A TEST OF THE FRUSTRATION EXPLANATION OF OLFACTORY CONTROL OF DOUBLE-ALTERNATION RESPONDING IN RATS

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A TEST OF THE FRUSTRATION EXPLANATION OF OLFACTORY CONTROL OF DOUBLE-ALTERNATION RESPONDING IN RATS

An Abstract

Presented to

the Graduate Council of

Austin Peay State University

In Partial Fulfillment

of the Requirements for the Degree

Master of Arts

in Psychology

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by

Ava Jean Howard

August, 1978

ABSTRACT

Three groups of rat subjects were used in a two-phase study designed to examine the frustration explanation of olfactory control of double-alternation responding. In the first and second phases, all groups of subjects received a 32% sucrose solution on reward trials. For nonreward trials, in the first phase, one group of subjects received a 3% sucrose solution, a second group received water, while a third received nothing. On nonreward trials in the second phase, those subjects who had received a 3% sucrose solution received nothing, and those who had received nothing in the first phase received a 3% sucrose solution. The nonreward conditions remained the same for the second group of subjects.

Results of statistical analyses showed that appropriate patterning developed most strongly during Phase I in the goal section for the subjects receiving nothing on nonreward trials. Patterning for this group was also shown in the start and run measures during Phase I. In Phase 2, patterning developed in the goal section for those subjects who had formerly received a 3% sucrose solution, but in this phase, received nothing. The results found in this study are partially supportive

of the frustration interpretation of olfactory control of double-alternation responding.

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August, 1978

To the Graduate Council:

I am submitting herewith a Thesis written by Ava Jean Howard entitled "A Test of the Frustration Explanation of Olfactory Control of Double-Alternation Responding in Rats." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Arts, with a major in Psychology.

Stephen F. Glass
Major Professor

We have read this thesis and recommend its acceptance

Cyril J. Sadowski
Second Committee Member

Garland E. Blair
Third Committee Member

Accepted for the Council

William H. Ellis
Dean of the Graduate School

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CHAPTER I

INTRODUCTION

Those conducting animal-learning studies have typically assumed that the performance of one subject had no bearing upon the performance of subsequently tested animals. However, McHose and Ludvigson (1966) reported the development of differential responding in nondifferentially rewarded control subjects. To explain this unusual phenomenon, McHose and Ludvigson (1966) postulated that distinctive odors had been exuded by previously run animals receiving differential reinforcement. These odors, in turn, served as discriminative cues for the control subjects. Ludvigson and Sytsma (1967) supported this prediction by demonstrating that animals could learn a double-alternation pattern of reward (R)-nonreward (N) under odor-maximizing conditions, but not under odor-minimizing conditions. Ludvigson and Sytsma (1967) further suggested that the most salient odor cues appeared to be those associated with frustrative or nonreward events. It needs to be made clear, though, that patterning was due to odor cues left by prior animals, not frustration, per se. This fact was clearly demonstrated by the squad of subjects run under

odor-minimizing conditions by Ludvigson and Sytsma (1967). Prerequisite conditions for the development of frustration (i.e., an expectancy of reward followed periodically by nonreward events) were in effect. However, patterning failed to develop due to the lack of predictability of odor cues. Other studies (e.g., Bloom and Phillips, 1973; Prytula, Lawler, and Davis, 1975) have reported that patterning is eliminated and/or does not develop when runway air is exhausted by a fan. As the prerequisites for frustration would certainly not be influenced by this particular manipulation, the odor-cue basis of this phenomenon appears quite well founded.

Subsequent to the Ludvigson and Sytsma (1967) publication, an impressive amount of data supportive of the "odor hypothesis" has been accumulated. Within this body of data, two main trends appear to have emerged.

The first trend has concentrated upon demonstrating a discriminative-cue role for such odors. Several investigations (e.g., Bloom & Phillips, 1973; Davis, Prytula, Harper, Tucker, Lewis & Flood, 1974; Ludvigson, 1969; Ludvigson & Sytsma, 1967; Prytula & Davis, 1974, 1976; Seago, Ludvigson & Remley, 1970) have reported data supportive of this function in the double-alternation situation.

Beginning with the Ludvigson and Sytsma (1967) and Ludvigson (1969) studies, the hypothesis that rats exude odors which can serve as powerful sources of contamination among treatments or among subjects within a treatment was supported. In the Ludvigson (1969) study, rats received reward and nonreward in double-alternation sequences, with these sequences being varied among members of a squad. It was shown that differential odors given off by preceding subjects on reward and non-reward trials could serve as discriminative cues signalling reward or nonreward. It was also shown that an odor cue from the immediately preceding trial could be neutralized by prior odors of the other kind.

The study by Davis, et al., (1974) was a drive-state dependency study. To elaborate, two groups of rats were used, one group serving as startbox odor donors, and the other as run animals actually traversing the runway. Three phases were used. During the first two phases the run subjects were water reinforced, and the odor donors food reinforced. During the first phase, the reinforcement schedules for the run and donor-odorant subjects were positively correlated, but negatively correlated during the second phase. Both groups were food reinforced and the schedules

were positively correlated in the third phase. The investigators found that significant double-alternation patterning was shown by the run subjects in the goal measure during Phases 1 and 2, but during Phase 3, significant patterning was shown in start, run and goal measures.

