

**RUNWAY PERFORMANCE OF NORMAL AND  
ANOSMIC RATS AS A FUNCTION OF INCENTIVE  
MAGNITUDE AND INCENTIVE MAGNITUDE SHIFT**



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AS A FUNCTION OF INCENTIVE MAGNITUDE AND  
INCENTIVE MAGNITUDE SHIFT

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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

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by  
Bernabe Marrero

August 1973

## ABSTRACT

Anosmic and Normal rats served as subjects in an investigation concerned with the role of odor cues in runway behavior. Two groups of anosmic subjects received 50 acquisition trials with large reward and small reward respectively. Two groups of normal subjects received identical acquisition training. Following acquisition all subjects received 20 small reward trials. These 20 trials constituted an incentive reduction phase for the subjects that had received large reward during acquisition. The results of the acquisition phase indicated that reward magnitude was a significant determinant of performance for the normal subjects, but not for the anosmic subjects. During the incentive reduction phase, the performance of both groups of normal subjects was significantly depressed below that of the anosmic subjects, especially in the goal measure on the initial trials. No significant behavioral changes were noted in the anosmic subjects during the incentive reduction phase. These results are seen as being supportive of the odor hypothesis.

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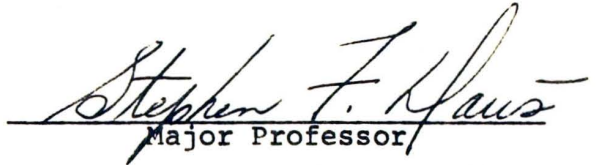
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by  
Bernabe Marrero  
August 1973

To the Graduate Council:

I am submitting herewith a Thesis written by Bernabe Marrero entitled "Runway Performance of Normal and Anosmic Rats as a Function of Incentive Magnitude and Incentive Magnitude Shift". I recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Arts, with a major in Psychology.

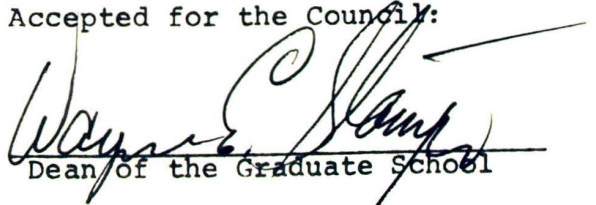
  
Major Professor

We have read this thesis and  
recommend its acceptance:

  
Minor Professor

  
Third Committee Member

Accepted for the Council:

  
Dean of the Graduate School

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## CHAPTER I

### INTRODUCTION

The study of motivated behavior contains two important aspects; internal physiological states which cause the release of energy for the production of the activity, and external stimuli which arouse, direct and serve to bring that particular activity to a conclusion. The internal motivating conditions of activity are referred to as needs and include such states as thirst and hunger. External motivational stimuli such as the smell of reward, familiarity with reward conditions, or environment, are referred to as positive incentives when they enhance the subject's behavior. When they hinder the subject's behavior, they are referred to as negative incentives.

The manipulation of external motivational stimuli, such as training subjects under different levels of incentive magnitude and/or shifting the incentive magnitude, has been the basis of many studies of instrumental learning. Research on incentive reduction has been concerned with observed changes in responding to a reduction in the quantity or quality of a reinforcement. The initial incentive reduction experiments are typically attributed to Crespi (1942). In his experiments Crespi (1942) used

three groups of rat subjects which received, during their 25 days (1 trial/day) of training in a straight runway apparatus, either a small (16 unit), moderate (64 unit) or large (256 unit) reward according to which of the three groups the subjects were assigned. Following training all subjects received the small (16 unit) reward for an additional 8 trials. The data indicated that there was a significant decrement in performance on the part of those subjects that had their incentive reduced. In fact, this performance abruptly fell to a point that was significantly lower than that of the group which had received the small reward continuously. Crespi (1942) called this decrement in performance a "depression" effect; currently it is referred to as "Negative Contrast Effect" (NCE). A corresponding increase in performance, above that of subjects trained on large reward, shown by subjects shifted from small to large reward was termed as "elation" effect. Currently this phenomenon is called a "Positive Contrast Effect" (PCE).

Zeaman (1949) was the first to replicate Crespi's (1942) findings. Zeaman (1949) found that the subjects showed an NCE when reward was reduced from 2.4g to .05g after initial training at a 2.4g level. He also found subjects upshifted from .05g to 2.4g reinforcement displayed a PCE. Subsequent research in the area of incentive reduction has been concerned with investigating the parameters influencing the NCE. For example, it has

been demonstrated that by giving partial reinforcement training prior to incentive reduction (Bohmer and Ison, 1966) or by gradually down-shifting the reinforcement magnitude (Gonzalez, Gleitman and Bitterman, 1962) the NCE may be lessened or possibly eliminated. Along similar lines, in a study by Davis and North (1967) the NCE was not exhibited by subjects receiving varied reinforcement training prior to the incentive reduction phase. Davis and North (1968) also found that subjects given a large number of large reward trials showed a greater disruption in performance especially in start speeds, during an incentive reduction phase than did a group which received only a small number of large reward trials before their incentive was reduced.

Other factors which have been found to influence the NCE are drive level and age of the subject. Ehrenfreund and Badia (1962) reported that strength of drive level (severity of food deprivation) was positively related to the magnitude of the NCE. Roberts (1966) reported that immature rat subjects did not show an NCE when shifted from large to small reward, whereas adult subjects did.

Typically, explanations of the NCE have utilized Amsel's (1958, 1962) frustration theory. According to this theory, when the subject receives a smaller reward or incentive in a situation which had previously provided a large reward, an aversive reaction (i.e., frustration)

is produced. As with other aversive conditions, the subject seeks to avoid the aversive state and thus the NCE is produced. Accordingly the goal, when the reduced reward is received, is predicted to be the point of maximum frustration. Hence, the NCE should occur with maximal intensity in the goal measure. Typically, this has been the case.

