error	58	.00783		

Table XII Summary Table of Analysis of Variance of Log Transformed Arm Latencies for Trial 1 and Trial 2 of Acquisition for Treatment Groups Differing in Association from the Varied Level of the Sequence Factor.

Source	df	ms	F	P
Between	53			
Association (A)	1	.03700		
Pooled Error	52	.43002		
Within	162			
Repetition (B)	1	.00022		
A x B	1	.01046	1.79110	
Pooled Error	49	.00584		
Trials (T)	1	.03267	3.54723	
A x T	1	.06751	7.33008	<.01
Pooled Error	49	.00921		
B x T	1	.00000		
A x B x T	1	.00663	1.87288	
Pooled Error	58	.00354		

Table XIII Summary Table of Analysis of Variance of Log Transformed Combined Latencies for Trial 2 and Trial 3 of Acquisition for Treatment Groups Differing in Association from the Varied Level of the Sequence Factor.

Source	df	ms	F	P
Between	53			
Association (A)	1	.02462		
Pooled Error	52	1.32077		
Within	162			
Repetition (B)	1	.00913	1.12025	
A x B	1	.00010		
Pooled Error	49	.00815		
Trials (T)	1	.37096	7.52760	<.01
A x T	1	.20853	4.23153	<.05
Pooled Error	49	.04928		
B x T	1	.00946		
A x B x T	1	.01540	1.38864	
Pooled Error	58	.01109		

Table XIV Summary Table of Analysis of Variance of Log Transformed Stem Latencies for Trial 2 and Trial 3 of Acquisition for Treatment Groups Differing in Association from the Varied Level of the Sequence Factor.

Source	df	ms	F	P
Between	53			
Association (A)	1	.04749		
Pooled Error	52	.62238		
Within	162			
Repetition (B)	1	.00128		
A x B	1	.00004		
Pooled Error	49	.00828		
Trials (T)	1	.41509	7.12601	<.05
A x T	1	.25889	4.44446	<.05
Pooled Error	49	.05825		
B x T	1	.02634	2.13625	
A x B x T	1	.01761	1.42822	
Pooled Error	58	.01233		

Table XV Summary Table of Analysis of Variance of Log Transformed Arm Latencies for Trial 2 and Trial 3 of Acquisition for Treatment Groups Differing in Association from the Varied Level of the Sequence Factor.

Source	df	ms	F	P
Between	53			
Association (A)	1	.00257		
Pooled Error	52	.33689		
Within	162			
Repetition (B)	1	.00022		
A x B	1	.00157		
Pooled Error	49	.00242		
Trials (T)	1	.01378	3.99420	
A x T	1	.01399	4.05507	<.05
Pooled Error	49	.00345		
B x T	1	.00084		
A x B x T	1	.00034		
Pooled Error	58	.00264		

APPENDIX B

Acquisition Training Schedules and Running Latencies

Table 1. Training schedule of rewarded (R) and nonrewarded (N) trials.

		Group NRP		Group NRC	
Day	Trial	C-arm	P-arm	C-arm	P-arm
1	1	R			R
	2		N		N
	3		R	R	
2	1	R			R
	2		N		N
	3	free choice		free choice	
	4		R	R	
3-8	1	R			R
	2		N		N
	3		R	R	
9	1	R			R
	2		N		N
	3	free choice		free choice	
	4		R	R	
10-15	1	R			R
	2		N		N
	3		R	R	
16	1	R			R
	2		N		N
	3-8	six free choice extinction trials		six free choice extinction trials	

Table 2. Training schedule of rewarded (R) and nonrewarded (N) trials for the two groups of Ss receiving first-trial reward in both same and different arms.