The lack of patterning in the start and run measures during Phases 1 and 2 and the establishment of such patterning during Phase 3 indicated the presence of two odor sources; odors exuded in the goalbox by previous run subjects, and odors exuded in the startbox by previous donor subjects. The results further indicated that the donor-subject odors were not effective determinants of behavior unless the deprivation states of the two groups coincided.

The two sources of odor mentioned above were also investigated by Prytula and Davis (1974, 1976). The Prytula and Davis (1974) data indicated that performance in the initial segments of the apparatus depended upon odors produced by startbox-confined donor subjects, while in the terminal segment, performance depended upon odors produced by previously run subjects. Prytula and Davis (1976) reported the results of two experiments. Odor-donor cues were present in the startbox in Experiment 1

and led to the development of significant double-alternation patterning in start, run and goal measures. A shift in the odor-donor reward-nonreward schedule to anything less than perfect correspondence with that of the run subjects led to an immediate and lasting disruption in start- and run-measure patterning. In Experiment 2 the locus of the odor-donor cues was moved to the middle of the run section of the apparatus. When the odor-donor and run-subject schedules were perfectly correlated, patterning developed only in the run and goal measures. As in the first experiment, a shift in the odor-donor schedule resulted in a pronounced and lasting disruption of run-measure performance. These studies and the one reported by Prytula and Davis (1974) are important in demonstrating the importance of these two sources of odors that may be used as discriminative cues. Additionally, they point out clearly that odor-donor cues must be completely redundant and predictive of the run subject's goal events before they will be utilized as discriminative cues by the run subjects. It has also been shown that odors may serve as discriminative cues for single-alternation responding (Amsel, Hug & Surridge, 1969), and T-maze responding (Morrison & Ludvigson, 1970).

The second trend taken by odor research has been to investigate the possibility that reward and nonreward odors may serve as mild unconditioned stimuli for approach and avoidance responses, respectively. Supportive of this interpretation, Mellgren, Fouts and Martin (1973) reported data indicating that rats left the midportion of a three-compartment testing chamber significantly faster when the odor of nonreward was present. Rats tested with the odor of reward present were found to leave this compartment significantly slower. When no odor of any sort was present in the middle compartment, the subjects ran through the apparatus much more quickly than when there was an odor present (regardless of the kind of odor). Studies supportive of the unconditioned aversive nature of the odor of nonreward have also been reported (Collerain, 1978; Collerain and Ludvigson, 1977; Wasserman and Jensen, 1969). Wasserman and Jensen (1969) reported that subjects confronted with the odor of nonreward extinguished more rapidly than subjects not confronted by such odors. Collerain and Ludvigson (1977) and Collerain (1978) demonstrated that subjects would perform a hurdle-jump response significantly faster to escape the odor of nonreward than subjects confronted by the odor of reward or a "neutral" odor (i.e., an odor

produced by an animal receiving neither reward nor nonreward).

Collerain and Ludvigson (1977) suggested that odor production could be directly linked to frustration, using Amsel's (1958) theory of frustration as a base upon which to build their interpretation. Basically, this theory postulates that frustration is produced when an organism is confronted by nonreward after receiving reward (i.e., after an expectancy for reward has been established). The amount of frustration elicited by the receipt of nonreward is further assumed to be a direct function of the magnitude of the reward (i.e., the magnitude of the expectancy of reward), and the number of times reward has been received (i.e., the strength of the expectancy of reward). The hurdle-jump data reported by Collerain and Ludvigson (1977) and Collerain (1978) supported the proposal that the development of frustration was the basic condition underlying odor production.

It is interesting to note that to date, literally all odor studies have employed a nonreward condition in which <u>nothing</u> was present at the goal. In view of this, one would wonder what would happen if the subject was, in fact, confronted with <u>something</u> (albeit, quantitatively

or qualitatively less than the reward event) on non-reward trials. The present two-phase study was designed to investigate this problem. To accomplish this, three groups of subjects were employed. All groups received 1 ml of a 32% sucrose solution on reward trials, during both phases. Nonreward consisted of 1 ml of a 3% sucrose solution, 1 ml of water, and nothing for the three groups, respectively, during Phase 1. During Phase 2, subjects receiving 3% sucrose on nonreward trials in Phase 1 received nothing on nonreward trials, and subjects receiving nothing on these trials in Phase 1 were shifted to 3% sucrose. Subjects receiving water on nonreward trials in Phase 1 continued to receive water in Phase 2. The decision to employ a liquid reinforcer was dictated by two considerations: (1) previous studies (Davis et al., 1974, 1976; Mellgren et al., 1973) have shown this reinforcement modality to be effective in the production of odor cues, and (2) the qualitative dimensions (e.g., sweetness) can be easily manipulated without changing the quantity dispensed to the subject.