Frustration theory has been responsible for an abundant amount of research. Evidence has recently been provided that the frustration reaction of the subject may be an important variable in the subject significantly altering the experimental environment. McHose and Ludvigson (1966) and Spear and Spitzner (1966) found that control subjects, who received the identical reward in two runways, displayed an apparent discrimination when interspersed with experimental discrimination subjects that received different reward magnitudes in these same runways. These experimenters proposed that the discrimination subjects had laid down perceptually different odors in the runways, and these odors influenced the responding of the control subjects.

A subsequent investigation by Ludvigson and Sytsma (1967) indicated that rat subjects could learn to respond appropriately (i.e., slow on nonreward trials and fast on reward trials) when trained on a double-alternation pattern of reward and nonreward which maximized the possible utilization of these odor cues. However, subjects trained

under conditions which minimized the use of odor cues could not learn the pattern.

To further test the odor hypothesis, Seago, Ludvigson and Remely (1970) used anosmic rats in the double alternation task. The anosmic rats ran with uniform speed on all trials while a group of intact control subjects that were run under odor maximizing conditions quickly learned the pattern. Subsequent studies have indicated that odor cues are not produced solely by rat subjects. Studies utilizing Mongolian gerbils (Topping and Cole, 1969) and mice (Davis, 1969) have produced results supportive of the odor hypothesis. Also, Davis, Crutchfield, Shaver, and Sullivan (1970) have indicated that an odor produced by one species (a gerbil) may be utilized by a different species (rat).

Wasserman and Jensen (1969) further investigated the specific nature of the odor phenomenon. Their subjects, 20 male rats, were run in a runway. Half of the animals were assigned to an odor-producing group. Five of these subjects received two training trials per day (1-97 mg. reward pellet); the other five received two extinction trials per day (a frustration condition). The ten experimental subjects received four rewarded trials per day. The first trial each day was run on a fresh paper floor, while the remaining three trials of the day were run on a paper floor used by a rewarded odorant rat, or paper floor used by a frustrated odorant rat. The speed of the experi-

mental subjects on trials on which they ran on the flooring of the frustrated rats was significantly slower than when the run was made on new flooring or flooring used by rewarded animals. Thus, it could appear that the production of distinctive odor cues may be limited to frustration or nonreward occasions. Subsequent investigation (Colleraine and Ludvigson, 1972) have produced data supportive of this interpretation.

Returning to NCE, two studies by Davis and Ludvigson (1969) attempted to determine the rule of odor cues in the NCE. In these studies the NCE was greatly alternated, but not totally eliminated in subjects that had the runway cleaned (odor minimizing conditions) prior to each trial. However, subjects run under odor-maximizing conditions (no cleaning employed) showed large NCE's when shifted from large to small reward. The authors concluded that odor cues apparently played a role in the NCE.

The present study was designed to further investigate the role of odor cues in the NCE. More specifically, it was felt that the use of the ultimate odor control procedure, anosmic subjects, would yield valuable information about the role and utilization of these cues. Additional information concerning the possibility of differential effects of reward magnitude in normal and anosmic rat subjects was to be derived from the study.

## CHAPTER II

### METHOD

#### Subjects

The subjects were 20 experimentally naive female, albino rats obtained from the Cherokee Labs, Atlanta, Georgia. Ten of the rats were rendered anosmic by surgical removal of the olfactory bulbs. At the beginning of the experiment the subjects were approximately 90 days old. They were housed in individual cages with water always available. Two weeks before the beginning of the experiment the subjects were placed on food deprivation and were maintained at 85 percent normal body weight during the experiment. The subjects were fed following the completion of the daily experimental session for all subjects.

#### Apparatus

The apparatus was a single, straight runway, 11.43 cm wide and 12.70 cm high. The runway was divided into a 38.10 cm long grey start box, a 91.44 cm long black run section, and a 30.48 cm long black goal box. Hardware cloth tops covered by a thin transparent sheet of plastic covered the entire apparatus. Vertical sliding doors separated the start box from the run section and the run section from the goal box. A timer was activated by

raising the start box door, and stopped by the interruption of the photoelectric beam located 15.24 cm beyond the start door, thus yielding a start latency. Two additional timers, activated respectively by the interruption of two photoelectric beams located 76.20 cm beyond the first beam and 5.08 cm in front of the goal cup, yielded run and goal latencies respectively.

### Procedure

Upon receipt all subjects were placed into individual cages and allowed ad lib food for 10 days. Upon the inception of the deprivation schedule the subjects were randomly assigned to the following groups; SS-A, LS-A, SS-R, and LS-R. The first two letters of each group designation refer to the reward magnitude, small (S) or large (L), received during Phase I and Phase II of the experiment, respectively, with the third letter indicating whether the subjects in a particular group were anosmic (A) or normal (R). The 6 days immediately preceding Phase I constituted pretraining for all experimental subjects. During the first 4 days each subject received 2 minutes handling and taming. On the last 2 days of pretraining all subjects received 5 minutes of exploration in the apparatus per day. On exploration trials both doors were raised, photoelectric equipment operative and a reward corresponding to that which was to be received during Phase I was placed in the goal cup. On all 6 days of pretraining all subjects received pellet habituation in the home cage.

Pellet habituation consisted of allowing the subjects to consume pellets, corresponding to those to be received during Phase I, prior to the feeding of the daily ration.

Groups SS-A and LS-A and SS-R and LS-R were run as two separate squads with the squad composed of Groups SS-R and LS-R being run first on all days in an attempt to minimize and control the transmission of any odor cues from the anosmic to the normal subjects. The odor of running subjects within each squad was randomized daily during both phases of the experiment.

During Phase I, acquisition, all subjects received 50 trials at the rate of two trials per day. Subjects in groups SS-A and SS-R received small reward (1, 45 mg. Noyes Pellet) on all Phase I trials, while subjects in Groups LS-A and LS-R received large reward (1, 300 mg. Noyes Pellet) on all Phase I trials. Phase II consisted of 20 trials (2 per day), and constituted an incentive shift phase for Groups LS-A and LS-R. During this phase all subjects received small reward on all trials.

