

**MOTIVATIONAL SPECIFICITY OF THE SIGNAL  
VALUE OF ODOR CUES**



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MOTIVATIONAL SPECIFICITY OF THE SIGNAL VALUE OF ODOR CUES

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An Abstract  
Presented to  
the Graduate Council of  
Austin Peay State University

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In Partial Fulfillment  
of the Requirements for the Degree  
Master of Arts  
in Psychology

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by  
Mary Jo Cowdrey Noble

August 1975

## ABSTRACT

Two groups of ten rats served as subjects in a three-phase study of the production and utilization of odor cues in the runway. Both groups were trained under double-alternation patterns of reward-nonreward, with one group serving as start-box odor-donor subjects and the second group serving as run subjects that actually traversed the runway. During Phases I and II the run subjects were food-reinforced and the odor-donor subjects were water-reinforced. These phases differed only with regard to the sequence of trial administration. In Phase III both groups were water-reinforced. The double-alternation reinforcement schedules were positively correlated in all three phases. The results indicated that significant double-alternation patterning occurred only in the goal measure during Phases I and II. However, significant patterning was shown in all three measures in Phase III. These results suggest quite strongly that odor cues are deprivation-state dependent and are seen as being supportive of a biological-constraints interpretation.

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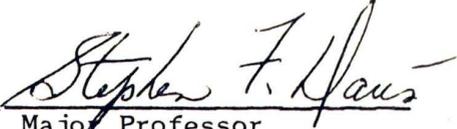
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by  
Mary Jo Cowdrey Noble

August 1975

To the Graduate Council:

I am submitting herewith a Thesis written by Mary Jo Cowdrey Noble entitled "Motivational Specificity of the Signal Value of Odor Cues". I recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Arts, with a major in Psychology.

  
Major Professor

We have read this thesis and recommend its acceptance:

  
Second Committee Member

  
Third Committee Member

Accepted for the Council:

  
Dean of the Graduate School

## ACKNOWLEDGMENTS

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TABLE OF CONTENTS

LIST OF FIGURES.....	Page vii
CHAPTER	
I. INTRODUCTION.....	1
II. METHOD.....	8
Subjects.....	8
Apparatus.....	8
Procedure.....	9
III. RESULTS.....	12
IV. DISCUSSION.....	14
BIBLIOGRAPHY.....	17
APPENDIX: FIGURES.....	19

LIST OF FIGURES

Figure	Page
1. Mean Start, Run, and Goal Speeds (meters per sec.) for the Run Subjects During Phases I and II.....	21
2. Mean Start, Run and Goal Speeds (meters per sec.) for the Run Subjects During Phase III.....	23

## CHAPTER I

### INTRODUCTION

Traditionally research in the area of animal learning has made the implicit assumption that the behavior of one animal in an experimental apparatus has no influence on the behavior of subsequent subjects in the same apparatus. Recently, however, an area of research has developed which has as its prime objective to delineate the effect of subject-emitted odor cues on the maze behavior of subsequent animal subjects. Pioneering work in this area (Ludvigson and Sytsma, 1967) established that rats exude potentially discriminable cues, primarily on nonrewarded trials, to subsequent subjects. The results of the Ludvigson and Sytsma (1967) study indicated that under odor-maximizing conditions a double-alternation pattern of responding could be learned, but not under an odor-minimized condition. These results strongly suggest that odors can, and probably have, served as a strong source of contamination in animal research for many years. Since the publication of the Ludvigson and Sytsma study in 1967, various studies have shown that odors can serve as discriminative cues that allow subjects to predict what kind of goal event will ensue. For example, Ludvigson (1969) reported results which suggested that differential odor cues from preceding subjects on reward (R) and nonreward (N) trials could serve discriminatively to signal R or N, unless prior odors of the other type had neutralized the odor cue from the immediately preceding trial.

