

**PREDICTIVITY OF OLFACTORY CUES, DOUBLE-
ALTERNATION PATTERNING, AND
INTERTRIAL EVENTS**

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PREDICTIVITY OF OLFACTORY CUES, DOUBLE-ALTERNATION
PATTERNING, AND INTERTRIAL EVENTS

An Abstract
Presented to
the Graduate Council of
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In Partial Fulfillment
of the Requirements for the Degree
Master of Arts

by
William S. Talley, Jr.
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ABSTRACT

Twenty-four male albino rats served as subjects in an investigation into the possibility of an interaction existing and operating between memorial processes and olfactory cues. Using the double-alternation pattern utilized in previous research on odor cues and their operation, odor-donor subjects received reward and non-reward events in the startbox of a straight runway during the first phase of a four-phase experiment. Runway-trained subjects received an identical pattern of reward-nonreward events at the goal during this phase. During the second and fourth phases the odor-donor subjects were not present in the startbox, however, they were present, once again, during the third phase of the experiment. Thus, the veridicality and predictiveness of the odor cues exuded by these subjects was not changed during phases two and four. As anticipated from previous data, appropriate responding was somewhat disrupted during phase two but was maintained quite strongly during phase four. The results of the experiment are strongly supportive of an hypothesized interaction between memorial processes and utilization of odor cues.

PREDICTIVITY OF OLFACTORY CUES, DOUBLE-ALTERNATION
PATTERNING, AND INTERTRIAL EVENTS

A Thesis
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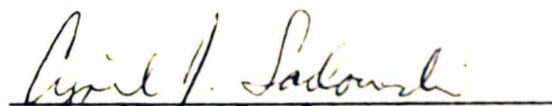
by
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August 1977

To the Graduate Council:

I am submitting herewith a thesis written by William S. Talley, Jr. entitled "Predictivity of Olfactory Cues, Double-Alternation Patterning, and Intertrial Events." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Arts, with a major in Psychology.

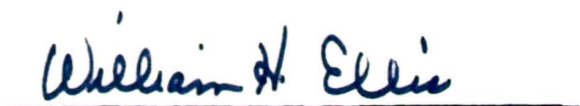

Major Professor

We have read this thesis and
recommend its acceptance:


Minor Professor
or
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Third Committee Member

Accepted for the Council:


Dean of the Graduate School

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TABLE OF CONTENTS

CHAPTER	PAGE
I. INTRODUCTION.....	1
II. METHOD... ..	11
Subjects.....	11
Apparatus.....	11
Procedure.....	12
III. RESULTS.....	15
IV. DISCUSSION.....	17
APPENDIX A: FIGURES.....	21
REFERENCES.....	26

LIST OF FIGURES

FIGURE	PAGE
1. Mean start speeds (meters per second) during all phases.....	23
2. Mean goal speeds (meters per second) during all phases.....	25

CHAPTER I

INTRODUCTION

Psychologists have long used animals as subjects in learning experiments. This has been due, no doubt, in part to necessity and in part to convenience. Moreover, until quite recently, virtually all psychologists felt safe in making the assumption that the performance or the treatment of one animal in an experimental apparatus did not in any way affect the performance of subsequent subjects in the same apparatus. In this case, many monumental studies, particularly those dealing with latent learning, would certainly lose their impressiveness. Without this assumption, there exists a strong possibility that intersubject dependence would confound the results of runway experiments.

Experiments dealing with latent learning were critical of the hypothesis, suggested by such researchers as Thorndike (1913), Pavlov (1927), and Hull (1935, 1937), that reinforcement was necessary for any associative learning to take place. Tolman and Honzik (1930) used a conventional, enclosed multiple-T maze of fourteen units to examine the possibility of learning without reinforcement, i. e., latent learning. In this experiment, rats were divided into control and experimental groups. The control

animals received one reward trial per day. The animals in the experimental group were likewise given one trial per day, but without reward. This procedure was followed for ten days. By the tenth day, the animals in the control group made fewer errors and traversed the maze much more rapidly than did the experimental subjects. On the eleventh day, the procedure was altered: all subjects were rewarded upon successful completion of the maze. On the twelfth day, the experimental animals exhibited running speeds and error rates similar to those of the control group. Tolman and Honzik (1930) reported these results as being indicative of learning having taken place without reward being present. Reward, then, was needed only to elicit the exhibition of learning (performance) rather than to ensure that learning took place. Obviously, Tolman and Honzik did not consider the possibility that the performance of the previous animal might have some effect upon the behavior of the next animal. Possibly such an effect was present in this situation.