## CHAPTER III

### RESULTS

Figures 1-3 present the mean start, run, and goal speeds (meters per second) during the acquisition phase. Analysis of variance incorporating the following factors; anosmic vs normal subjects, small reward vs large reward, and trial blocks was performed on the data for all three speed measures for trial blocks 19-25, (the point in training at which asymptotic performance appeared to have been reached). The results of these analyses indicated that the anosmic-normal X small-large reward magnitude interactions were significant in all three measures (start,  $F = 14.09$ ,  $df = 1/19$ ,  $p < .01$ ; run,  $F = 6.135$ ,  $df = 1/19$ ,  $p < .05$ ; goal,  $F = 4.72$ ,  $df = 1/19$ ,  $p < .05$ ). The trial blocks factor was significant in the goal measure ( $F = 3.114$ ,  $df = 6/120$ ,  $p < .05$ ). No other significant effects were found. Tables 1-3 summarize these analyses.

The significant anosmic-normal X small-large reward interactions were further investigated by the use of the Newman-Keuls procedure. Results of these analyses indicated that in the goal measure Group LS-R approached the goal significantly ( $p < .01$ ) faster than Group SS-R. In the run measure, Groups LS-R and SS-A were both found to be running significantly ( $p < .01$ ) faster than Groups SS-R.

In the start measure Group LS-R started significantly ( $p < .01$ ) faster than all other groups. Also, Group SS-A started significantly faster than Group SS-R ( $p < .01$ ) and Group LS-A ( $p < .05$ ). These results are generally supportive of the graphical impressions that reward magnitude exert on effect, especially in the normal subjects during the acquisition phase.

Figures 4-6 show mean start, run, and goal speeds (meters per second) at terminal acquisition and during the incentive shift phase. Analyses of Variance performed on the incentive shift data indicated that the trial blocks factor was significant in all three measures (start,  $F = 5.834$ ,  $df = 9/180$ ,  $p < .01$ ; run,  $F = 2.538$ ,  $df = 9/180$ ,  $p < .05$ ; goal,  $F = 2.489$ ,  $df = 9/180$ ,  $p < .05$ ). The analyses also indicated that the anosmic-normal X trial blocks interactions were significant in all three measures (start,  $F = 3.147$ ,  $df = 9/180$ ,  $p < .01$ ; run,  $F = 3.102$ ,  $df = 9/180$ ,  $p < .05$ ; goal,  $F = 2.68$ ,  $df = 9/180$ ,  $p < .05$ ). Tables 4-6 summarize these analyses.

To further investigate the significant anosmic-normal X trial blocks interactions, simple main effects analyses were performed for all three speed measures. These analyses indicated that in the start measure a significant ( $F = 5.43$ ,  $df = 1/8$ ,  $p < .05$ ) difference occurred at trial block 9. Significant differences occurred at trial blocks 1, 3, and 10 ( $F = 6.11$ ,  $8.13$ , and  $20.78$ ;  $df = 1/8$ ;  $p < .05$ ,  $< .05$  and  $< .01$ , respectively in the run

measure. In the goal measure significant differences were found at trial blocks, 1, 3, 9, and 10 ( $F = 23.06, 7.28, 7.10, 18.03$ ;  $df = 1/8$ ;  $p < .01, < .05, < .05$ , and  $< .01$ , respectively).

## CHAPTER IV

### DISCUSSION

Considering the results of the acquisition phase (Figures 1-3), several striking effects are readily apparent. First, there is a significant reward magnitude effect shown by the normal subjects. In other words, normal subjects receiving large reward showed superior performance in all three measures relative to normal subjects receiving small reward. These results are consistent with the traditional assumption (e.g. Hull, 1952) concerning the role of reward magnitude, and data recently reported by Daly (1972). However, this data would appear to be in direct contradiction to data recently reported by McCain (1969, 1970, 1971). The studies reported by McCain (1969, 1970, 1971) indicated that reward magnitude differences did develop, however they were limited to the early portions of acquisition, dissipated as acquisition progressed, and were totally nonexistent after approximately 50 trials. One might raise the question as to why these discrepancies occurred. Although both the McCain (1969, 1970, 1971) and Daly (1972) studies used 6 trials per day and a 500 mg. reward magnitude for the large reward group, an apparent difference can be seen in the type measures recorded and reported. In the McCain

(1969, 1970, 1971) studies a total latency measure (mean median running time) was used, whereas Daly (1971) reported speed measures, and also reported group speeds for start, run and goal selections of the apparatus. The present study used the more typically encountered speed measure, and the results are consistent with those reported by Daly (1972).

Traupmann and Wong (1972) pointed to another possible reason that reward magnitude effects were not displayed in the McCain (1969, 1970, 1971) studies; satiation. Traupmann and Wong (1972) suggest that the receipt of 3,000 mg. (total) reward during an experimental session lasting only 36 minutes quite possibly satiated the large reward subjects. Thus, satiation in conjunction with the use of the median latency measure used by McCain (1969, 1970, 1971) may have artificially obscured reward magnitude effects. Obviously, satiation still remains a possible factor in the Daly (1972) study as she also used a total of 3,000 mg. reward. However, the use of the more sensitive speed measures, as noted above, apparently avoided the problems seemingly encountered by McCain (1969, 1970, 1971). Satiation would not appear to be a problem in the present study as only 600 mg. (total) reward was received by the large reward subjects during an experimental session.

On the other hand, the performance of the anosmic subjects during acquisition presents a strikingly different picture. In no measure did the large reward, anosmic

subjects show performance superior to that of the small reward, anosmic subjects. In fact, in one instance the start measure, where Group SS-A was found to be significantly superior to Group LS-A one might be tempted to hypothesize that large reward was even somewhat aversive. Similar, although nonsignificant, trends can be seen in the run and goal measures. Obviously, the effect of rendering the Ss anosmic had pronounced effects on their performance. These findings certainly are suggestive of possible avenues for further research.