		Group RP		Group RC	
Day	Trial	C-arm	P-arm	C-arm	P-arm
1	1	R or	R	R or	R
	2		N		N
	3		R	R	
2	1	R or	R	R or	R
	2		N		N
	3	free choice		free choice	
	4		R	R	
3-8	1	R or	R	R or	R
	2		N		N
	3		R	R	
9	1	R or	R	R or	R
	2		N		N
	3	free choice		free choice	
	4		R	R	
10-15	1	R or	R	R or	R
	2		N		N
	3		R	R	
16	1	R or	R	R or	R
	2		N		N
	3-8	six free choice extinction trials		six free choice extinction trials	

Table 3.

Running Latency
Group RC 1st Replication

	Trials	Day 13		Day 14		Day 15	
		Stem	Arm	Stem	Arm	Stem	Arm
R or R	1	.716	.56	.464	.22	.647	.28
N	2	.486	.36	.581	.27	.385	.32
R	3	.370	.28	.294	.18	.299	.21
RRLL, LLRR							
LRRL, RLRL							
R or R	1	.816	.52	.550	.45	.966	.29
N	2	.942	.42	.650	.47	.301	.30
R	3	.515	.51	.382	.31	.529	.21
RRLL, LRLR							
LRRL, LLRR							
R or R	1	.771	.32	.519	.28	.986	.30
N	2	.801	.32	.594	.32	.672	.38
R	3	.388	.22	.353	.31	.298	.29
RRLL, LLRR							
LRLR, LRRL							
R or R	1	.705	.34	1.435	.48	.919	.27
N	2	.509	.30	.865	1.11	9.481	1.01
R	3	.505	.30	.586	.40	.593	.33
RLLR, LRRL							
LLRR, RRLL							
R or R	1	.663	.34	1.044	.34	2.811	.23
N	2	6.689	.56	5.875	.46	8.447	.37
R	3	.683	.37	.756	.25	.676	.29
LLRR, RLRL							
LRLR, RRLL							
R or R	1	.437	.26	.485	.25	.444	.30
N	2	.428	.32	.397	.25	.343	.30
R	3	.334	.22	.307	.20	.259	.23
RLRL, LRLR							
RRLL, RLLR							

Table 4.

Running Latency
Group RC 2nd Replication

	Trials	Day 13		Day 14		Day 15	
		Stem	Arm	Stem	Arm	Stem	Arm
R or R	1	.811	.51	.379	.34	.593	.49
N	2	.538	.75	4.204	.52	.828	.66
R	3	.393	.44	.337	.44	.421	.39
RLLR, LRRL							
RLRL, LRLR							
R or R	1	1.015	.55	.749	.56	9.587	3.84
N	2	1.439	.75	3.237	2.84	5.664	.93
R	3	.975	.56	.757	.58	1.160	.70
RLRL, LRLR							
LLRR, RRLL							
R or R	1	.592	.53	.386	.25	.550	.27
N	2	.268	.36	.466	.27	.530	.49
R	3	.375	.18	.329	.21	.420	.22
RLRL, LRRL							
LLRR, LRLR							
R or R	1	1.273	.88	1.917	.79	1.758	.77
N	2	1.454	.64	1.847	.54	1.222	.84
R	3	.570	.70	.723	.64	.459	.72
LRLR, RRLL							
RLRL, LRRL							
R or R	1	.693	.55	.361	.48	.824	.79
N	2	2.288	.55	.962	.59	1.250	.82
R	3	.332	.47	.214	.37	.322	.51
LRLR, RLRL							
RRLL, LLRR							
R or R	1	.427	.56	.374	.48	.630	.94
N	2	.420	.60	.870	.56	.448	.48
R	3	.402	.47	.523	.42	.405	.46
RRLL, LRLR							
RLRL, LLRR							

Table 5.