In a study using mice, Davis (1970) found that the mice were able to learn a double-alternation sequence under conditions where odor cues were maximized, but not when the cues were minimized, a finding which approximated the results of the Ludvigson and Sytsma (1967) study which employed rats as subjects. A study by Means, Hardy, Gabriel, and Uphold (1971) reported the results of three experiments to test the adequacy of odor trials as discriminative cues in a T-maze. The first experiment showed that rats could select the arm entered by a reinforced subject when paper flooring (i.e., odor retention) was used and changed between pairs of subjects. Experiment II utilized essentially the same procedure, with the exception that a regular wooden floor was used throughout the trials. Here, however, the subjects did not display discriminative learning. Later the subjects on wooden floors were able to learn discriminations after the number of preceding rewarded subjects was increased from one to six (Experiment III). This led Means et al (1971) to conclude that discriminative odor trails were a weak odor cue, but sufficient to influence discrimination learning.

Using an unusually large number of subjects, two-hundred and twenty-five rats, McHose (1973) tested for preference of reward, nonreward, or neutral odor trails. The findings from this study revealed that preference to a particular odor trail depended largely on previous schedule of reward training. Rats that had been continuously reinforced with a constant reward value preferred R to N odors, while subjects that received partial or varied reward training, or downward shifts in reward

amount did not. These findings, although detracting somewhat from the generality of the odor hypothesis, offer further evidence of the effect of odor on research due to the emphasis placed on previous reinforcement history.

A study by Prytula and Davis (1974) indicated that double-alternation runway performance can be influenced by two sources of odor: 1) odor cues from donor-odorant subjects (i.e., subjects placed directly into the apparatus); and 2) odor cues from previous subjects that have actually traversed the runway. The results of this study indicated that in the initial segments (i.e., start and run measures) performance depended upon odor cues from donor subjects confined in the start box. However, performance in the terminal segment (i.e., goal) of the apparatus was primarily influenced by odor cues from previous runway-trained subjects.

A two-phase study conducted by Prytula and Payne (1974) revealed findings similar to those of a study previously reported by Bloom and Phillips (1973) dealing with the intensity of odor cues. Bloom and Phillips (1973) found that double-alternation patterning would develop among subjects when the air in the runway was not being exhausted by a fan, but would not develop when the air was exhausted. Prytula and Payne (1974) employed two identically trained groups of subjects, the only difference in procedure being that one group was trained and extinguished under an odor-intensified (fan blocked) condition, while the second group was trained and extinguished under an odor-reduced (fan open) condition. The results revealed that subjects trained

under odor intensification discriminated the reward-nonreward schedule perfectly and were less resistant to extinction than subjects trained under odor reduction. The Bloom and Phillips (1973) study had also indicated that extinction occurred more rapidly following the odor intensifying condition.

From another aspect of the odor hypothesis, studies have been conducted which indicate that odors of reward may elicit unconditioned approach responses while odors of nonreward may elicit avoidance responses. Wasserman and Jensen (1969) found that experimental extinction utilizing electric shock produced the emission of an olfactory stimulus which can be discriminated by a subsequently run subject, and which, further, elicited behavior that interfered with running for food reward. Similar behaviors were observed by Mellgren, Fouts, and Martin (1970), and by Prytula and Davis (1974), through negatively correlating the R and N conditions of the donor-odorant subjects with those of the run subjects. Due to an apparently more potent odor being exuded by a frustrated donor-odorant subject in the start box, the run subject appears to be escaping from the aversive odor and the alternation in responding is reduced.

Following from the fact that most research on odor production has used food reinforcement or nonreinforcement, with the exception of the Mellgren et al (1973) study which utilized water, Davis and Prytula, Harper, Tucker, Lewis, and Flood (1974) devised a study to test the effects of inter- and intra-reinforcement cues. In this three-phase study, the runway trained

