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THE INTERACTION OF DELAY AND MAGNITUDE OF REWARD ON ACQUISITION AND EXTINCTION IN THE STRAIGHT ALLEY RUNWAY

A Thesis
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In Partial Fulfillment
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Master of Arts

by
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This thesis, written and submitted by

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Table of Contents

Chapter

Page

List of Figures

I. Introduction

When a rat is placed on a runway and food is at the end of the alley, it is safe to assume that he will learn to run the alley for the reward of food. However, there are many factors that can be varied to affect his performance (overt evidence of learning) in the runway. In this experiment, the performance of the subjects will change by varying the size of the reward or by varying the delay of the reward. Specifically, as the amount of reward at the end of the alley is increased, the speed of running the alley is increased; and as the delay of reward is increased, the speed of running the alley is decreased (Thorndike, 1898; Pubols, 1960).

Numerous studies have been concerned with rates of acquisition and extinction under different amounts of magnitudes and frequencies (percentages) of reward, while only a few have been concerned with delay of reward. The purpose here is to predict behavior when magnitude and delay of reward are varied independently.

<u>The effect of reward magnitude on runway performance</u>. In a review of literature concerned with the effect of reward magnitude on runway performance (Pubols, 1960), it was concluded that "acquisition performance is an increasing function of the reward magnitude (p. 11)." Others have confirmed Pubols' conclusion (Armus, 1959; Pavlik and Reynolds, 1960; Hill and Spear, 1963; Clayton and Koplin, 1964; Ratliff, 1965).

Pubols' review is also concerned with the effect of magnitude of reward on extinction. He states that "the magnitude of reward affects resistance to extinction indirectly through differences in terminal levels of reward performance (p. 111)." So it would follow that animals given large magnitudes of reward during acquisition have more resistance to extinction. Yet in an earlier study, Zeaman (1949) found that animals given small reward magnitudes were more resistant to extinction. Studies done since Pubols' review support Zeaman's findings (Hulse, 1958; Armus, 1959; Lawson, *et al*, 1959; Wagner, 1961).

The interaction of delay and magnitude of reward on runway performance. Davenport (1962) presented learning curves for amount versus delay of reward. Choices showed the initial preference for the larger amount, yet the final preference was for the shorter delay. Logan (1965) found comparable results but not enough to confirm Davenport's (1962) findings. However, Logan (1965) states that there is reason, from his data, to believe that amount of reward did control earlier choices. No mention as to the rate of learning the correct choices was made, whereas Hill and Spear (1963) have shown that the rate of learning depends on the difference in the amount, between two choices, when either the smaller or larger choice is held constant across groups.

Purpose of the present study. The purpose of this study is to clarify and accurately describe the interactive effects of several amounts of reward and delay on acquisition and extinction of rats in a straight runway. A factorial study involving several levels of reward and delay is presented to further describe and possibly predict what effects these independent variables have on learning curves.

The major purpose of this paper, then, is to determine the interactive effects of delay and magnitude of reward, and to present the results in a clarifying and informative manner.

II. Method

Subjects. Forty-five 90 day old, experimentally naive, female, albino rats of the Sprague-Dawley strain, with initial weights of 100-150 grams were used for the study. The animals were kept on a 23 hour food deprivation schedule. The weight fluctuation throughout the study was less than 10 grams (refer to Figure 1). The deprivation level was determined by the amount of weight loss at the start of the deprivation schedule. Free access to water was permitted except during the running sessions.

Apparatus. Figure 2 represents the straight alley runway sixty inches long which was used to measure response latencies. The start box (SB), 12 inches long, the goal box (GB), 12 inches long, and the alley, 36 inches long, had plexiglass sides and top. The floor and back were constructed of pressed unfinished hardboard. The inside dimensions were 4½ inches deep and 5 inches wide throughout.