During the past decade, an increasing array of data has been collected which tends to indicate that the assumption made in most enclosed runway studies, independence of inter-subject performance, should be carefully considered before being accepted, and quite possibly should be discarded altogether. The data to which reference is made deals with an olfactory mechanism

of some type by which a subject is able to communicate frustration or other types of reactions to subsequent subjects.

The possibility that odors were being utilized as performance cues by animal subjects was considered by W. S. Small (1901) in his experiments using rats in a Hampton Court maze. Small observed that an animal very often would not use the path taken by the immediately preceeding animal. While he felt that this observation held no implications for the shaping of the animal's behavior, he did suggest that it might be an area which could yield some interesting research.

It was later observed by John B. Watson (1907) that anosmic rats learned mazes more slowly than did normal animals. In keeping with Small's conclusions, however, Watson decided that olfactory cues played no significant role in the shaping of the behavior of an organism, more specifically, the white rat.

The research suggested by Small (1901) remained undone for over sixty years, and it was left for Ludvigson and Systma (1967) to demonstrate the importance of odor cues in maze performance. The Ludvigson and Systma study indicated that rats could learn a double-alternation (RRNNRRNN) pattern [i.e. fast to reward (R); slow to nonreward (N)] in a straight runway when odor cues were maximized, but were unable to do so when odor cues were minimized. These results were viewed with some surprise

because an earlier study (Bloom and Capaldi, 1961) had indicated that the rat was unable to learn this type of pattern when training was based solely on memory and internal cues. Ludvigson and Systma (1967) hypothesized that the odor produced by the animal was a function of the presence or absence of reward. Thus, it seemed logical to expect that the strongest patterning would occur in the goal portion of the runway since any odors produced as a result of the presence or absence of reward would presumably be strongest at the goalbox, the point of origin for the odor cues. Their findings were entirely in keeping with this hypothesis. Double-alternation patterning was strongly established in the final or goal portion of the runway and nonexistent in more remote sections.

Subsequent to the publication of this landmark paper by Ludvigson and Systma (1967), many studies have been published concerning the olfactory control of animal maze behavior. The first research generated by this new development consisted of attempts to validate the existence and operation of such cues. Some attempts at validation of the odor cues included research done by Amsel, Hug, and Surridge (1969), Ludvigson (1969), and Mellgren, Fouts, and Martin (1973). This research yielded many interesting facts. Amsel, Hung, and Surridge (1969) found that by maximizing odor cues, albino rats could learn appropriate single-alternation responding. Ludvigson (1969) continued

to examine the patterning which developed in the goal portion of a runway maze under double alternation conditions. Mellgren, Fouts, and Martin, (1973) found that odors of reward and nonreward appeared to possess mild unconditioned properties of attractiveness and aversiveness, respectively.

This study by Mellgren, Fouts, and Martin, (1973) was interesting in that it proposed the existence of an odor of reward as well as an odor of nonreward. Earlier studies, such as that reported by Collierian and Ludvigson (1972), had suggested the effectiveness of only the odor of frustrative nonreward.

Another approach to the problem of validation of the operation of odor cues was adopted by Pitt, Davis and Brown (1973). These authors demonstrated that odor cues were much less salient when the runway was covered with wire mesh rather than the more conventional plexiglass lids. Because appropriate double-alternation responding was not successfully established in this apparatus, they concluded that it was likely that the effective odorants were airborne, so they dissipated rather quickly. Support for this contention came from a report published by Bloom and Phillips (1973) in which it was demonstrated that an exhaust fan could effectively minimize odor cues (and patterning) in the enclosed apparatus.

In further testing the odor hypothesis, Seago, Ludvigson, and Remley (1970) rendered a group of albino rats surgically anosmic. A control group of normal animals was also utilized. All subjects were run under odor-maximizing conditions in the double-alternation task. Normal subjects were able to master the pattern but the anosmic animals, being unable to process the odor stimuli, ran uniformly fast on all trials throughout the experiment.