subjects during the first two phases of the study were water reinforced and the donor-odorants were food reinforced. In the third phase both groups were food reinforced. The results of this study indicated that appropriate double-alternation was shown by the run subjects during the first two phases only in the goal section of the apparatus. However, when the deprivation state of the donor-odorant subjects was shifted to coincide with that of the run subjects (Phase III) the run subjects displayed double-alternation patterning in all segments of the apparatus. Thus, it would appear that the only odor cues utilized by the run subjects during Phases I and II were those odors emitted by previous run subjects. However, during Phase III it would appear that both run-subject and donor-odorant cues were attended to by the run subjects. Therefore, an important generalization suggested by the Davis, et al (1974) study was that odor-donor cues are utilized as discriminative cues only when the deprivation states of both the run and donor subjects coincide. Obviously, research of this nature has important ramifications in the general area of drive-state discrimination, and more specifically for theories of learning that incorporate drive-stimulus notions (e.g., Hull, 1943, 1952; Spence, 1956, 1960). If different drives can, in fact, be discriminated, then it would be possible for the underlying stimuli associated with these drives to enter into the stimulus control of the instrumental response. Although some reports (e.g., Amsel, 1949; Levine, 1953) have indicated that drive discrimination is possible, the question of drive specificity,

and hence, drive discrimination, is still replete with failures to obtain predicted results (see Manning, 1956).

The present study was designed to be a partial replication of the Davis et al (1974) study. It will be recalled that these investigators employed two groups of subjects: odor-donors placed in the start box, and runway trained subjects. As already noted, significant double-alternation patterning was shown by the runway trained subjects only in the goal measure when the deprivation states of these two groups differed (i.e., odor-donor subjects were food deprived and run subjects water deprived). Further, it was shown that a shift in the odor-donor reinforcement schedule had no effect on the performance of the run subjects when the deprivation states differed. However, when the deprivation states were made similar (i.e., both groups placed on food deprivation) significant double-alternation patterning was displayed in all segments of the apparatus. As in the Davis, et al (1974) study, the present experiment utilized three phases, however, unlike the Davis et al (1974) study the odor-donor subjects were water deprived and the run subjects food deprived during the first two phases. All subjects were water deprived during the third phase. A second difference concerned the reinforcement schedule employed during phase two. Unlike the Davis et al (1974) study in which the odor-donor and run subjects reward schedules were negatively correlated during the second phase, during the present study reward schedules for both the odor-donors and the run subjects were reversed (i.e., NNRRNNRR). Obviously, this study would

appear to be of considerable importance on several counts. First, it was designed to provide additional information concerning the production and utilization of odor cues. Second, if results similar to those obtained by Davis et al (1974) are found, this would lend support to the position taken by these authors that odor cues are, in fact, deprivation-state dependent. Third, if the deprivation-state dependence of odor cues is demonstrated, this would lend support to the drive-discrimination position mentioned above, and, in turn, lend support to traditional learning theories that emphasize such a mechanism.

## METHOD

Subjects

Twenty male albino rats, approximately ninety days old at the beginning of the experiment were purchased from the Holtzman Company, Madison, Wisconsin, and served as subjects. Upon arrival the subjects were randomly assigned to two equal groups; Odor-Donor and Run. Seven days before the start of the experiment the Odor-Donor subjects were placed on a 23-hour water deprivation schedule while the Run subjects were placed on a food deprivation schedule which maintained them at 85% ad lib. body weight. These deprivation schedules continued in effect during Phases I and II. During Phase III all subjects were maintained on the water deprivation schedule. Water or food was available to the food-deprived and water-deprived subjects, respectively, on an ad lib. basis in the home cage. Maintenance of the deprivation schedule took place following the daily experimental session.

Apparatus

The apparatus was a single straight runway, divided into a gray start box, a black run section, and a black goal box. Start, run, and goal times were recorded on all trials after the interruption of a series of photoelectric cells and the activation of a microswitch located on the start door. A plastic receptacle fitted into the end wall of the goal box served as the goal cup. During Phase III the goal cup was

modified to allow the external attachment of a  $\frac{1}{2}$  pint water bottle, with the sipper tube of the water bottle projecting slightly into the apparatus when the bottle was in place. During all three phases, a water bottle, attached externally to the side of the start box with the sipper tube extending slightly into the start box was employed.

### Procedure

The experiment proper was preceded by a five-day pretraining phase. At the beginning of pretraining, each subject was assigned a permanent identifying number (1 to 10) within his respective group. On the fourth and fifth days of pretraining each Run subject received a five minute exploration period in the unbaited apparatus. The Odor-Donor subjects received additional handling and taming on these days. During all five pretraining days the Run subjects received pellet-habituation to the 500 mg Noyes reward pellets in the home cage (Days 1-3) and in the goal box (Days 4-5).