Running Latency
Group RC 3rd Replication

	Trials	Day 13		Day 14		Day 15	
		Stem	Arm	Stem	Arm	Stem	Arm
R or R	1	.623	.64	2.061	.27	.613	.90
N	2	.663	.78	.784	.53	.732	.55
R	3	.267	.47	.432	.31	.348	.36
LRRL, RLLR							
LRLR, RLRL							
R or R	1	.540	.64	.478	.46	.850	.67
N	2	.321	.40	.425	.39	1.466	.40
R	3	.634	.35	.326	.42	.385	.40
RLLR, LLRR							
LRLR, RRLL							
R or R	1	1.149	.76	.505	.42	1.534	.70
N	2	2.724	.61	4.536	.45	8.867	.42
R	3	.371	.42	.431	.40	.667	.45
RLLR, RRLL							
LRRL, RLRL							
R or R	1	.450	.49	.350	.47	.809	1.08
N	2	.518	.48	.549	.44	.616	.69
R	3	.494	.53	.445	.49	.520	.67
LLRR, RRLL							
RLRL, RLLR							
R or R	1	2.429	.54	.452	.70	.943	.68
N	2	3.759	.45	.573	.38	.707	.47
R	3	.518	.53	.405	.44	.413	.54
RLLR, RRLL							
LRRL, LRLR							
R or R	1	.314	.45	.947	.59	2.048	.41
N	2	1.727	.61	.655	.41	1.483	.46
R	3	.329	.49	.316	.44	.367	.41
LRLR, RLRL							
LLRR, RLLR							

Table 6.

Running Latency
Group RC 4th Replication

	Trials	Day 13		Day 14		Day 15	
		Stem	Arm	Stem	Arm	Stem	Arm
R or R	1	.468	.48	.395	.42	.514	.38
N	2	.729	.60	.706	.54	.487	.46
R	3	.509	.39	.416	.47	.372	.43
LLRR, LRLR							
LRRL, RLLR							
R or R	1	.614	.56	.505	.52	.812	.44
N	2	.697	.54	.808	.55	.681	.56
R	3	.282	.51	.388	.35	.390	.30
RLRL, RLLR							
RRLL, LRRL							
R or R	1	.745	.88	2.419	.83	1.736	.65
N	2	2.768	.90	4.279	.97	1.100	.58
R	3	.797	.86	1.582	.67	.645	.63
RLRL, LRRL							
LLRR, LRLR							
R or R	1	.898	.45	.625	.38	.631	.58
N	2	2.183	.57	2.083	.50	.767	.39
R	3	.703	.65	.591	.78	2.061	.47
RLLR, RLRL							
LRRL, LLRR							
R or R	1	.438	.53	.766	.70	.371	.55
N	2	.493	.70	.563	.75	.504	.42
R	3	.346	.58	.371	.55	.335	.42
LRRL, RRLL							
RLLR, RLRL							
R or R	1	.751	.59	1.020	1.11	.744	.59
N	2	.545	.41	.612	.70	.705	.60
R	3	.399	.45	.480	.55	.410	.58
LRRL, RRLL							
RLLR, RLRL							

Table 7.

Running Latency
Group RP 1st Replication

	Trials	Day 13		Day 14		Day 15	
		Stem	Arm	Stem	Arm	Stem	Arm
R or R	1	3.653	.75	1.030	.52	4.125	.30
N	2	.620	.75	5.648	.34	.505	.21
R	3	.534	.55	.716	.24	.835	.23
LLRR, LRRL							
RRLL, RLLR							
R or R	1	3.711	1.25	2.011	1.90	1.707	.49
N	2	1.243	14.48	.515	.48	4.338	.38
R	3	9.085	.62	9.014	.51	.729	.30
LRLR, LLRR							
RLLR, RLRL							
R or R	1	1.766	.98	.881	1.90	.900	.49
N	2	.566	.56	.671	.38	.836	.36
R	3	.480	.44	.485	.29	.367	.21
RRLL, LLRR							
RLRL, RLLR							
R or R	1	.511	.65	.596	.30	.656	.30
N	2	.591	.70	.413	.34	.596	.25
R	3	.266	.42	.430	.24	.245	.19
RRLL, LLRR							
RLLR, LRRL							
R or R	1	.543	.70	.359	.38	.706	.34
N	2	.363	.54	.315	.40	.383	.22
R	3	.446	.76	.257	.39	.453	.34
RLLR, LRRL							
RRLL, LLRR							
R or R	1	.711	.48	.426	.58	.782	.31
N	2	.901	.50	.227	.22	.448	.22
R	3	.347	.38	.223	.19	.322	.21
RLLR, RRLL							
LRLR, LLRR							

Table 8.