Turning to the incentive shift phase, it can be seen from Figures 4-6 that a depression effect did not develop for either the normal or the anosmic subjects that were shifted from large to small reward. On first glance, this might be taken to indicate the absence of any supportive evidence for the odor hypothesis. However, a closer inspection of the data indicates the possible operation of odor cues. As noted in the results section the trial blocks X group interaction was significant in all three measures thus indicating a differential change on the part of one of the main groups (i.e., anosmics or normals). The results of the simple main effects analysis clearly point out two things with regard to this differential change during the incentive shift phase. First, the major changes shown during this phase are shown by the normal subjects. Both the shifted Ss (Group LS-R) and the control subjects (Group SS-R) show a reaction to the shift

in reinforcement which occurred for Group LS-R, thus suggesting the possibility that subjects in Group LS-R are indeed producing frustrative odor cues which are utilized by all normal subjects. Second, it is interesting to note that significant differences between the normal and anosmic subjects are shown as early as the first day of the incentive shift phase in the goal measure (i. e., the point of maximum frustration where odor would be expected to be produced most strongly). Thus, the results strongly suggest that odors are being produced and used by the normal subjects. Group LS-A subjects, however, do not show any appreciable difference in behavior during the incentive shift phase indicating that odor cues do indeed play an important role in determining responding under incentive reduction conditions.

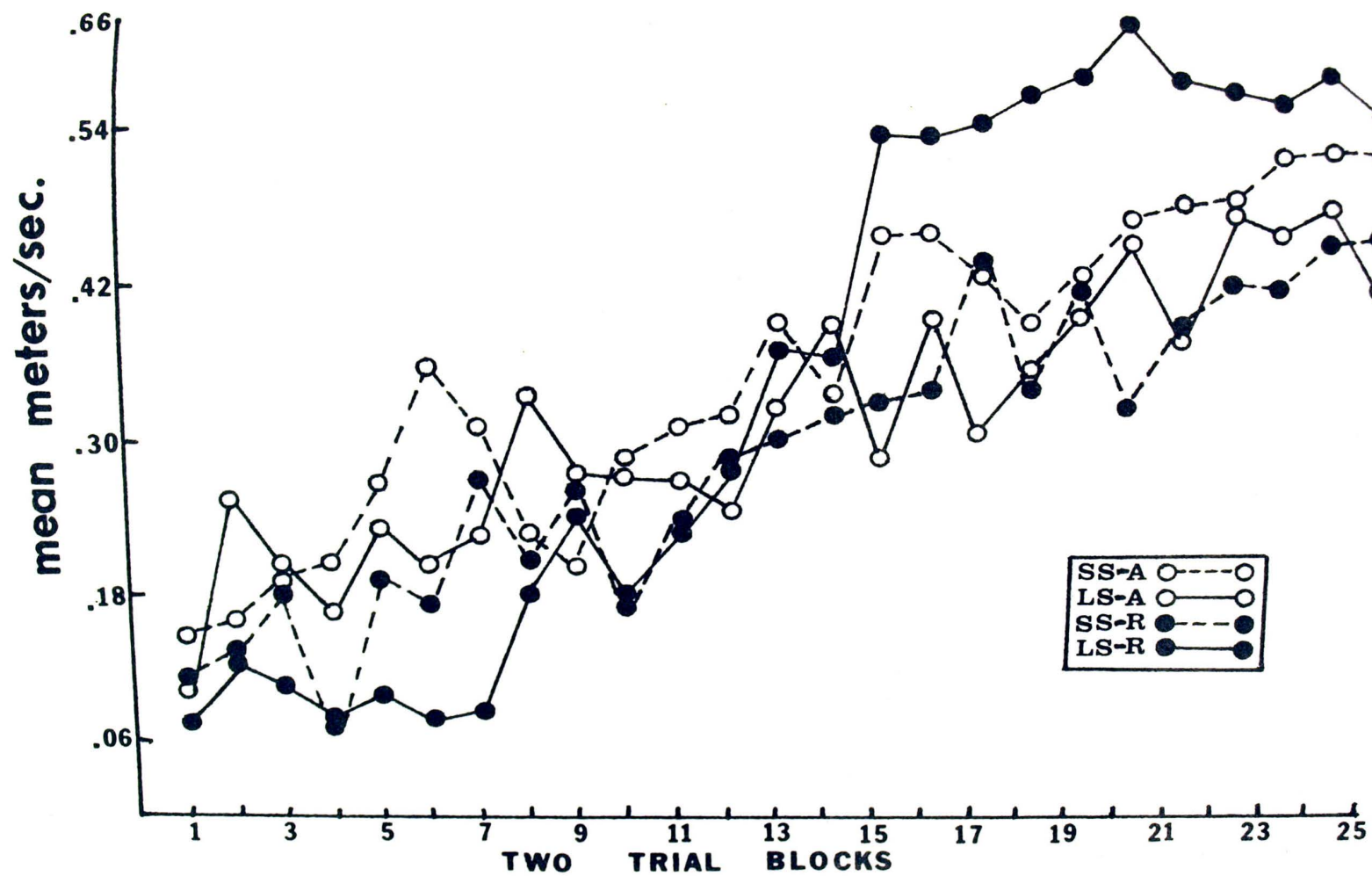
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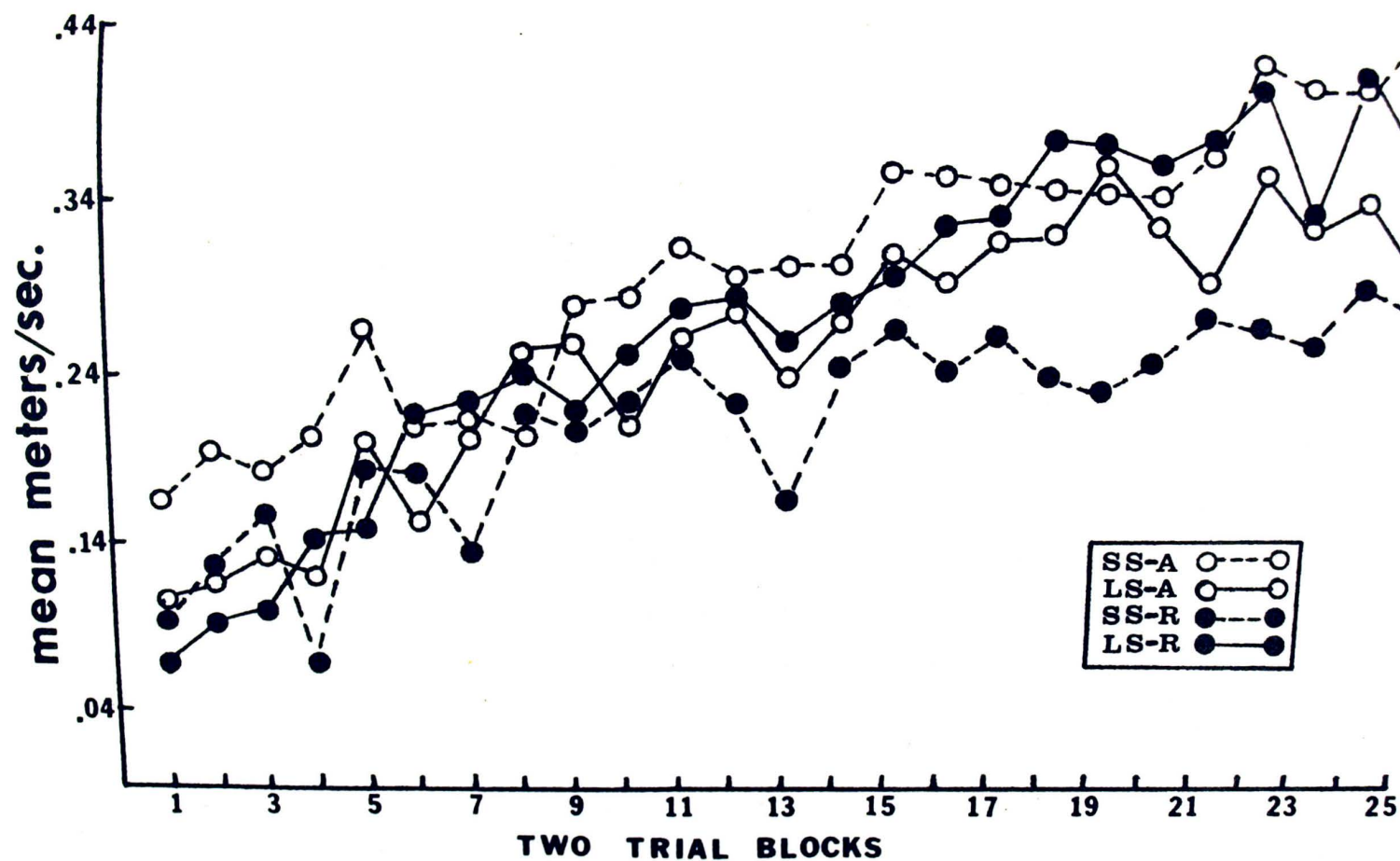
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## APPENDIX A: FIGURES