Animals other than rats have also given strong support to the odor hypothesis. For example, Davis (1970) demonstrated appropriate double-alternation responding in mice. Another study, Davis, Crutchfield, Shaver, and Sullivan (1970) indicated that it may be possible that odors are not species specific. In this study, Mongolian Gerbils were used as odor donors and albino rats were used as run subjects. Subjects were assigned to one of seven pairs consisting of one rat and one gerbil. In both of the two phases involved in the experiment the animals were run in these pairs. Throughout the experiment, all subjects received six trials (three R, three N) in a randomized order daily. During phase one, there was complete correspondence between goal events for the gerbils and goal events for the rats. In phase two, the correspondence between goal events was reduced to fifty percent. An overall speed was reported for the rats. The results indicated that not only were the rats able to utilize the

cues emitted by the gerbils, the R-N discrimination occurred so quickly that the experimenters were inclined to postulate that the odors emitted by different species were highly distinctive and therefore more readily used as discriminative stimuli.

All studies mentioned thus far have relied upon a predictive odor cue to facilitate patterning, whether it be single- or double-alternation. Prytula and Davis (1976) departed from this usual pattern and chose to examine the question of whether appropriate double-alternation responding might be maintained, once established, in the absence of predictive cues. The technique used in this study was of the odor-donor variety similar to that reported by Davis (1970). In this technique, all animals were assigned to either odor donor or run subject groups prior to the onset of pretraining. Each subject is subsequently assigned to a permanent pair and animals are run as a pair throughout the duration of the experiment. Odor donors, in this case do not actually traverse the runway. Instead, they are placed into the startbox and there receive reward or non-reward events which are completely predictive of the goal event for the runway-trained subject. The runway-trained subject is placed into the runway startbox and allowed to traverse the maze in the usual manner. Following this paradigm, then, Prytula, Davis, Fite and Wells (1976) elected to have four phases in

the experiment. During phase one, odor donors in the start-box and runway trained subjects received the same double-alternation reward-nonreward schedules. Under these conditions, strong patterning developed in the start, run, and goal measures of the runway. In phase two of the experiment, donor subjects continued to receive the same pattern of reward-nonreward events. These events, however, occurred in a neutral box outside the runway. For phase three, the odor donors were returned to the startbox to receive their reward or nonreward events. In the fourth phase, reward and nonreward events were again administered in the neutral box. The sequence, with regard to odor donors in the startbox was IN-OUT-IN-OUT. As previously stated, patterning was established in phase one in all three measures: start, run, and goal. In phase two patterning in the start and run measures was disrupted. Patterning in the goal measure during this phase was unaffected. With the return of the donor subjects to the startbox in phase three, patterning was immediately reestablished in the start measure. With removal of the odor donors again in phase four, significant patterning was still displayed by run subjects in all three measures.

At this point, Prytula et al. (1976) suggested several possible explanations for this maintenance of patterning. It was suggested that there was the possibility that it was due to the display of some type of memorial process.

Espousal of this position leads to the necessity of interfacing odor cues and memorial processes. Prytula and Davis cautiously suggested that donor odors interact with and possibly cue or prompt memory in those cases where odors are completely predictive of the goal event. They also discussed the possibility of other explanations, such as the possibility that the animals were simply learning the pattern or that some other cues were being utilized by the run subjects. The possibility of pattern learning was discounted in light of other studies (Davis, Prytula, Noble and Mollenhour, 1976) done by these researchers. One study in which the odor cues were not completely predictive lasted some twenty-seven days and failed to demonstrate patterning.