Running Latency

Group RP 2nd Replication

	Trials	Day 13		Day 14		Day 15	
		Stem	Arm	Stem	Arm	Stem	Arm
R or R	1	2.572	1.29	1.839	11.54	1.821	.98
N	2	1.912	.91	1.781	.87	2.018	.85
R	3	1.864	1.70	2.318	.75	2.360	.88
RRLL, LRLR							
LLRR, RLRL							
R or R	1	.683	.88	.412	.73	.643	.88
N	2	.491	.64	.243	.47	.592	.59
R	3	.307	.71	.254	.52	.327	.53
RLLR, LRRL							
RLRL, LRLR							
R or R	1	.545	.70	.458	.82	.699	.73
N	2	.497	.51	.450	.62	.414	.97
R	3	.378	.70	.409	.52	.378	1.10
RLLR, LLRR							
LRRL, RLRL							
R or R	1	1.070	.80	.590	.40	.458	.84
N	2	.995	.57	.272	.48	.272	.62
R	3	.400	.50	.229	.42	.325	1.05
LLRR, RLRL							
RRLL, RLLR							
R or R	1	.259	.58	.569	.59	.383	.38
N	2	.187	.60	.208	.51	.177	.51
R	3	.230	.56	.163	.51	.198	.54
LLRR, RLRL							
LRRL, LRLR							
R or R	1	.684	.73	.637	.84	.666	.49
N	2	.374	.55	.274	.58	.444	.47
R	3	.497	.67	.333	.56	.384	.37
LRLR, RRLL							
RLLR, RLRL							

Table 9.

Running Latency

Group RP 3rd Replication

	Trials	Day 13		Day 14		Day 15	
		Stem	Arm	Stem	Arm	Stem	Arm
R or R	1	.359	.52	.444	.47	.450	.45
N	2	.365	.37	.266	.51	.490	.50
R	3	.387	.46	.264	.43	.253	.50
LLRR, RRLL							
RLLR, LRLR							
R or R	1	.304	.40	.564	.77	.390	.51
N	2	.247	.37	.291	.59	.365	.45
R	3	.438	2.10	.250	.36	.843	1.12
LRRL, LLRR							
LRLR, RRLL							
R or R	1	.598	.69	.672	.55	.426	.48
N	2	.664	.46	.436	.43	.389	.49
R	3	.353	.48	.317	.44	.285	.41
RLRL, LLRR							
RLLR, LRRL							
R or R	1	.507	.46	.971	.74	.800	.78
N	2	.398	.67	.390	.65	.565	.53
R	3	.369	.58	.302	.37	.296	.52
RLLR, RRLL							
LLRR, LRRL							
R or R	1	.269	.53	.325	.35	.640	.55
N	2	.315	.43	.218	.30	.454	.44
R	3	.311	.47	.276	1.01	.344	.32
LRLR, LRRL							
RRLL, LLRR							
R or R	1	.292	.41	.539	.44	.532	.40
N	2	.093	.47	.271	.35	.450	.39
R	3	.379	.50	1.087	.77	9.748	9.66
RLRL, RLLR							
LRRL, LLRR							

Table 10.