Based upon the frustration interpretation (Collerain & Ludvigson, 1977; Collerain, 1978), it would be predicted that maximum Phase 1 patterning would be shown by the subjects receiving nothing on nonreward. Attenuated

patterning would be predicted on the part of those subjects receiving sucrose and water on nonreward trials. It might be further anticipated that those subjects receiving sucrose on nonreward would show the weakest patterning. These predictions are based upon the assumption that the greatest discrepancy (i.e., greatest frustration and, hence, odor) between the expectation of reward and what is actually received on nonreward trials would occur for the group receiving nothing on nonreward events. Hence, a lesser amount of frustration would be predicted for the group receiving water on nonreward events, and even less frustration would be predicted for the group receiving 3% sucrose on nonreward. If the frustration interpretation is correct, an attenuation in patterning would be predicted during Phase 2 for the group shifted from nothing to 3% on nonreward trials, and an increase in patterning would be predicted for the subjects shifted from 3% to nothing on nonreward trials.

CHAPTER II

METHOD

Subjects

Twenty-one 90-day-old male albino rats, purchased from the Holtzman Co., Madison, Wis., were randomly distributed across three groups (n=7). The subjects were maintained on a 23-hour-water-deprivation schedule. The deprivation schedule was imposed one week prior to the start of the experiment and remained in effect for the duration of the experiment. All animals were housed in individual cages located in a separate room from that in which experimental testing took place. Purina laboratory chow was available on a free-feeding basis to all subjects.

Apparatus

A straight runway (11.4 cm wide, 12.7 cm high), having a gray startbox (28.1 cm), black run section (91.4 cm) and a black goalbox (30.5 cm) served as the experimental apparatus. Guillotine doors separated the respective sections. Start, run and goal times, produced by the activation of a microswitch, attached to the start door, and the interruption of a series of photoelectric cells located 15.2 cm, 92.4 cm and 116.8 cm beyond the start door were recorded on all trials. A sheet of

transparent plastic covered the top of the apparatus to prevent odors from dissipating.

Procedure

Coincidental with the initiation of deprivation, three equal groups 32-3(0), 32-W(W), 32-0(3) were randomly formed. Subjects in group 32-3(0) received one ml of a 32% sucrose solution on R trials and one ml of a 3% sucrose solution on N trials. Subjects in Group 32-W(W) received one ml of a 32% sucrose solution on R trials, and one ml of water on N trials. Subjects in Group 32-0(3) received a one ml solution of 32% sucrose on R trials, and nothing on N trials. During the N trials, the subjects were confined to the goalbox for 30 sec. before being removed. These conditions were in effect during Phase 1. During Phase 2, all subjects continued to receive one ml of the 32% sucrose solution on R trials. However, subjects that received 3% sucrose on N trials in Phase 1 received nothing on N trials in Phase 2. Subjects that received nothing on N trials in Phase 1 were shifted to 3% sucrose on N trials in Phase 2.

During pretraining, the four days immediately preceding Phase 1, all rats were handled and tamed on Days 1 and 2. On Days 3 and 4 of pretraining, each

subject received a 5-minute exploration period in the apparatus. During exploration periods, all photoelectric equipment was operative.

During both phases of the experiment, each rat received eight daily trials (4R and 4N) in a double alternation (RRNNRRNN) sequence. The procedure for running a trial was as follows: the appropriate subject was removed from the home cage and placed into the startbox. After a 3-second confinement period, the rat was allowed to traverse the runway. Phase 1 was 14 days (112 trials) in length, and Phase 2 was 7 days (56 trials) in length. All daily trials were administered to an entire group before other groups were run, with all subjects within a particular group receiving Trial 1 before 2, and so forth. Subjects were run in numerical order (1-7) within each group for the duration of the experiment. The order for running groups was cyclic, i.e., 1-2-3, 2-3-1, 3-1-2, 1-2-3, etc. All subjects received access to water for one hour following each daily experimental session.

CHAPTER III

RESULTS

Prior to analyses all latencies were reciprocated, and when multiplied by the appropriate constant, yielded speed scores in meters per second. For purposes of graphical presentation and analysis, the speed scores for the eight-trial, double-alternation sequence were combined in the following manner: the first two trials were averaged to yield an R composite score, the next two trials were averaged to yield an N composite score, and so forth. Mean start, run, and goal speeds for Groups 32-0(3), 32-W(W), and 32-3(0) are shown in Figures 1-3 respectively.

Phase I

Analysis of variance incorporating one between subject factor (Groups) and two within subjects factors (R vs. N, and Days) was performed on the speed data for each measure from Days 9-14 of Phase I [the point at which patterning appeared to have been established in the goal measure by Group 32-0(3)]. The results of the analyses for each runway segment will be presented separately. The Newman-Keuls procedure was used in all instances to test specific contrast effects.

Start. The Days, $F(8,120) = 8.54$, $p < .01$; R vs. N, $F(1,15) = 44.86$; and Groups by R-N interaction, $F(2,15) = 23.43$, $p < .01$, were found to be significant by the overall analysis of variance. This analysis is summarized in Table 1. Further investigation of the significant Days factor indicated that subjects started significantly ($p < .01$) faster on Days 8-10 than they did on Days 6 and 7. Starting speeds did not differ on Days 6 and 7. Simple main effects analysis of variance was used to probe the significant interaction, and indicated that the R vs. N factor was significant, $F(1,15) = 52.71$, $p < .01$, only for Group 32-0(3).