Cramer clocks (.01 sec.) were used to measure the running latencies in three separate segments of the runway. The location of the photocells in the runway for clock triggering were at 4, 25, and 41 inches from the SB door. The times recorded were SB latencies, from the time the animal orients to the SB door to 4 inches in the runway. Runway latencies were measured from the time the animal broke the photoelectric beam of the second clock, two-thirds the distance down the runway. Goal box response times were measured from the time the animal takes to tranverse the last 15 inches of the runway plus 5 inches into the GB, breaking the photoelectric beam of the third clock.

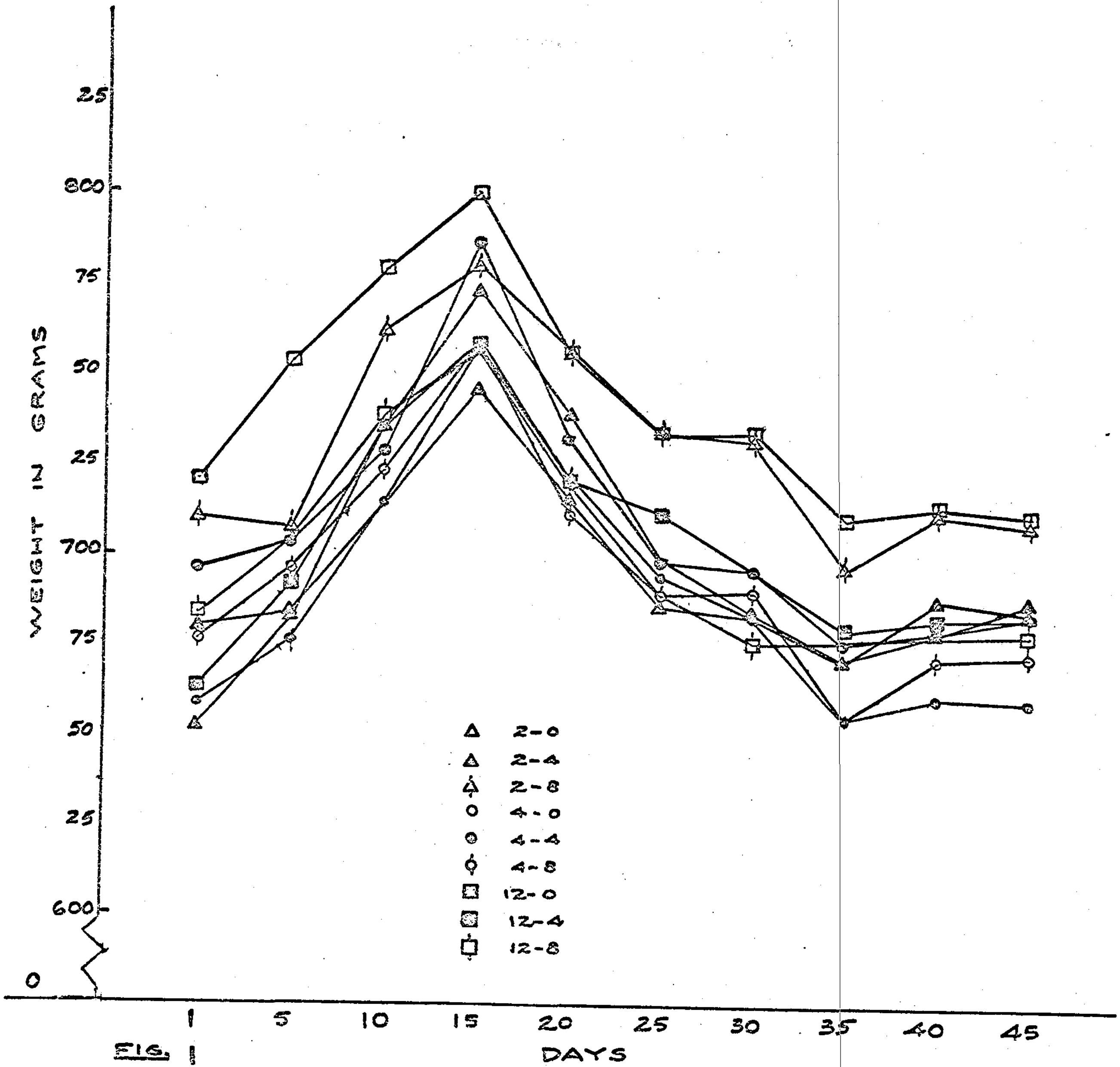

FIG. 1

ANIMAL WEIGHTS FOR DURATION OF ACQUISITION AND EXTINCTION

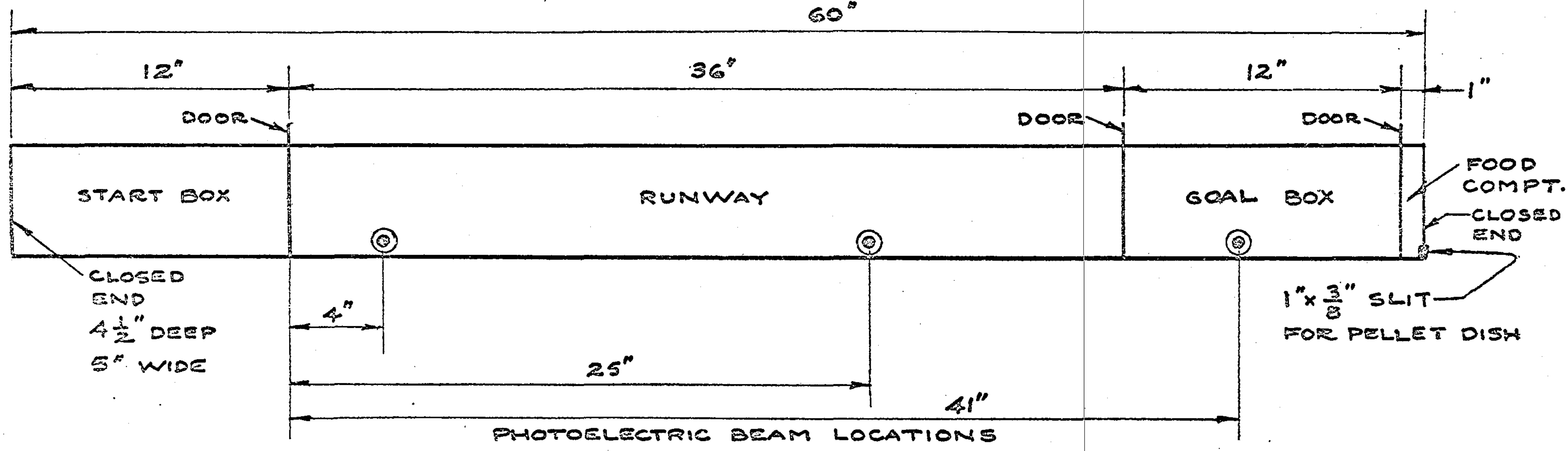

FIG. 2

FRONT VIEW OF STRAIGHT ALLEY RUNWAY

Design. A 3 X 3 (3 space X space 3) factorial paradigm combining three magnitudes, 2, 4, and 12, 4.5 mg. Noyes pellets, with three reward delays of 0, 4, and 8 seconds after entering the GB was used. There were five animals randomly assigned to each cell. The values of these two parameters were chosen in order to examine a specific area within the continuum of reward parameters under which animals were known to have successfully performed.

Prehandling. Seven days prior to the first experimental day, the animals, on deprivation diet, were allowed to run freely in an open field box for 2 minutes each day. Prehandling consisted of picking each animal up every 15 seconds, and then holding it for 5 seconds each of the 7 days. During the time allowed in the open field box, the animals were presented with five 4.5 mg. Noyes pellets to eat; the uneaten pellets were returned to the home cage with the animal. The daily food ration was administered 30 to 45 minutes after the prehandling and the experimental sessions.