Running Latency
Group RP 4th Replication

	Trials	Day 13		Day 14		Day 15	
		Stem	Arm	Stem	Arm	Stem	Arm
R or R	1	.703	.49	.797	.30	.374	.30
N	2	.337	.62	.433	.45	.326	.36
R	3	.194	.42	.315	.39	.230	.28
LRRL, LLRR							
RLRL, RLLR							
R or R	1	.469	.60	.702	.83	.495	.52
N	2	.789	.60	.500	.46	.332	.39
R	3	.957	.57	.549	.32	.555	.45
LLRR, LRLR							
RLLR, LRRL							
R or R	1	.409	.69	.681	.74	.491	.64
N	2	.314	.47	.604	.47	.470	.45
R	3	2.078	.71	2.690	.61	1.706	.50
RLRL, RRLL							
RLLR, LRLR							
R or R	1	2.499	2.49	5.445	3.50	2.982	.53
N	2	6.514	.60	2.470	1.37	2.602	.31
R	3	2.744	.80	2.606	.50	2.148	.33
LRRL, RLRL							
RRLL, LLRR							
R or R	1	.574	.65	.512	.71	.444	.65
N	2	.400	.68	.458	.61	.392	.58
R	3	.332	.40	.399	.50	.311	.42
RLLR, LRLR							
RLRL, LRRL							
R or R	1	.812	.67	.803	.80	.825	.60
N	2	.494	.59	3.397	.71	1.657	.73
R	3	.317	.54	.368	.56	.376	.50
LLRR, RLRL							
LRRL, LRLR							

Table 11.

Running Latency

Group NRC 1st Replication

		Trials	Day 13		Day 14		Day 15	
			Stem	Arm	Stem	Arm	Stem	Arm
	R	1	.485	.37	.996	.35	.857	.47
	N	2	1.503	.44	9.329	.57	4.118	5.40
R		3	.714	.39	1.782	7.45	1.275	.39
	R	1	3.219	.36	.805	.30	.565	.34
	N	2	2.951	.40	9.349	.29	9.598	.59
R		3	1.594	.31	.536	.39	.880	.86
	R	1	1.535	1.00	1.524	.51	.854	1.05
	N	2	1.435	.53	1.729	.60	4.098	1.30
R		3	.954	3.00	.936	.50	4.064	.46
R		1	.512	.29	1.027	1.31	1.460	1.27
N		2	9.008	1.04	9.323	8.47	1.149	6.90
	R	3	1.639	6.90	4.032	1.27	1.160	.53
R		1	1.828	1.75	1.590	.25	1.022	1.70
N		2	3.891	1.69	1.133	.27	1.455	1.40
	R	3	1.102	.76	.983	.39	.771	.57
R		1	1.25	.59	1.279	.52	.856	.47
N		2	9.025	.55	5.748	1.10	5.337	1.70
	R	3	.580	.49	.506	.27	.566	.48

Table 12.

Running Latency

Group NRC 2nd Replication

		Trials	Day 13		Day 14		Day 15	
			Stem	Arm	Stem	Arm	Stem	Arm
	R	1	.420	.51	.314	.64	.284	.42
	N	2	9.450	10.69	3.721	.60	4.215	.60
R		3	.334	.60	.316	.60	.315	.54
	R	1	1.298	1.15	.536	.65	2.070	.62
	N	2	2.396	.75	1.746	.49	1.086	.70
R		3	1.345	2.30	1.738	.94	.752	.75
	R	1	.801	.90	.733	.54	.977	.64
	N	2	8.894	5.44	1.603	.56	9.950	.50
R		3	1.369	1.13	2.757	1.94	1.313	1.03
R		1	.437	.79	.260	.50	.294	.46
N		2	1.171	.70	1.287	.61	.979	1.58
	R	3	.811	.65	.505	.65	.466	.55
R		1	.457	.51	.507	.47	.411	.62
N		2	1.245	.70	.746	.58	.703	.45
	R	3	.554	.62	.492	.51	.414	.55
R		1	.784	.65	.546	.66	.391	.50
N		2	.741	.65	4.042	.55	6.675	1.12
	R	3	.332	.75	.453	.45	.451	.74

Table 13.