Run. The overall analysis of variance performed on the run measure speeds indicated that the Groups, $F(2,15) = 9.66$, $p < .01$; Days, $F(8,120) = 4.00$, $p < .01$; Groups by Days interaction, $F(16,120) = 4.67$, $p < .01$; Groups by R-N interaction, $F(2,15) = 27.64$, $p < .01$, effects were significant. This analysis is summarized in Table 2. Further analysis of the significant Groups effect indicated that Groups 32-W(W) and 32-3(0) did not differ but were running significantly ($p < .01$) faster than Group 32-0(3). Analysis of the significant Days effect indicated subjects were running faster ($p < .05$) on Day 12 than on Days 6-11 and Day 14.

Running speeds on Days 6-11 and 13-14 did not differ from each other. Simple main effects analysis of variance were used to probe the significant Groups by Days interaction, and indicated a significant ($p < .01$) Groups effect at Days 6-14. Further inspection indicated that Groups 32-3(0) and 32-W(W) ran significantly ($p < .01$) faster than Group 32-0(3) on all days. It also found that Group 32-3(0) ran faster than Group 32-W(W) on Day 10. Simple main effects analysis of the significant Groups by R-N interaction indicated that a significant R-N difference existed only for Group 32-0(3), $F(1,15) = 56.00$, $p < .01$. Further, simple main effects analyses indicated that significant R vs. N differences occurred at Day 8, $F(1,135) = 4.92$, $p < .05$; Day 9, $F(1,135) = 4.33$; Day 11, $F(1,135) = 10.67$, $p < .01$, and Day 14, $F(1,135) = 7.83$, $p < .01$.

Goal. Overall analysis of goal-measure speeds yielded significance for the Groups, $F(2,15) = 73.94$, $p < .01$; Days, $F(8,120) = 2.90$, $p < .01$; Groups by Days interaction, $F(16,120) = 2.70$, $p < .01$; R vs. N, $F(1,15) = 18.19$, $p < .01$; Groups by R-N interaction, $F(2,15) = 10.48$, $p < .01$; Days by R-N interaction, $F(8,120) = 2.25$, $p < .01$; and Groups by Days by R-N interaction, $F(16,120) = 2.25$, $p < .01$, factors. This

analysis is summarized in Table 3. Simple main effects analyses of the significant Groups by Days interaction yielded a significant ($p < .01$) Groups effect on Days 6-14. Further inspection of this effect indicated that Groups 32-3(0) and 32-W(W) were approaching the goal faster ($p < .01$) than Group 32-0(3) on Days 6-14. It was also found that Group 32-3(0) approached the goal significantly ($p < .05$) faster than Group 32-W(W) on Days 10 and 14. Simple main effects analyses of the significant Groups by R-N interaction indicated that a significant R vs. N difference occurred only within Group 32-0(3), $F(1,15) = 37.38$, $p < .01$. Further, simple main effects analyses of the significant Days by R-N interaction indicated that significant R vs. N differences were found on Days 6, 7-11, 13-14 ($p < .01$) and Day 12 ($p < .05$).

Phase 2

Analyses of variance, similar to those used for the Phase I data, were performed on the speed scores from Phase 2. No significant effects were found in the start and run measures. The Groups by R-N interaction was found to be significant, $F(2,15) = 7.50$, $p < .01$, in the goal measure. Further inspection of this interaction indicated that a significant R vs. N difference

was shown only by Group 32-3(0). The data for the start, run and goal measures are shown in Tables 4-6.

CHAPTER IV

DISCUSSION

The development of strong double-alternation patterning in the goal measure during Phase 1 is consistent with previous data (e.g., Ludvigson & Sytsma, 1967). The finding that such patterning was displayed only by Group 32-0(3) is somewhat surprising. It will be recalled that maximum patterning was expected to be shown by this group due to stronger frustration (i.e., odors) produced by the receipt of nothing on N trials. However, the occurrence of frustration was also predicted for Group 32-W(W), due to the contrast produced by the receipt of water on N trials. Hence, some patterning might have also been predicted for this group in the goal measure. As can be seen from Figure 3, this patterning did not develop. Also of interest was the fact that some (albeit weak) patterning was expected to occur for Group 32-3(0), due to frustration produced by the contrast of receiving a 3% sucrose solution on N trials. Again, this expectation was not supported by the data.

It is interesting to note that patterning in the start and run sections by Group 32-0(3) during Phase 2 was also shown. Previous data (e.g., Ludvigson & Sytsma, 1967; Prytula & Davis, 1974, 1976) have shown the

development of patterning only in the goal section, unless startbox-placed odor donors were employed. In explaining this discrepant finding, several points are worthy of consideration. First, goal-measure patterning was established quite rapidly (by Day 5) by Group 32-0(3) in the present study. Previous studies (e.g., Davis, et al., 1974; Prytula & Davis 1974; Davis, Prytula, Noble & Mollenhour, 1976) using food reward have reported that patterning was established somewhat later (e.g., Days 12, 8, and 10, respectively). This would suggest the possibility that odors in the present study, based upon water deprivation, may have been somewhat stronger than those produced by frustration of food reward in the previous studies. It seems reasonable to speculate that such stronger odors had a better chance of disseminating (albeit weakly) to the more remote sections of the apparatus, thus producing the patterning that was observed.

Based upon the Phase 1 data, the occurrence of patterning in Group 32-3(0) during Phase 2 is not surprising. As this group received nothing on N trials during Phase 2, frustration-generated odors should have been maximal. The fact that patterning was again established rapidly (by Day 7) lends additional support to the proposed "strength-of-odor" notion mention above.