During all three phases of the experiment proper, all subjects received eight trials, four reward (R) and four non-reward (N), per day with all subjects completing trial one before trial two was begun, etc. The order for running subjects was randomized each day. During Phase I (96 trials) and Phase III (88 trials), both the Run subjects and the Odor-Donor subjects received their eight daily trials in an RRNNRRNN sequence. In Phase II (24 trials), both groups received their eight daily trials in an NNRRNNRR sequence. During all three phases the reinforcement schedules were positively correlated,

but deprivation states were positively correlated (i.e., both groups were water deprived) only in Phase III. Phase II reversed the sequence of R and N events, yet maintained the positive correlation.

Running a trial during Phases I and II involved placing the proper Odor-Donor subject (i.e., Odor-Donor 1 was used when Run subject 1 was to be run, etc.) directly into the start box. (A full water bottle was in place on an R trial and an empty bottle in place on an N trial.) The Odor-Donor subject was then removed from the start box after a thirty-second confinement period had elapsed, and the appropriate Run subject placed immediately into the start box. At the end of a ten-second confinement period, the Run subject was allowed to traverse the runway. On reward trials the Run subject received a 500 mg Noyes pellet. On nonreward trials the Run subject was confined to the goal box for 30 seconds.

A one-day period followed completion of Phase II and preceded Phase III. At the end of Phase II the Run subjects were shifted from food-deprivation to water-deprivation. As in Phase I and II, the Odor-Donor subjects were confined in the start box thirty seconds with a full water bottle on R trials and an empty bottle on N trials. The same procedures were employed with the Run subjects in the goal box during Phase III. As in Phases I and II, the Run subjects were confined for 10 seconds in the start box prior to traversing the runway.

It should be noted that the tops of the apparatus were covered by a thin sheet of transparent plastic to prevent odors

from dissipating. Also, the sipper-tube access hole in the start box was plugged following an Odor-Donor trial to prevent odors from dissipating.

## RESULTS

The start, run, and goal latencies for each Run subject for each trial were reciprocated and when multiplied by the appropriate constant yielded speed scores in meters per second. For purposes of statistical analysis and graphing the speed scores for each Run subject for each block of 8 daily trials were combined in the following manner. The two adjacent trials of the same nature (e.g., the first two R trials, the first two N trials, etc.) were combined and averaged thus yielding composite  $R_1$ ,  $R_2$ ,  $N_1$ , and  $N_2$  scores. Figure 1 presents the mean start, run, and goal speeds for the Run subjects during Phases I and II. The transformed scores for Phases I-III were subjected to a Subjects X Treatments (R vs. N) X Treatments (Days) analysis of variance. Tukey's procedure was used for all significant contrasts.

The Phase I analyses were performed over the data from Days 10 to 12 (the point in training at which patterning appeared to have been established in the goal measure and asymptotic behavior shown in the start and run measures). The results of these analyses indicated that the R vs. N factor was significant,  $F(1,45) = 9.76$ ,  $p < .01$ , in the goal measure. No other significant effects were found. Thus, the statistical analyses are supportive of the graphical impression that significant R vs. N patterning did develop during Phase I, and that this patterning was limited to the goal measure.

Analyses of the Phase II data indicated that the R vs. N factor was significant,  $F(1,45) = 11.23$ ,  $p < .01$ , and, as in Phase I, that this significance was limited to the goal measure. No other significant effects were produced by the Phase II analyses.

Mean start, run, and goal speeds (meters per sec.) for the Run subjects during Phase III are shown in Figure 2. Analyses, similar to those performed on the data from Phases I and II, were performed on the speed data for Days 7 to 10 (the point at which double-alternation patterning appeared to have been established in all three measures) of Phase III. The results of these analyses indicated that the R vs. N factor was significant in all three measures [start,  $F(1,63) = 5.96$ ,  $p < .05$ ; run,  $F(1,63) = 8.80$ ,  $p < .01$ ; and, goal,  $F(1,63) = 18.14$ ,  $p < .01$ ]. Additionally, the R-N by Days interaction was found to be significant,  $F(3,63) = 4.53$ ,  $p < .05$ , in the start measure. Further analyses of the significant interaction indicated that the R vs. N speeds did not differ significantly on Day 7, but did differ significantly ( $p < .05$ ) on Days 8 to 10.