Fig. 1 - Mean Acquisition Start Speeds (meters per second)



**Fig. 2 - Mean Acquisition Run Speeds (meters per second)**



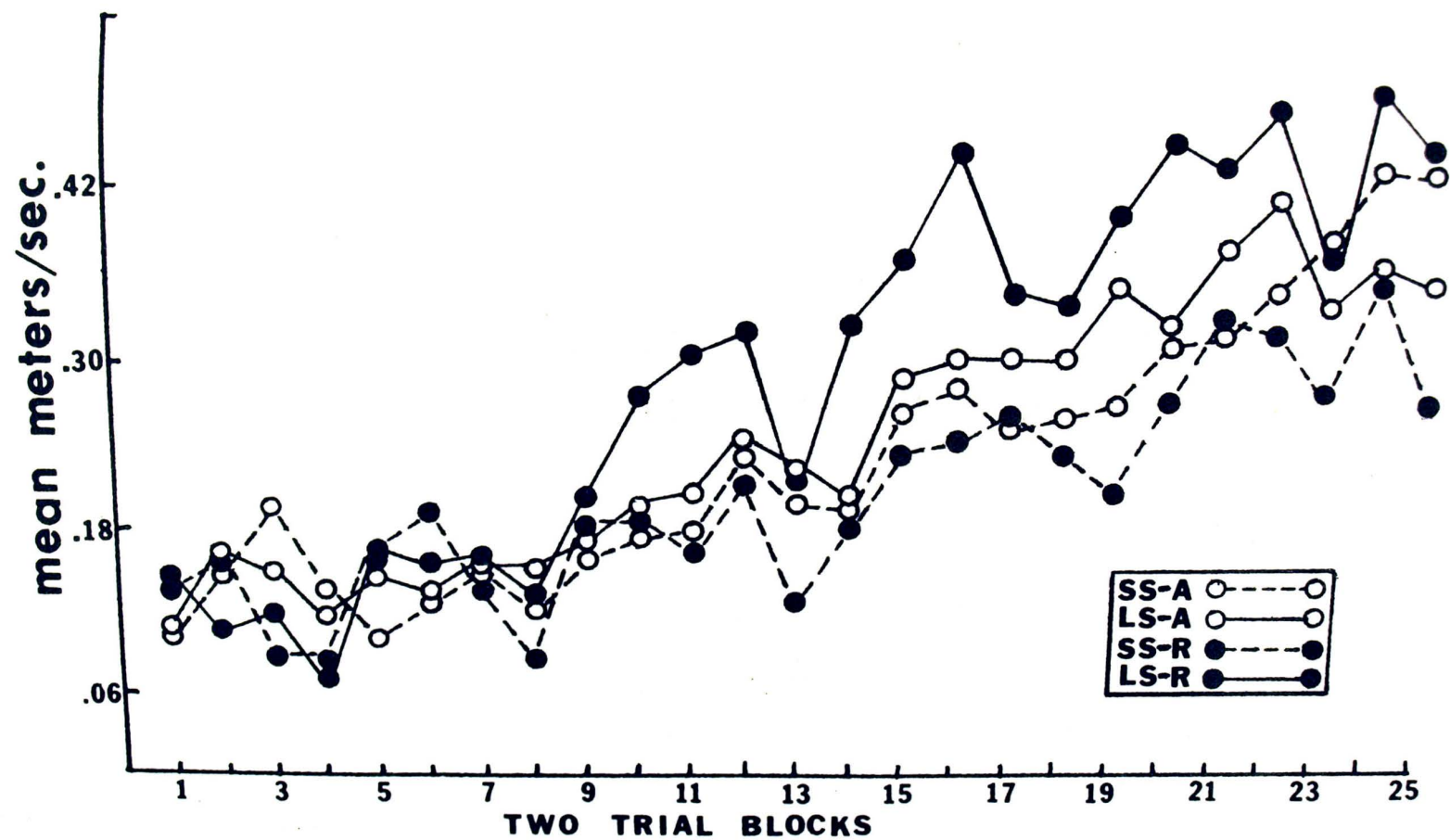


Fig. 4 - Mean Start Speeds (meters per second)  
at Terminal Acquisition and During  
Incentive Shift

**Fig. 3 - Mean Acquisition Goal Speeds (meters per second)**

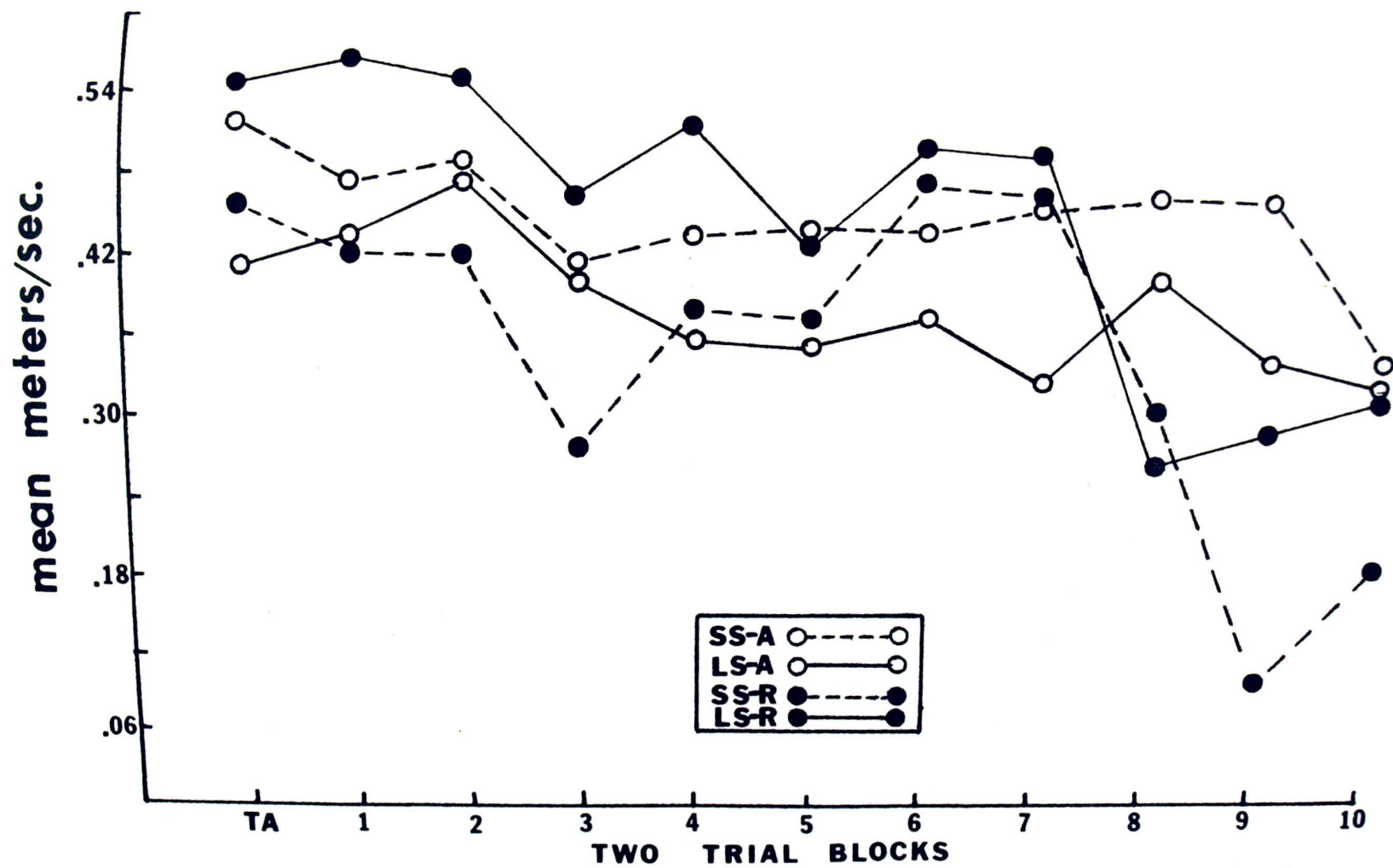


Fig. 5 - Mean Run Speeds (meters per second)  
at Terminal Acquisition and During  
Incentive Shift