The collapse of patterning in Group 32-0(3) would indicate that frustration elicited in Phase 1 by the receipt of nothing on N trials had been substantially, if not completely, eliminated by shifting the N events to the 3% sucrose level. The continued absence of patterning shown by Group 32-W(W) suggests that frustration-generated odor cues did not develop in these subjects over the course of the entire 168 trials.

In summary, the present data are at least partially supportive of the frustration-theory interpretation of the odor phenomenon. Odor-mediated responding was shown by Group 32-0(3), the group predicted to have the greatest amount of frustration on N trials. The lack of patterning on the part of Groups 32-W(W) (Phases 1 and 2) and 32-3(0) (Phase 1), suggests that the presence of some reinforcer on N trials was sufficient to preclude the development of frustration, hence, odors. Possibly if the substance received on N trials was made somewhat aversive, for example, through the addition of a substance such as quinine, a frustration reaction and associated odors might be produced.

REFERENCES

Amsel, A., Hug, J.J. & Surridge, C.T. Subject to subject trial sequence odor trials, and patterning at 24-h ITI. Psychonomic Science, 1969, 15, 787-793.

Bloom, J.M. & Phillips, J.M. Conspecific odors as discriminative stimuli in the rat. Behavioral Biology, 1973, 8, 279-283.

Collerain, I. Frustration odor of rats receiving small numbers of prior rewarded running trials. Journal of Experimental Psychology: Animal Behavior Processes, 1978, 4, 120-130.

Collerain, I.J. & Ludvigson, H.W. Hurdle-jump responding in the rat as a function of conspecific odor of reward and nonreward. Animal Learning & Behavior, 1977, 5, 177-183.

Davis, S.F., Prytula, R.E., Harper, W.E., Tucker, H.K., Lewis, C., & Flood, C. Double-alternation runway performance as a function of inter- and intra-reinforcement odor cues. Psychological Reports, 1974, 35, 787-793.

Davis, S.F., Prytula, R.E., Noble, M., & Mollenhour, M.N. Motivational specificity of the signal value of odor cues. Animal Learning & Behavior, 1976, 4, 407-410.

Ludvigson, H.W. Runway behavior of the rat as a function of intersubject reward contingencies and constancy of daily reward schedule. Psychonomic Science, 1969, 15, 41-43.

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. & Ludvigson, H.W. Differential conditioning with nondifferential reinforcement. Psychonomic Science, 1966, 6, 485-486.

Mellgren, K.L., Fouts, R.S. & Martin, J.W. Approach and escape to conspecific odors of reward and non-reward. Animal Learning & Behavior, 1973, 1, 129-132.

Morrison, R.R. & Ludvigson, H.W. Discrimination by rats of conspecific odors of reward and nonreward. Science, 1970, 167, 904-905.

Prytula, R.E. & Davis, S.F. Runway performance as a function of positively and negatively correlated olfactory cues. Psychological Reports, 1974, 35, 735-740.

Prytula, R.E. & Davis, S.F. The relationship between locus of odor cues and double-alternation responding in the rat. Animal Learning & Behavior, 1976, 4, 352-356.

Prytula, R.E., Lawler, S.M., & Davis, S.F. Odor-mediated double-alternation responding: A multiple-baseline reversal demonstration. Bulletin of the Psychonomic Society, 1975, 6, 181-184.

Seago, J.D., Ludvigson, H.W., & Remley, N.R. Effects of anosmia on apparent double alternation in the rat, Journal of Comparative and Physiological Psychology, 1970, 71, 435-442.

Wasserman, E.A. & Jensen, D.D. Olfactory stimuli and the "pseudo-extinction" effect. Science, 1969, 166, 1307-1309.