The present study was designed to investigate further the possibility of such a relationship existing between odor cues and memory processes. Following the pattern used by Prytula et al. (1976), odor donor subjects received reward and nonreward events in the startbox of a straight runway during the first phase of a four phase experiment. Runway-trained subjects received an identical pattern of reward and nonreward events at the goal during this phase. During the second and fourth phases, the odor donor subjects were not present in the startbox. However, they were present, once again, during the third phase of the experiment. It should be noted that, in order to preclude

the possibility that the donor subject may be cueing other members of the colony through some means other than odor (gnashing of teeth, for example), these subjects received reward outside the runway in a neutral box following selected nonreward trials in phase three. Hence, the veridicality and predictiveness of the odor cues exuded by the donor subjects were not changed during phases two and four and remained completely predictive of the goal event for the runway-trained subjects. Based on the data from Prytula et al. (1976) it is expected that appropriate responding will be somewhat diminished during the start measure of phase two but will be maintained rather strongly during phase four, if indeed, an interaction is operating between memorial processes and odor cues.

CHAPTER II

METHOD

Subjects

Twenty-four naive male albino rats, approximately ninety days old at the onset of the experiment, were purchased from the Holtzman Company, Madison, Wisconsin and served as subjects. Seven days prior to pretraining, the subjects were placed on a food-deprivation schedule which maintained each subject at approximately 85% of free-feeding body weight. This deprivation schedule was maintained throughout the remainder of the experiment. Subjects were fed immediately following each daily experimental session. All subjects were housed in individual cages with water freely available.

Apparatus

The apparatus utilized in the experiment consisted of a single straight runway (11.43 cm. wide; 12.70 cm. high). A grey startbox (28.10 cm. long) was separated by a masonite guillotine door from the rest of the runway. The raising of this door served to activate, via a micro-switch, a Standard Electric Timer. Breaking a photo-electric beam located 15.24 cm. beyond the start door

stopped the first timer (Start Time) and started a second timer. Breaking a second beam located 76.20 cm. beyond the first beam stopped the second timer (Run Time) and started the third timer. The third timer was stopped by breaking a third photoelectric beam located 5.08 cm. forward of the goal cup. A small plastic receptacle recessed into the end wall of the goalbox served as the goal cup. The top of the runway was covered by a thin sheet of plastic to prevent the dissipation of odors.

Procedure

Prior to the onset of a four day pretraining period, all subjects were randomly assigned to one of two equal groups: Odor-Donor and Run. Further, each subject was assigned a permanent number (1-12) within his respective group. On the first and second days of pretraining, all animals were handled and tamed. On the third and fourth days, each Run subject received a five-minute period of exploration in the unbaited apparatus. Odor-Donor subjects received an equal amount of handling on those days. On the four pretraining days, all subjects were habituated to the 45-mg. Noyes pellets in the home cage.

Each subject received eight trials: four reward (R) and four nonreward (N) in a double alternation pattern (RRNNRRNN) throughout all four phases of the experiment. All subjects received trial one before trial two, and so

forth. The order for running the subjects was randomized daily. For each trial the appropriate Odor-Donor was selected for use with the Run subject; that is, Odor-Donor one was used with Run subject one, etc.

During phase one, the procedure for running a trial was as follows: The Odor-Donor was removed from the home cage and placed directly into the startbox. On reward trials, he was removed following the consumption of the reward (twelve 45 mg. Noyes pellets). On nonreward trials, he was removed after being confined for thirty seconds. Following this the Run subject was immediately placed into the startbox. The Run subject was confined in the startbox ten seconds and then allowed to traverse the runway. Phase one lasted fourteen days (112 trials).

Phase two differed from phase one in that the Odor-Donor subjects received the usual pattern of reward and nonreward in a neutral box. At no time during phase two were the Odor-Donor subjects in the startbox of the runway. Runway-trained subjects, on the other hand, received treatment identical to that of phase one.

Phase three was identical to phase one with the following exceptions: Following the first two nonreward trials, on days one through three, each Odor-Donor subject was placed into the neutral box outside the runway and reward was administered. On days four through six, reward was

administered in the neutral box following the last two nonreward trials. These conditions were imposed in order to eliminate the possibility of communication between donors and the remainder of the colony by some means other than odor (gnashing of teeth or ultra-sound, for example).

During phase four, conditions were again identical to those employed in phase two. Phases two, three and four were each six days (48 trials) in duration.

CHAPTER III

RESULTS

Prior to analysis all time measures were reciprocated, and when multiplied by the appropriate constants, yielded speed scores in meters per second. Figures 1 and 2 show the mean start and goal speeds for Days 8-14 of phase one (the point at which double-alternation patterning appeared to have developed), and phases 2-4. Analyses of variance were performed on this data. The results of these analyses will be considered separately for each phase.