Running Latency
Group NRC 3rd Replication

		Trials	Day 13		Day 14		Day 15	
			Stem	Arm	Stem	Arm	Stem	Arm
	R	1	.553	.26	.599	.32	.566	.48
	N	2	7.255	.54	.905	.24	8.900	.45
R		3	.415	.31	.254	.29	.346	.50
	R	1	.642	.54	.632	.62	.432	.48
	N	2	1.813	.65	.971	.58	.379	.51
R		3	.517	.50	.440	.51	.321	.53
	R	1	.494	.61	.415	.73	.314	.30
	N	2	3.698	.67	1.456	.64	.585	.44
R		3	.361	.65	.433	.55	.386	.49
R		1	.567	.70	.687	.52	.833	.50
N		2	.403	.74	1.267	.60	.505	.66
	R	3	.487	.65	.403	.50	.473	.43
R		1	.641	.62	.551	.54	.600	.51
N		2	2.924	.62	.591	1.00	1.217	.48
	R	3	.497	.50	.404	.52	.321	.48
R		1	1.328	.47	.322	.49	.381	.46
N		2	.781	.79	1.089	1.55	.934	1.78
	R	3	.510	.62	.450	.66	.438	.50

Table 14.

Running Latency

Group NRC 4th Replication

		Trials	Day 13		Day 14		Day 15	
			Stem	Arm	Stem	Arm	Stem	Arm
R		1	.633	.44	.552	.32	.445	.26
N		2	5.629	.46	9.914	.40	9.888	.99
	R	3	.418	.70	.410	.76	.365	.59
R		1	2.305	.57	1.484	.55	1.598	.52
N		2	1.478	.76	2.419	.80	.979	.49
	R	3	1.198	.39	.769	.92	.384	.88
R		1	.480	.85	.228	.53	.260	.43
N		2	3.163	.45	.818	1.05	8.354	.39
	R	3	.353	.47	.333	.39	.256	.45
	R	1	.424	.48	.340	.58	.400	.61
	N	2	1.452	.71	4.108	.43	4.410	.41
R		3	.629	.28	.466	.37	.386	.43
	R	1	.556	.57	.671	.48	1.124	.97
	N	2	1.763	.55	1.224	.51	1.996	.68
R		3	.548	.59	4.050	.58	2.549	.63
	R	1	.585	.50	.608	.69	.536	.62
	N	2	2.830	.99	4.254	.65	4.404	.75
R		3	.446	.40	.395	.39	.359	.59

Table 15.

Running Latency

Group NRP 1st Replication

		Trials	Day 13		Day 14		Day 15	
			Stem	Arm	Stem	Arm	Stem	Arm
R		1	.486	.43	.324	.23	.259	.30
	N	2	.508	.36	.322	.24	.526	.35
	R	3	.351	.32	.280	.25	.263	.25
R		1	2.318	.32	1.343	1.40	.961	.23
	N	2	.703	.32	.530	.35	.398	.28
	R	3	.387	.43	.350	.28	.291	.34
R		1	.696	.27	.632	.25	.571	.27
	N	2	.678	.23	.377	.27	.449	.25
	R	3	.440	.19	.306	.32	.299	.24
	R	1	.301	.33	.365	.31	.363	.25
N		2	.383	.41	.285	.34	4.945	.31
R		3	.308	.19	.293	.19	.351	.21
	R	1	1.723	.40	.215	.32	.496	.27
N		2	.619	.45	.576	.41	.681	.30
R		3	.547	.28	.439	.22	.388	.20
	R	1	.564	.30	.421	.36	.565	.37
N		2	1.347	.22	.562	1.32	.318	1.45
R		3	.633	.44	.321	.36	.409	.46

Table 16.