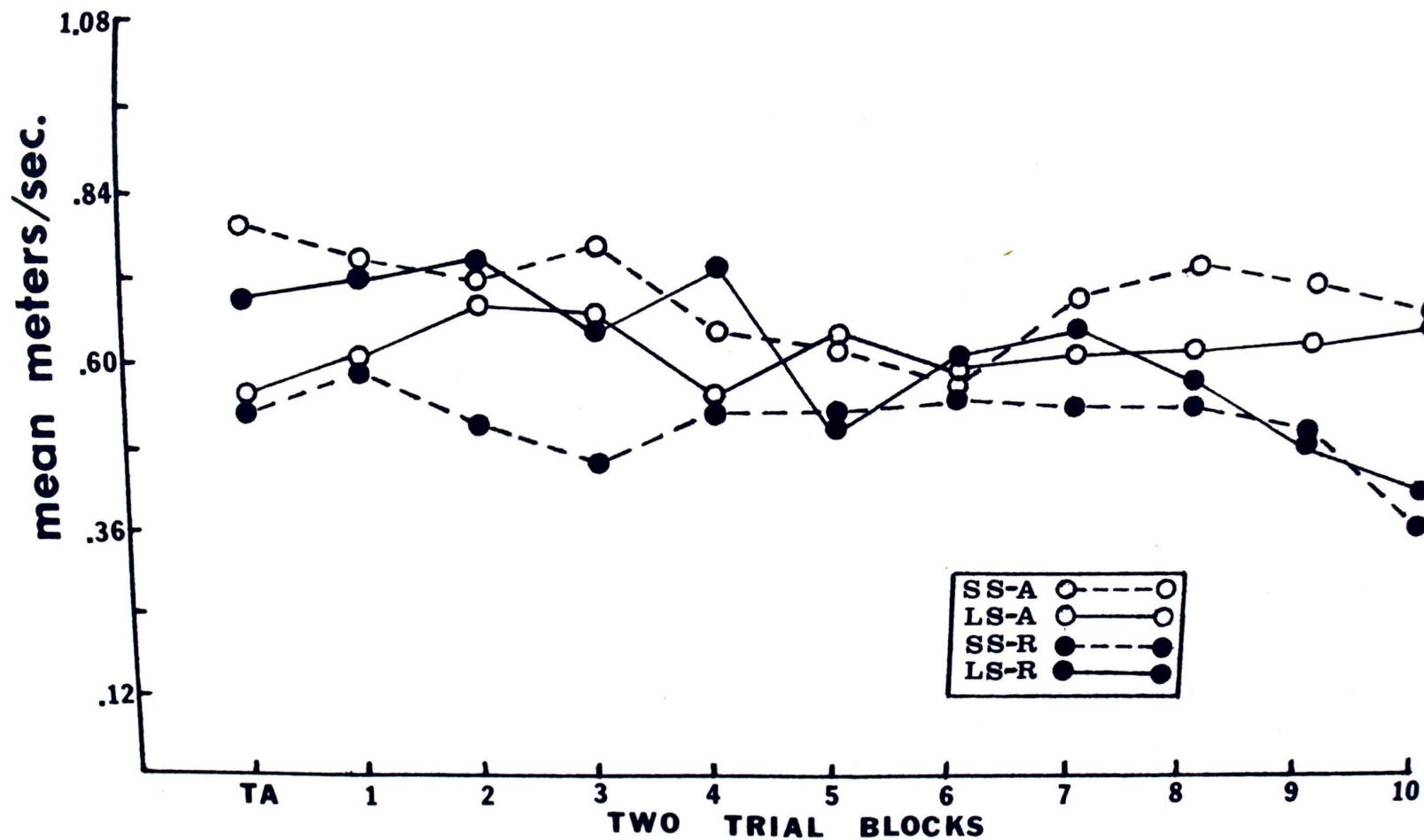
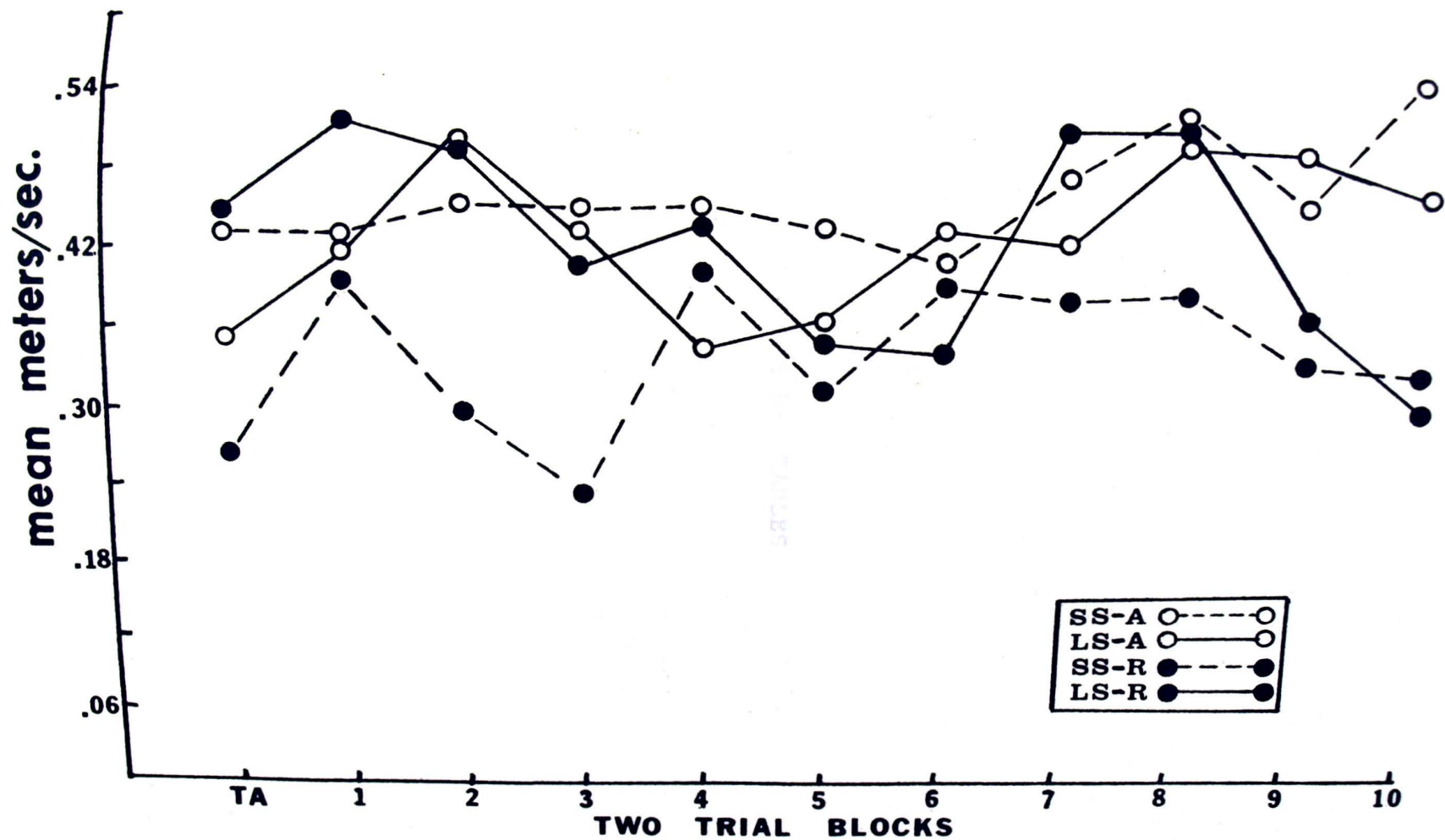