APPENDIX A: FIGURES

Fig. 1 - Mean Start Speeds

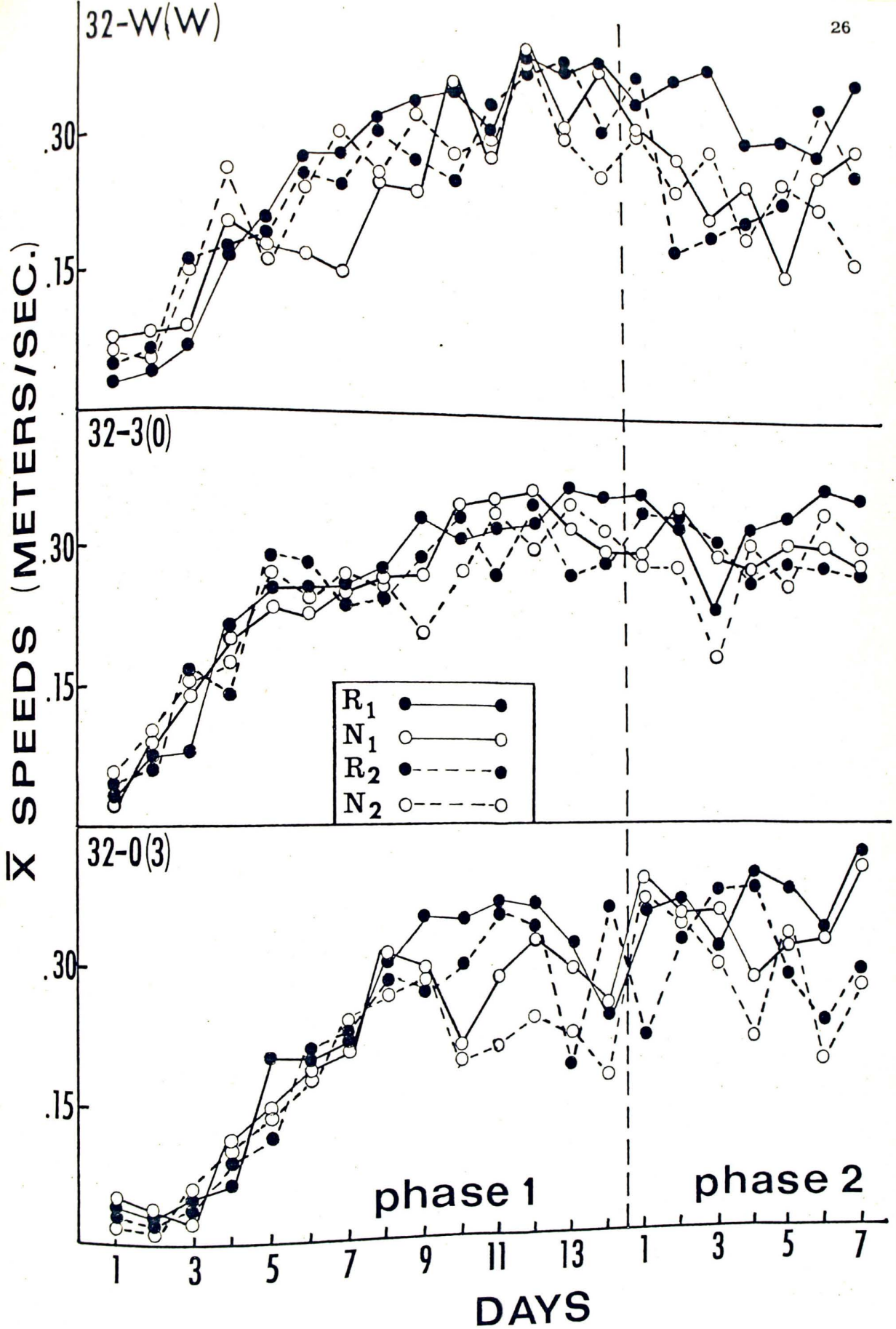

32-W(W)
32-3(0)
32-0(3)
.30
.15
$\bar{X}$ SPEEDS (METERS/SEC.)
R_1
N_1
R_2
N_2
phase 1
phase 2
1 3 5 7 9 11 13 1 3 5 7
DAYS