Running Latency

Group NRP 2nd Replication

		Trials	Day 13		Day 14		Day 15	
			Stem	Arm	Stem	Arm	Stem	Arm
R		1	.228	.40	.443	.41	.374	.41
	N	2	.553	.60	2.798	.49	.643	.66
	R	3	.654	.50	.369	.42	.650	.62
R		1	.391	.50	1.200	.40	.496	.38
	N	2	1.000	.71	.547	.42	.724	.78
	R	3	.454	.44	.352	.46	.445	.53
R		1	.465	.75	.426	.49	.507	.58
	N	2	1.690	.71	2.606	.58	1.700	.48
	R	3	1.255	.55	.725	.48	.843	.46
	R	1	.616	.59	.516	.57	.450	.45
N		2	1.207	4.92	5.852	5.80	1.147	8.66
R		3	.737	.61	.701	.42	.672	.43
	R	1	.349	.52	.324	.62	.732	.48
N		2	.254	.49	.519	.40	.579	.42
R		3	.253	.55	.334	.48	.265	.40
	R	1	.263	.42	.335	.55	.301	.42
N		2	.291	.45	.651	3.32	.258	.43
R		3	.349	.66	.291	.70	.181	.37

Table 17.

Running Latency

Group NRP 3rd Replication

		Trials	Day 13		Day 14		Day 15	
			Stem	Arm	Stem	Arm	Stem	Arm
	R	1	.397	.50	.516	.75	.413	.45
N		2	.567	.44	.598	.52	.475	.45
R		3	.413	.44	.364	.69	.275	.34
	R	1	.367	.76	.709	.68	.632	.66
N		2	.208	.63	1.754	.80	.684	.56
R		3	.632	.62	.252	.52	.365	.44
	R	1	.440	.43	.355	.57	.246	.37
N		2	.461	.52	.496	.75	.272	.42
R		3	.267	.41	.488	.65	.216	.24
R		1	.533	.48	.250	.42	.260	.22
	N	2	.483	.31	.281	.25	5.702	.39
	R	3	.322	.33	.263	.24	.285	.26
R		1	.278	.50	1.055	.49	.557	.44
	N	2	5.765	.75	1.562	.53	.518	.44
	R	3	.716	.54	.497	.59	.359	.48
R		1	.395	.59	.415	.41	.422	.57
	N	2	.460	.63	6.331	10.00	1.209	16.25
	R	3	.300	.74	.244	.41	.262	.52

Table 18.

Running Latency

Group NRP 4th Replication

		Trials	Day 13		Day 14		Day 15	
			Stem	Arm	Stem	Arm	Stem	Arm
R		1	.443	.61	.472	.79	.354	.65
	N	2	.415	.59	.623	.62	.444	.69
	R	3	.484	.55	.368	.42	.366	.59
R		1	.322	.61	.893	.47	.750	.71
	N	2	.527	.57	.704	.49	2.831	.65
	R	3	.767	.63	.682	.84	.455	.98
R		1	.511	.48	.672	.46	.406	.68
	N	2	.377	.54	.436	.50	.309	.52
	R	3	.376	.49	.486	.56	.286	.46
	R	1	3.787	.97	6.209	.85	.846	.72
N		2	2.657	.90	1.876	.77	.594	.65
R		3	1.756	.30	1.743	.53	.432	.67
	R	1	1.149	.56	.588	.76	.668	.55
N		2	1.033	.95	.796	.41	.927	.39
R		3	.684	.45	.578	.29	.541	.41
	R	1	.983	.90	.514	.53	.420	.54
N		2	2.237	1.40	2.080	.71	.863	.72
R		3	.339	.51	.311	.47	.257	.45

VITA

Ronald Seymour Johnson, born on February 11, 1944, in Savannah, Georgia, attended Savannah High School. After graduating from SHS in 1962, he attended Shorter College through his sophomore year when he entered Wake Forest University majoring in Psychology. He was awarded the degree of Bachelor of Arts in June, 1966. In September, 1966, he began work toward the degree of Master of Arts in Psychology at the University of Richmond where he was initiated into Psi Chi in 1967. He expects to be awarded the Master of Arts degree in August, 1968. In September, 1968 he will begin teaching Experimental Psychology at Emory and Henry College.