## DISCUSSION

As can be seen from Figure 1, the striking features of Phases I and II are: (1) the development of significant double-alternation patterning by the Run subjects only in the goal measure, and (2) the lack of behavioral change on the part of the Run subjects when the double-alternation sequence was reversed (i.e., Phase II). These results are in general agreement with the odor hypothesis (see, Ludvigson and Sytsma, 1967; Prytula and Davis, 1974) in that appropriate double-alternation patterning was shown, at least in the goal measure. However, in comparison with the Ludvigson and Sytsma (1967) study where food deprivation was employed exclusively, the water-deprivation patterning shown in the present investigation was slower to develop. This finding was also reported by Davis, et al. (1974), and adds support to the contention made by those authors that a qualitative and/or quantitative difference may exist between odor cues produced under water- and food-deprivation. This difference may, as suggested by Davis, et al. (1974), be attributable to the relative severity of the respective water- and food-deprivation schedules.

Concerning the motivational specificity of odor cues, the present study, although a converse arrangement to that of the Davis, et al. (1974) study, offers similar results. During Phase I, no patterning was exhibited in the start and run measures, suggesting that odors produced by the Odor-Donor subjects had no

influence on the behavior of the Run subjects. In Phase II when the reinforcement schedule was reversed from that of Phase I (RRNNRRNN to NNRRNNRR), still no influence of the Odor-Donor cues was discernable in the Run subjects in the start and run measures. Only in the goal measure did double-alternation patterning occur during these Phases, thus indicating that the Run subjects were responding to odor cues, but that the effective cues were limited to those odors exuded by previous Run subjects. Davis et al. (1974) observed this same pattern of results even though their odor-donor subjects were food deprived and their run subjects were water deprived. The striking similarity in the findings of these two studies seems to indicate that odor cues are indeed not generalizable across deprivation states.

This contention is further substantiated by the results of Phase III. It will be recalled that during Phase III of the present study both the Odor-Donor and Run subjects were maintained under water-deprivation. The reinforcement schedules were, as in Phases I and II, positively correlated. It can be seen from Figure 2 that strong double-alternation patterning developed in all three measures. The obvious implication being that when the deprivation states of the subjects were equated the odor cues produced by the Odor-Donor subjects were utilized by the Run subjects as a predictor of the impending goal event. The identical finding was reported by Davis, et al. (1974) when all of their subjects were placed on food-deprivation schedules.

The results of the present study would appear to contain several important pieces of information. First, they are supportive of the drive-specificity hypothesis and therefore supportive of theories of learning (e.g., Hull, 1943, 1952; Spence, 1956, 1960) that employ this model. Second, the present study demonstrates, rather convincingly, that separate components (i.e., start, run, and goal measures) of the instrumental response chain can be brought under independent control. In view of this, caution should be utilized in the measurement and reporting of such unitary measures as "total time" which might serve to obscure specific, and often distinctly different, effects occurring in the separate components. Third, the motivational specificity of odor cues suggests that many animal-learning situations are best cast within a biological-constraints model rather than a memory-mediated model. Thus, the results of Phases I-III of the present study indicate that the rat subject appears quite prepared to associate responses with certain stimuli (odor cues associated with the particular deprivation experienced by the subject) and unprepared to make other associations (odors produced under different deprivation states were not utilized. Lastly, the present study, as have previous studies (Ludvigson & Sytsma, 1967; Prytula & Davis, 1974; Davis, et al., 1974), calls attention to the necessity for taking possible odor cues into account in the conduct of animal studies. In the future animal studies will need, literally, to be cleaned up! Otherwise the data and interpretations generated by such studies will certainly be questionable at best.

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**APPENDIX: FIGURES**

Fig. 1 - Mean Start, Run, and Goal Speeds (meters per sec.)  
for the Run Subjects During Phases I and II.

MEAN SPEED (METERS/SEC.)