Fig. 2 - Mean Run Speeds

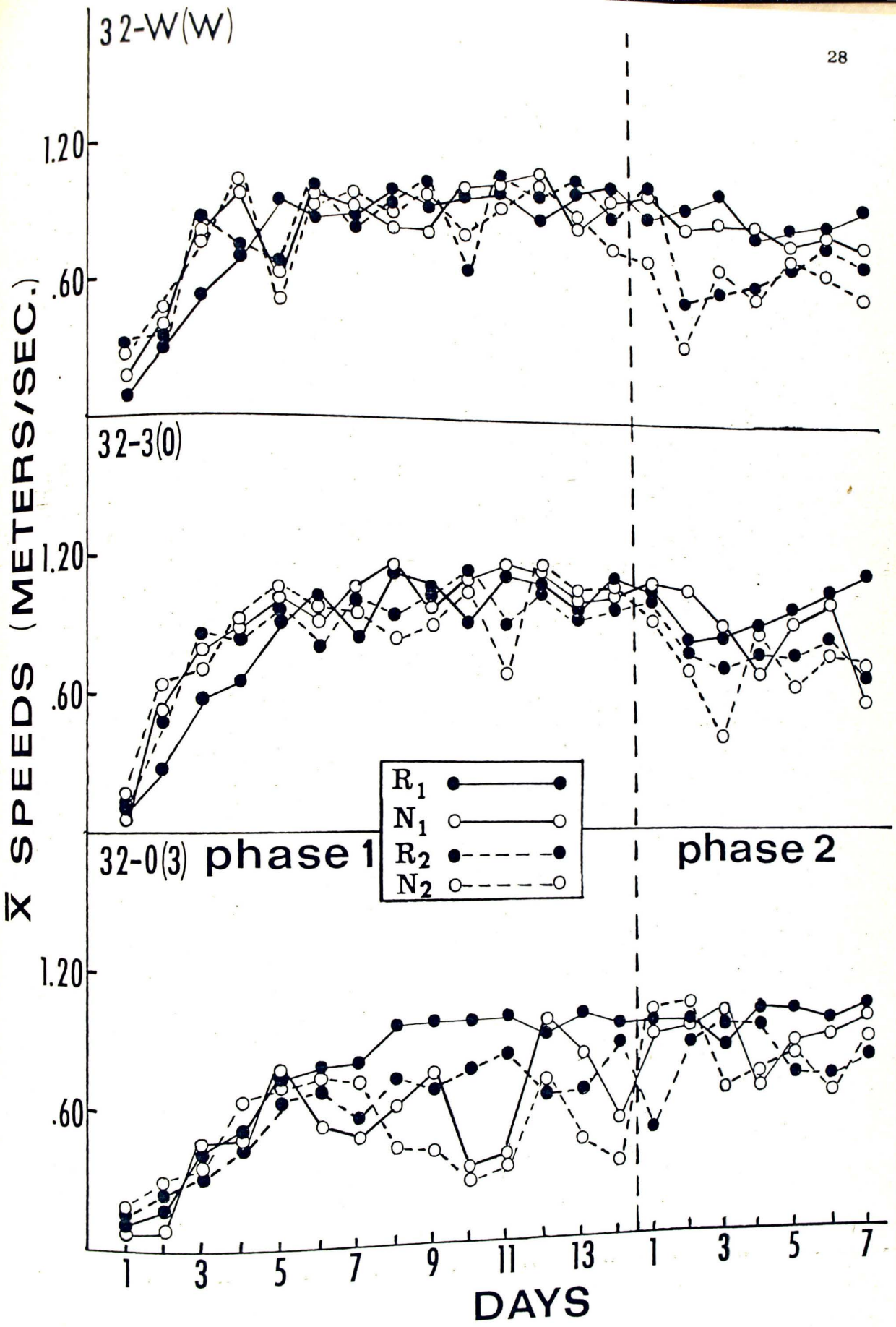
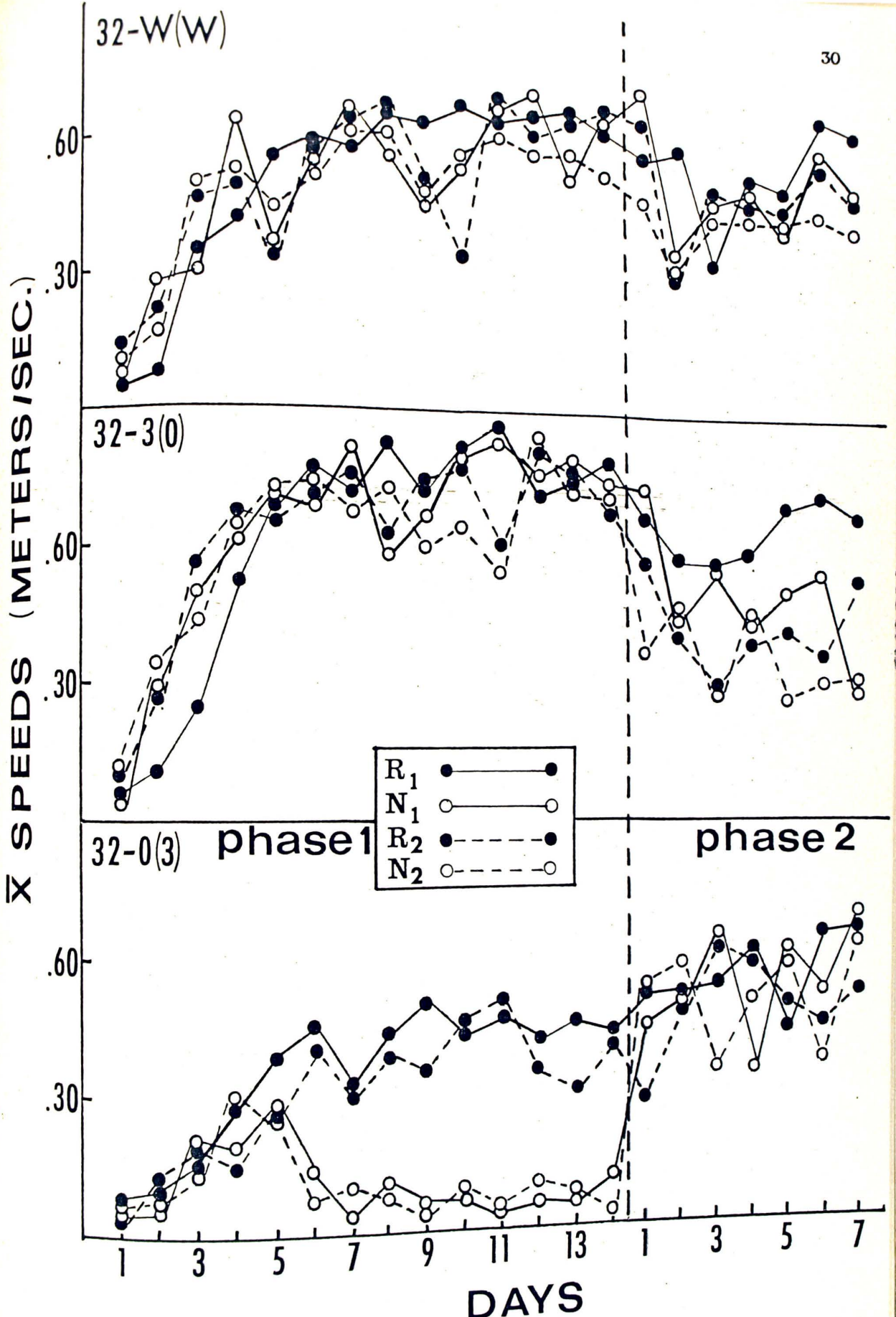