Phase One

Analysis performed on the data from Days 8-14 indicated that the R vs. N effect was significant in the start, $F(1,143) = 4.26$, $p .05$, and goal, $F(1,143) = 5.07$, $p .05$, measures. Thus, the statistical analyses corroborate the graphical impression (see Figures 1 and 2) that significant double-alternation patterning developed in the start and goal measures during Phase One.

Phase Two

Goal-speed analyses yielded a significant R vs. N effect, $F(1,121) = 7.21$, $p .01$, while the R-N Days interaction was found to be significant, $F(5,121) = 4.82$, $p .05$, in the start measure. Further inspection of the

significant start-measure interaction (Tukey's procedure) indicated that significant ($p \leq .05$) R vs. N difference existed only on Days 5 and 6 in the start measure.

Phase Three

Significant R vs. N effects were shown in Phase Three in both the start, $F(1,121) = 8.86$, $p \leq .01$, and goal $F(1,121) = 9.65$, $p \leq .01$, measures. No other significant effects were produced by analyses of this Phase.

Phase Four

Phase Four results mirrored those of Phase Three in that significant R vs. N effects were obtained in both the start, $F(1,121) = 4.02$, $p \leq .05$, and goal, $F(1,121) = 11.52$, $p \leq .01$, measures. As in Phase Three, these were the only significant effects produced by the analyses.

CHAPTER IV

DISCUSSION

The present study was designed to investigate the possibility that double-alternation responding, once established through the use of completely predictive odor cues, might be maintained in the absence of such cues so long as the predictability of the cues is not disrupted. The IN-OUT-IN-OUT pattern with regard to the presence of the odor donor animal in the start box of the runway served as the vehicle by which this possibility was explored.

An earlier study by Prytula et al. (1976) had utilized a similar pattern with results which formed the basis for the expectations of the present experiment. These authors had found that if double-alternation responding was established through the use of odor cues in phase one and subsequently removed during phase two, appropriate responding to the double alternation pattern was disrupted substantially in the start measure but was maintained with no disruption in the goal measure. With the reintroduction of the odor donor subjects in phase three, appropriate responding on the part of the runway trained subjects was re-established immediately in the start area of the runway.

When the odor donors were removed once again in phase four, it was found that double-alternation patterning was preserved to a considerable extent and was maintained, again, with no disruption in the goal measure. The results of the present experiment were entirely in keeping with expectations based on the experiment of Prytula et al. (1976).

One variation in the present study which is certainly worthy of note occurred during phase three. During this phase, odor donor subjects were present in the runway. In order to eliminate the possibility of communication of frustration from the donor to the remainder of the colony following nonreward trials, the following procedure was used: Odor donor animals were placed into the start box of the runway as in phase one with one difference; on days one, two, and three of phase three following the first two nonreward trials, the donors were placed in the neutral box outside the runway and rewarded. On days four, five, and six of this phase the donor subjects were rewarded in the neutral box following each of the second pair of nonrewarded trials. This procedure was followed to ensure that if the animals carried a communication back to the colony by means of ultrasound, teeth gnashing, or some other mechanism that the message would be contrary to the odor cue deposited in the startbox of the runway. If it was the case that the animals of the colony were attending to some nonverbal

communication within the colony as opposed to the odor cue hypothesized to be present in the start box, disruption of the double-alternation pattern might be expected. As can be seen from Figures 1 and 2, such was not the case. Appropriate double-alternation responding was maintained very strongly with no discernable changes on any N trials throughout phase three, thus lending strong support to the contention that the runway-trained subjects were, in fact, attending to the odor cue left in the start box by the donor subject and not communicating to other animals in any other manner.

The fact that patterning was maintained so strongly in both the start and goal measures during phase four lends support to the possibility that an interaction was operating between memorial processes and the utilization of odor cues. From the data presented, it would seem that, once established by means of completely predictive odor cues, appropriate responding to the established pattern can be maintained in the absence of these cues so long as there is no disruption of the pattern of goal events presented to the runway-trained subjects, and/or modification in the predictiveness of the odor-donor cues.