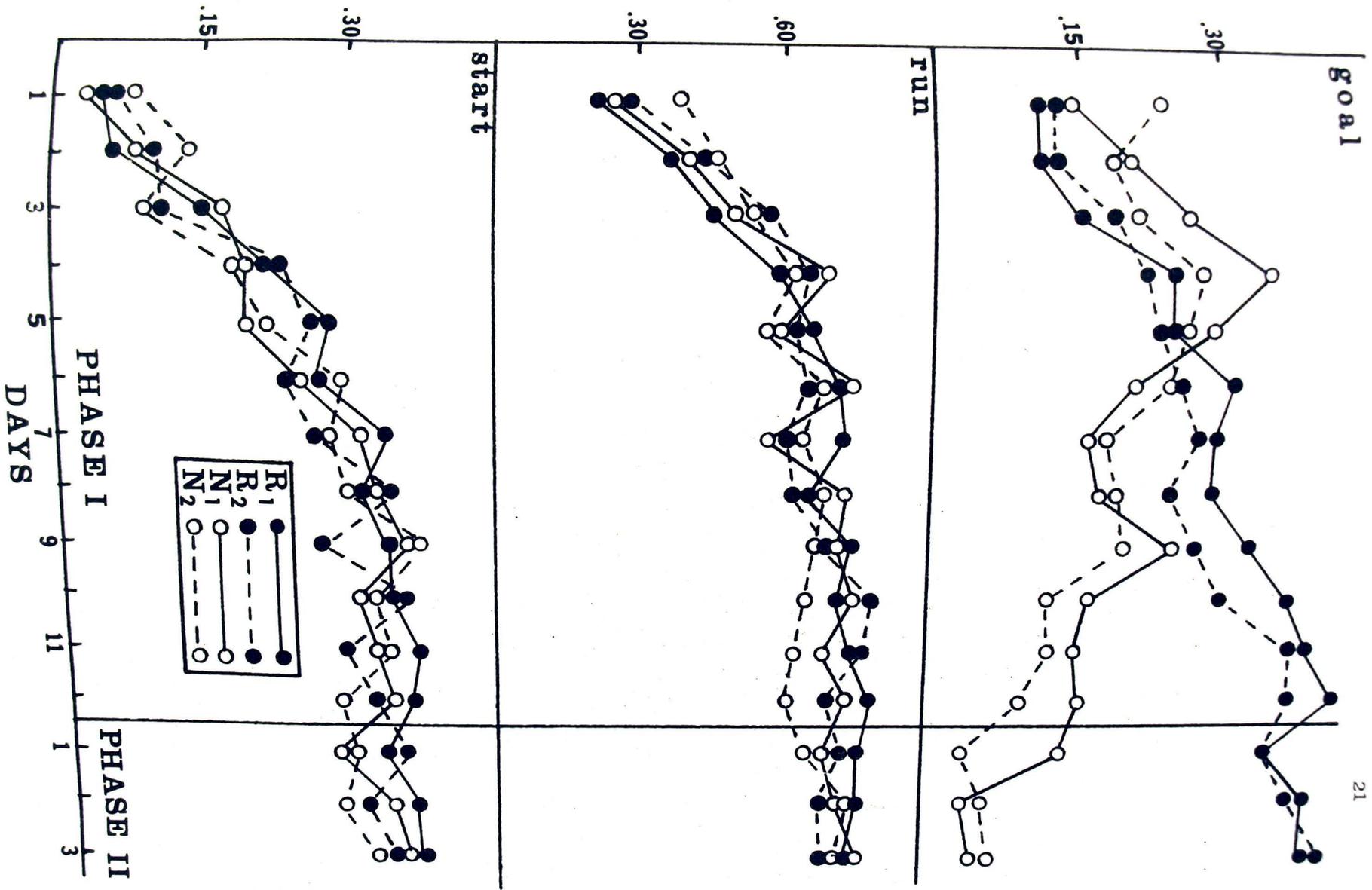


Fig. 2 - Mean Start, Run, and Goal Speeds (meters per sec.)  
for the Run Subjects During Phase III.

MEAN SPEED (METERS/SEC.)