32-W(W)
32-3(0)
32-0(3)
phase 1
phase 2
R_1
N_1
R_2
N_2
1.20
.60
$\bar{X}$ SPEEDS (METERS/SEC.)
1 3 5 7 9 11 13 1 3 5 7
DAYS

Fig. 3 - Mean Goal Speeds


32-W(W)
32-3(0)
32-0(3)
.60
.30
$\bar{X}$ SPEEDS (METERS/SEC.)
R_1
N_1
R_2
N_2
phase 1
phase 2
1 3 5 7 9 11 13 1 3 5 7
DAYS

APPENDIX B: TABLES

TABLE 1

SUMMARY OF START DATA ANALYSIS OF VARIANCE - PHASE 1

Source	SS	df	MS	F
Between Subjects	28.94	17		
A (Groups)	7.79	2	3.90	2.77
Subjects within Groups	21.25	15	1.41	
Within Subjects	85.91	306		
B (Days)	17.76	8	2.22	8.54**
AB	5.99	16	.37	1.42
BxSubjects within Groups	31.33	120	.26	
C (R vs. N)	3.14	1	3.14	44.86**
AC	3.27	2	1.64	23.43**
CxSubjects within Groups	1.12	15	.07	
BC	.53	8	.07	.44
ABC	3.97	16	.25	1.56
BCxSubjects within Groups	18.50	120	.16	
Total	114.85	323		

**$p < .01$

TABLE 2

SUMMARY OF RUN DATA ANALYSIS OF VARIANCE - PHASE 1

Source	SS	df	MS	F
Between Subjects	35.64	17		
A (Groups)	20.09	2	10.05	9.66**
Subjects within Groups	15.55	15	1.04	
Within Subjects	31.56	306		
B (Days)	.97	8	.12	4.00**
AB	1.27	16	.14	4.67**
BxSubjects within Groups	3.13	120	.03	
C (R vs. N)	.12	1	.12	1.09
AC	6.08	2	3.04	27.64**
CxSubjects within Groups	1.61	15	.11	
BC	3.88	8	.49	4.08**
ABC	2.21	16	.14	1.17
BCxSubjects within Groups	14.65	120	.12	
Total	67.20	323		

**$p < .01$

TABLE 3

SUMMARY OF GOAL DATA ANALYSIS OF VARIANCE - PHASE 1

Source	SS	df	MS	F
Between Subjects	175.89	17		
A (Groups)	159.72	2	79.86	73.94**
Subjects within Groups	16.17	15	1.08	
Within Subjects	73.64	306		
B (Days)	2.30	8	.29	2.90**
AB	4.36	16	.27	2.70**
BxSubjects within Groups	12.08	120	.10	
C (R vs. N)	16.19	1	16.19	18.19**
AC	18.66	2	9.33	10.48**
CxSubjects within Groups	13.35	15	.89	
BC	.69	8	.09	2.25*
ABC	1.36	16	.09	2.25**
BCxSubjects within Groups	4.65	120	.04	
Total	249.53	323		

*$p < .05$ **$p < .01$

TABLE 4

SUMMARY OF START DATA ANALYSIS OF VARIANCE - PHASE 2

Source	SS	df	MS	F
Between Subjects	48.75	17		
A (Groups)	1.94	2	.97	.31
Subjects within Groups	46.81	15	3.12	
Within Subjects	78.78	234		
B (Days)	3.36	6	.56	1.65
AB	4.61	12	.38	1.12
BxSubjects within Groups	30.73	90	.34	
C (R vs. N)	.89	1	.89	2.78
AC	.80	2	.40	1.90
CxSubjects within Groups	4.85	15	.32	
BC	1.35	6	.23	.74
ABC	3.89	12	.32	1.03
BCxSubjects within Groups	28.30	90	.31	
Total	127.53	252		

TABLE 5

SUMMARY OF RUN DATA ANALYSIS OF VARIANCE - PHASE 2

Source	SS	df	MS	F
Between Subjects	22.05	17		
A (Groups)	.18	2	.09	.06
Subjects within Groups	21.87	15	1.46	
Within Subjects	8.93	234		
B (Days)	.30	6	.05	.63
AB	1.98	12	.16	1.78
BxSubjects within Groups	8.18	90	.09	
C (R vs. N)	.28	1	.28	2.33
AC	.17	2	.09	1.00
CxSubjects within Groups	1.74	15	.12	
BC	.09	6	.02	1.00
ABC	.12	12	.01	.50
BCxSubjects within Groups	1.89	90	.02	
Total	30.98	252		

TABLE 6

SUMMARY OF GOAL DATA ANALYSIS OF VARIANCE - PHASE 2

Source	SS	df	MS	F
Between Subjects	36.82	17		
A (Groups)	.70	2	.35	.15
Subjects within Groups	36.12	15	2.41	
Within Subjects	74.26	234		
B (Days)	2.82	6	.47	1.81
AB	4.99	12	.42	1.62
BxSubjects within Groups	23.04	90	.26	
C (R vs. N)	.61	1	.61	2.77
AC	3.29	2	1.65	7.50*
CxSubjects within Groups	3.37	15	.22	
BC	1.10	6	.18	.55
ABC	4.91	12	.41	1.24
BCxSubjects within Groups	30.13	90	.33	
Total	111.08	252		

*$p < .01$