Further research should lead to a greater understanding of the exact nature of the hypothesized interaction between memorial processes and utilization of completely predictive odor cues. The purpose of the present study was primarily

to validate the results of Prytula et al. (1976) in order to add support to the possibility of the existence of such an interaction. It remains for further research to demonstrate more exactly the nature of such an interaction.

APPENDIX A: FIGURES

Figure 1. - Mean start speeds (meters per second)
during all phases.

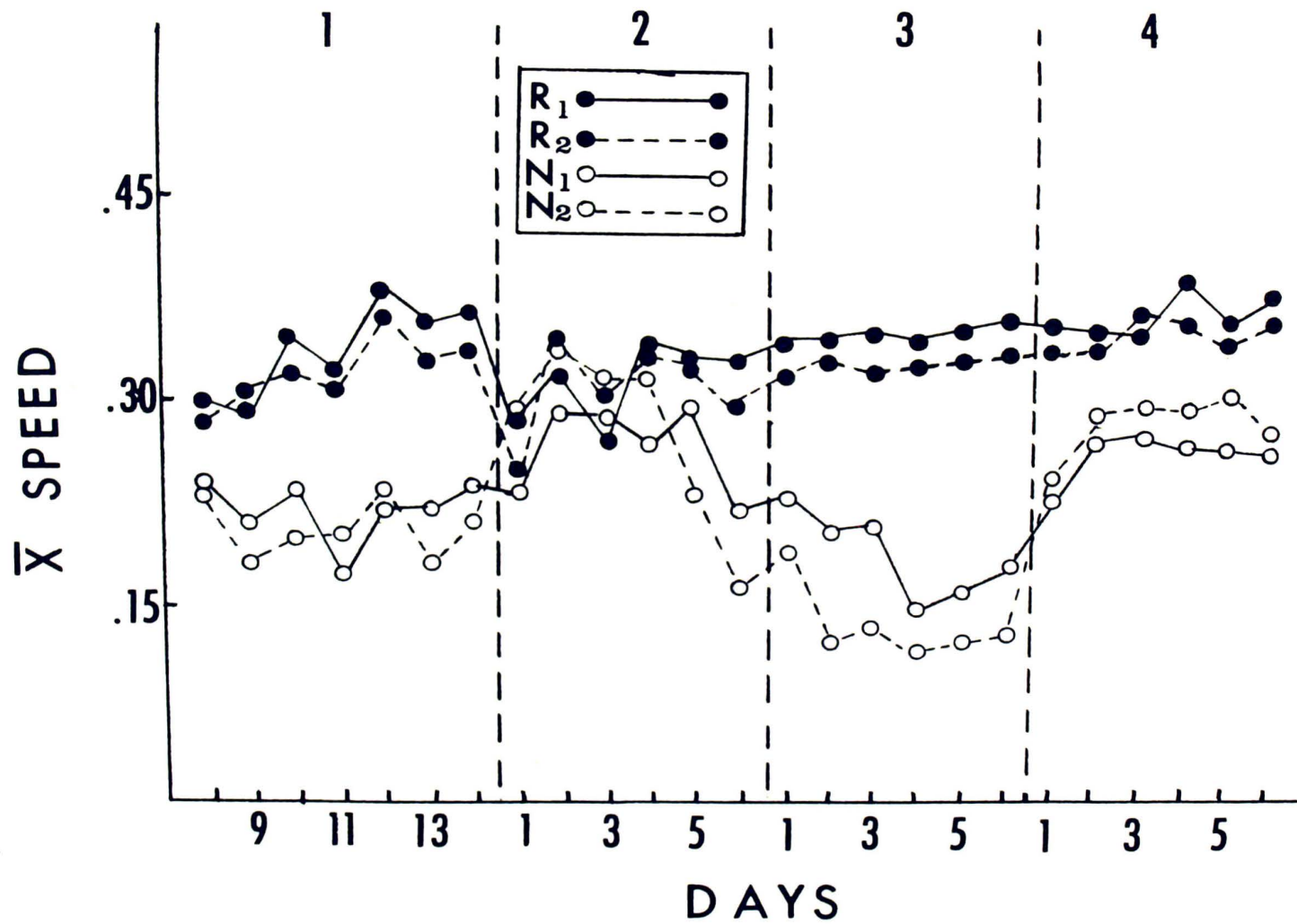
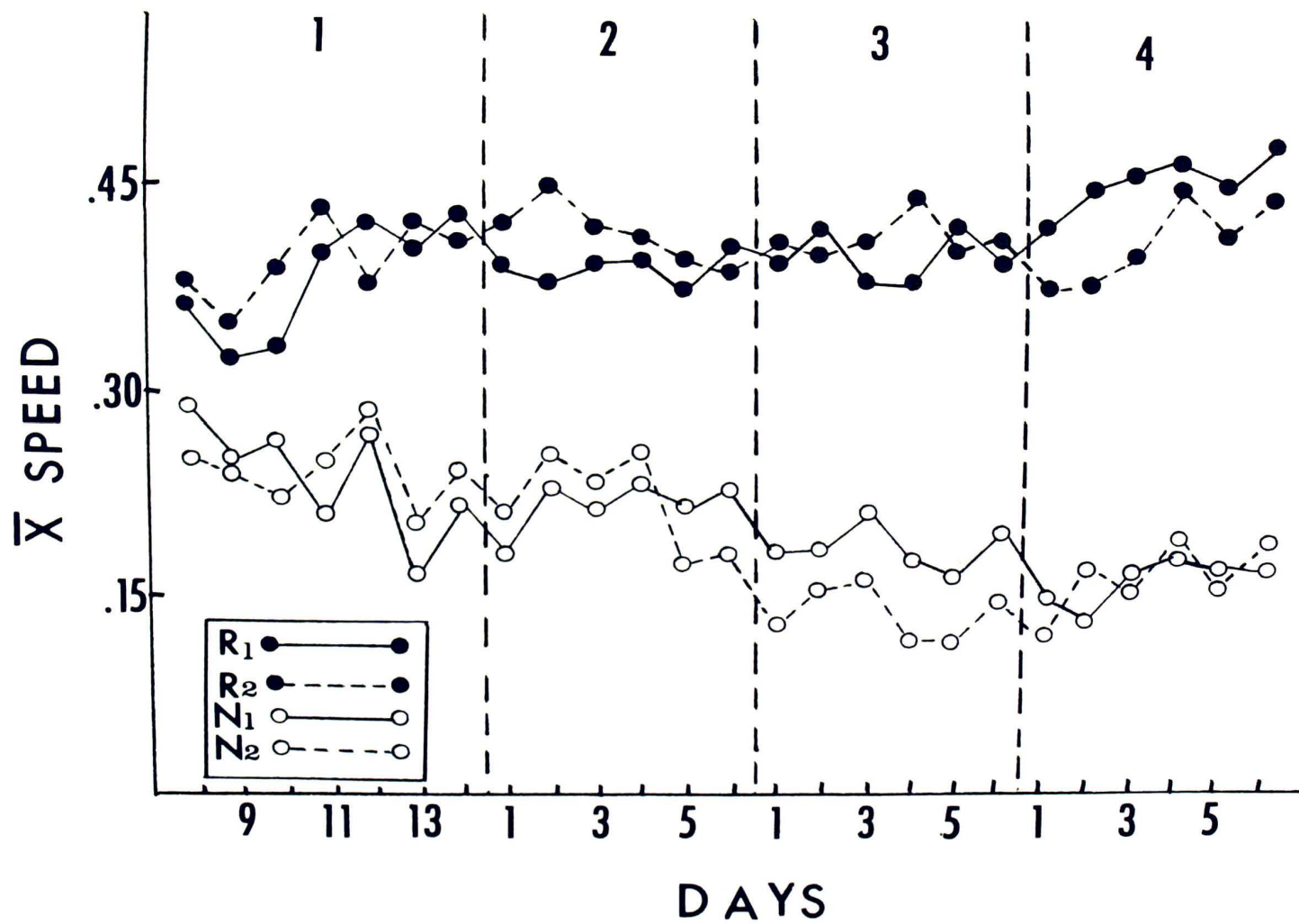


Figure 2. - Mean goal speeds (meters per second)
during all phases.



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