Acquisition. Acquisition began 24 hours after prehandling was terminated. One trial per day was run for each animal. The animals were placed in the SB, the GB door opened, and the SB door opened when the animal oriented toward it. Immediately upon the animal's exit from the SB, the door was closed to prevent retracing, and following the animal's entrance into the GB, the GB door was closed. Depending on the animal's experimental condition, the food compartment (FC) door was opened at the same time as the GB door (immediate reward groups) or the FC door was closed (4 or 8 seconds) in order to administer the delay effect. The animals were allowed to eat all of the pellets before being returned to the home cage.

There were six animals which failed to leave the SB on five consecutive trials within a 2 minute interval after the SB door was opened. These animals were then dropped from the study and replacements introduced.

Acquisition was terminated when asymptotic performance levels were attained in all nine groups as assessed individually; this happened to have occurred at the forty-first trial. Acquisition performance was determined at the point where the latency time no longer decreased (running speed increase) over a specified number of trials (a leveling of the response curve).

Extinction. During extinction each animal was run once a day, as in acquisition. All conditions remained identical to the conditions during acquisition except for the absence of the food pellets in the FC.

Three consecutive failures to enter the GB within thirty seconds was the extinction criterion. Each animal was discarded upon reaching that criterion. Extinctions ceased for all animals at 30 trials.

III. Results

Analysis of data. All running latencies for acquisition were first converted to reciprocals and an analysis of variance (Lindquist, 1953) was computed on all three clocks separately. For extinction data, as a whole, an Anderson transformation (Anderson, 1964) was computed because of the different levels of performance reached by the various groups at acquisition asymptote. With the help of the Anderson transformation, the varying number of trials and levels of performance were equated so that an analysis of variance could be properly applied to the extinction data. There was no slope analysis performed in this study. The various groups will be designated as follows: Group I, 2 magnitude, Group II, 4 magnitude, Group III, 12 magnitude.

Start box latency (C-1). Figure 3 represents the latency response curves for all groups leaving the start box.

An analysis of variance indicated that there were significant differences among all groups for delay, magnitude, and interaction of delay and magnitude across trials [delay $F = 5.3$, $p < .001$, magnitude $F = 13.0$, $p < .001$, interaction $F = 6.0$, $p < .001$].

Group II and Group III appeared to interact at the delay of 8 seconds for reward (refer to Figure 4). Group II ran slower at 4 seconds delay than Group III. However, when the delay was increased to 8 seconds, Group III ran slower than Group II. It appears that four pellets at 8 seconds delay was more rewarding, as assessed by shorter latency than twelve pellets at 8 seconds delay. Further examination of Figure 4 shows that Group III at 0 and 4 seconds delay performed