Fig. 6 - Mean Goal Speeds (meters per second)  
at Terminal Acquisition and During  
Incentive Shift



# Start Speed Analysis of Transition Phase

	SS	df	MS	F
Between Groups	11.15	19		
Within Groups	.36	1	.36	1.12
Total	11.51	20		
Between Groups	1.12	1	1.12	3.50
Within Groups	4.51	1	4.51	14.09**
Total	5.63	2		
Between Groups	5.16	16	.32	
Within Groups	9.47	120		

## APPENDIX B: TABLES

Between Groups	6	.071	.85
Within Groups	6	.05	.602
Total	6	.111	1.33
Between Groups	6	.01	.12
Within Groups	16	.083	

\*\*p < .01  
\*p < .05

Table 1. - Summary of Mean Start Speed Analysis of  
Variance - Acquisition Phase

Source	SS	df	MS	F
Between Subjects	11.15	19		
Anosmic vs Normal (A)	.36	1	.36	1.12
Small vs Large Reward (B)	1.12	1	1.12	3.50
A X B	4.51	1	4.51	14.09**
Subject Within Groups (error)	5.16	16	.32	
Within Subjects	9.47	120		
Trial Blocks (C)	.43	6	.071	.85
A X C	.30	6	.05	.602
B X C	.67	6	.111	1.33
A X B X C	.06	6	.01	.12
C X Subjects Within Groups (error)	8.01	96	.083	

\*\*p < .01

\*p < .05

Table 2. - Summary of Mean Run Speed Analysis of Variance - Acquisition Phase

Source	SS	df	MS	F
Between Subjects	8.95	19		
Anosmic vs Normal (A)	.45	1	.45	1.27
Small vs Large Reward (B)	.22	1	.22	2.59
A X B	2.27	1	2.27	6.135*
Subject Within Groups (error)	6.01	16	.37	
Within Subjects	3.16	120		
Trial Blocks (C)	.20	6	.033	1.24
A X C	.16	6	.026	1.04
B X C	.34	6	.056	2.24
A X B X C	.02	6	.003	.12
C X Subject Within Groups (error)	2.44	96	.025	

\*\*p < .01  
\*p < .05

Table 3. - Summary of Mean Goal Speed Analysis of Variance - Acquisition Phase

Source	SS	df	MS	F
Between Subjects	21.50	19		
Anosmic vs Normal (A)	.01	1	.01	.01 <sup>17</sup>
Small vs Large Reward (B)	2.09	1	2.09	2.24 <sup>17</sup>
A X B	4.39	1	4.39	4.72*
Subject Within Groups (error)	15.01	16	.93	
Within Subjects	9.35	120		
Trial Blocks (C)	1.31	6	2.18	3.114**
A X C	.35	6	.058	.82 <sup>47**</sup>
B X C	.51	6	.085	1.21 <sup>63</sup>
A X B X C	.37	6	.061	.87 <sup>76</sup>
C X Subject Within Groups (error)	6.81	96	.07	

\*\*p < .01  
\*p < .05

Table 4. - Summary of Mean Start Speed Analysis of Variance - Shift Phase

Source	SS	df	MS	F
Between Subjects	33.71	19		
Anosmic vs Normal (A)	.217	1	.217	.117
Small vs Large Reward (B)	.217	1	.217	.117
A X B	3.44	1	3.44	1.84
Subject Within Groups (error)	29.84	16	1.86	
Within Subjects	39.21	180		
Trial Blocks (C)	8.71	9	.968	5.834**
A X C	4.70	9	.522	3.147**
B X C	1.08	9	.120	.663
A X B X C	.717	9	.079	.476
C X Subject Within Groups (error)	23.99	144	.166	

\*\*p < .01  
\*p < .05

Table 5. - Summary of Mean Run Speed Analysis of Variance - Shift Phase

Source	SS	df	MS	F
Between Subjects	13.53	19		
Anosmic vs Normal (A)	1.29	1	1.29	1.82
Small vs Large Reward (B)	.058	1	.058	.08
A X B	.822	1	.822	1.16
Subject Within Groups (error)	11.36	16	.71	
Within Subjects	8.36	180		
Trial Blocks (C)	.888	9	.099	2.538*
A X C	1.09	9	.121	3.102*
B X C	.212	9	.023	.589
A X B X C	.518	9	.058	1.487
C X Subject Within Groups (error)	5.65	144	.039	

\*\*p < .01  
\*p < .05

Table 6. - Summary of Mean Goal Speed Analysis of  
Variance - Shift Phase

Source	SS	df	MS	F
Between Subjects	25.62	19		
Anosmic vs Normal (A)	2.28	1	2.28	1.70
Small vs Large Reward (B)	.383	1	.383	.285
A X B	1.467	1	1.467	1.09
Subject Within Groups (error)	21.49	16	1.34	
Within Subjects	20.14	180		
Trial Blocks (C)	2.15	9	.239	2.489*
A X C	2.32	9	.258	2.68**
B X C	1.45	9	.162	1.68
A X B X C	.363	9	.04	.417
C X Subject Within Groups (error)	13.84	144	.096	

\*\*p < .01  
\*p < .05