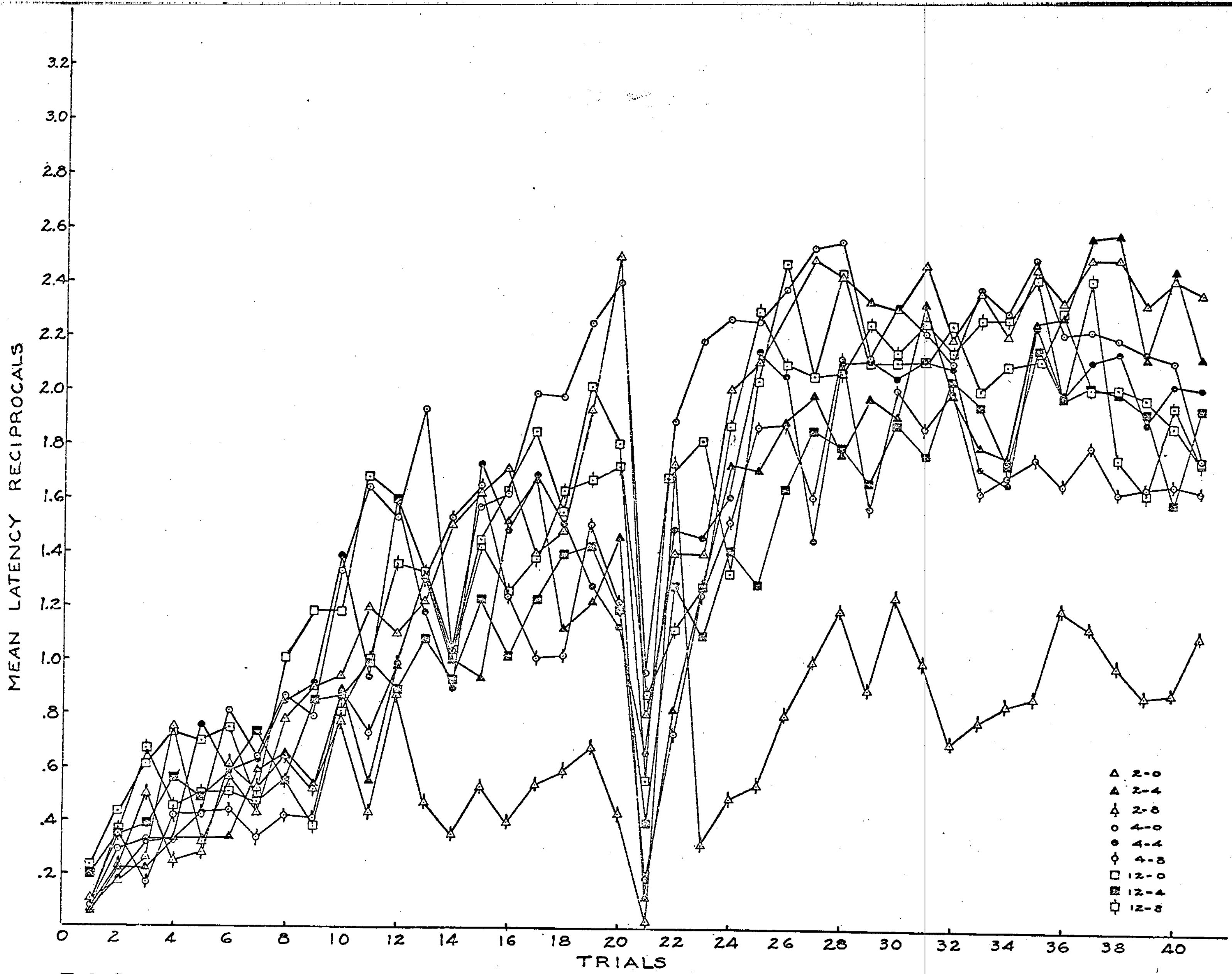

FIG 3

RECIPROCAL OF MEAN LATENCY FOR START BOX TIME IN .01 SECONDS DURING ACQUISITION

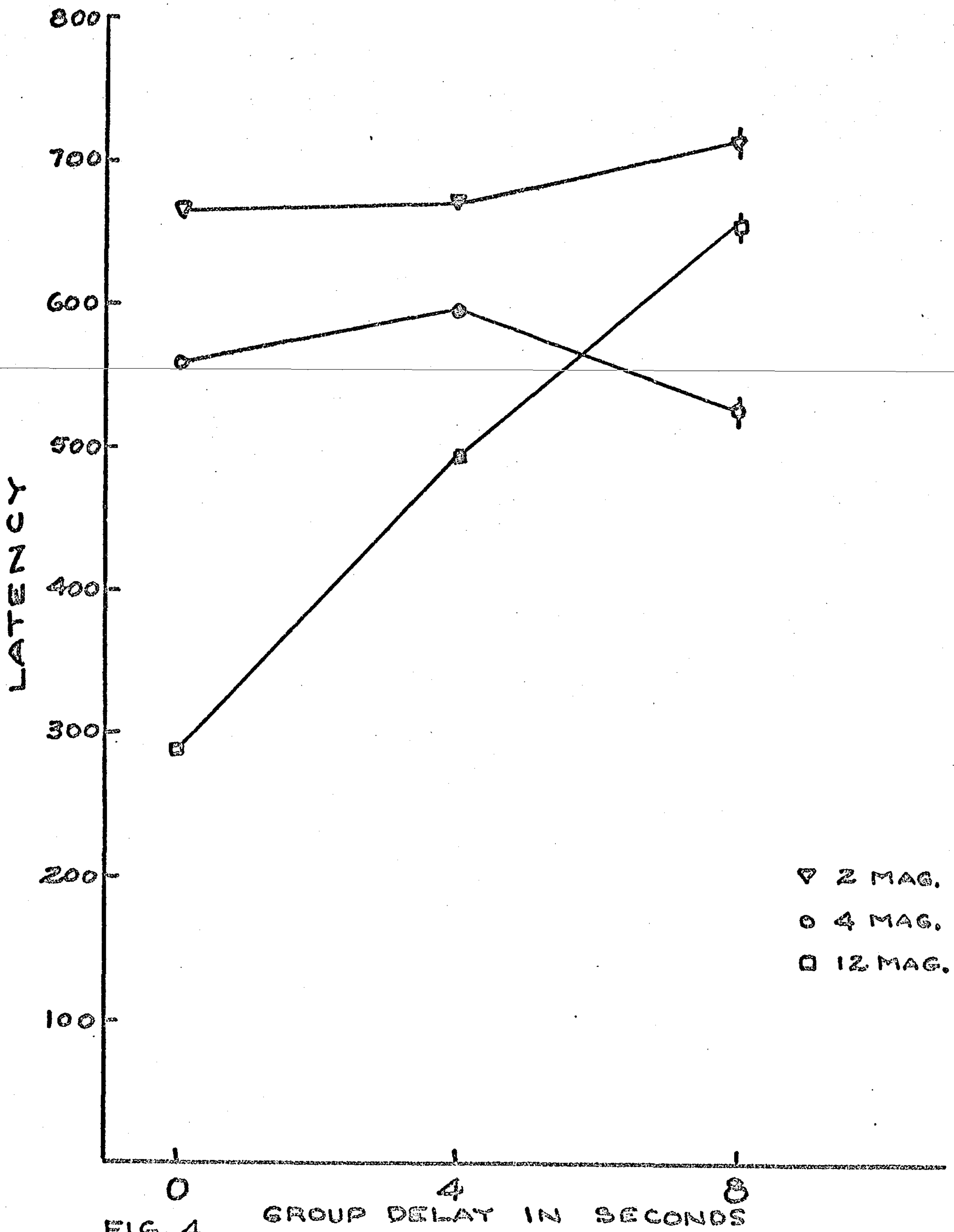

FIG. 4

INTERACTION OF MAGNITUDE AND DELAY OF REWARD DURING EXTINCTION FOR START BOX TIME better than Group II, yet possible competing responses or frustration components could have entered in when the reward delay was increased.

Runway latency (C-2). Figure 5 represents the latency response curves for all groups traversing the runway. The analysis indicated that there was no significant difference between any of the groups across trials [delay $F = 2.8$, magnitude $F = 2.6$, interaction $F = .6$].

The lack of significant difference and interaction (refer to Figure 6) between the groups indicates that mid-runway performance is not as instructive of the effects of delay and magnitude of reward on strength and rate of learning as start box or goal box latencies.

Goal box latency (C-3). Figure 7 represents the latency response curves for all groups entering the goal box.

The analysis indicated that there were significant differences between all groups across trials [delay $F = 4.4$, $p < .05$, magnitude $F = 5.3$, $p < .01$, interaction $F = 147.0$, $p < .001$].

After careful examination of the curves, it becomes evident that the significant differences among groups is actually caused by Group III. Group III at 4 seconds delay shows a great increase in latency from the zero delay conditions. Aside from this great reduction in performance of Group III there is a slight difference between groups, again suggesting that interaction of Group II and Group III at the 4 second delay point (Refer to Figure 8).

Throughout the runway acquisition, the performance of Group I was lower (slower latency) than either of the other groups with little significant effect due to delay.

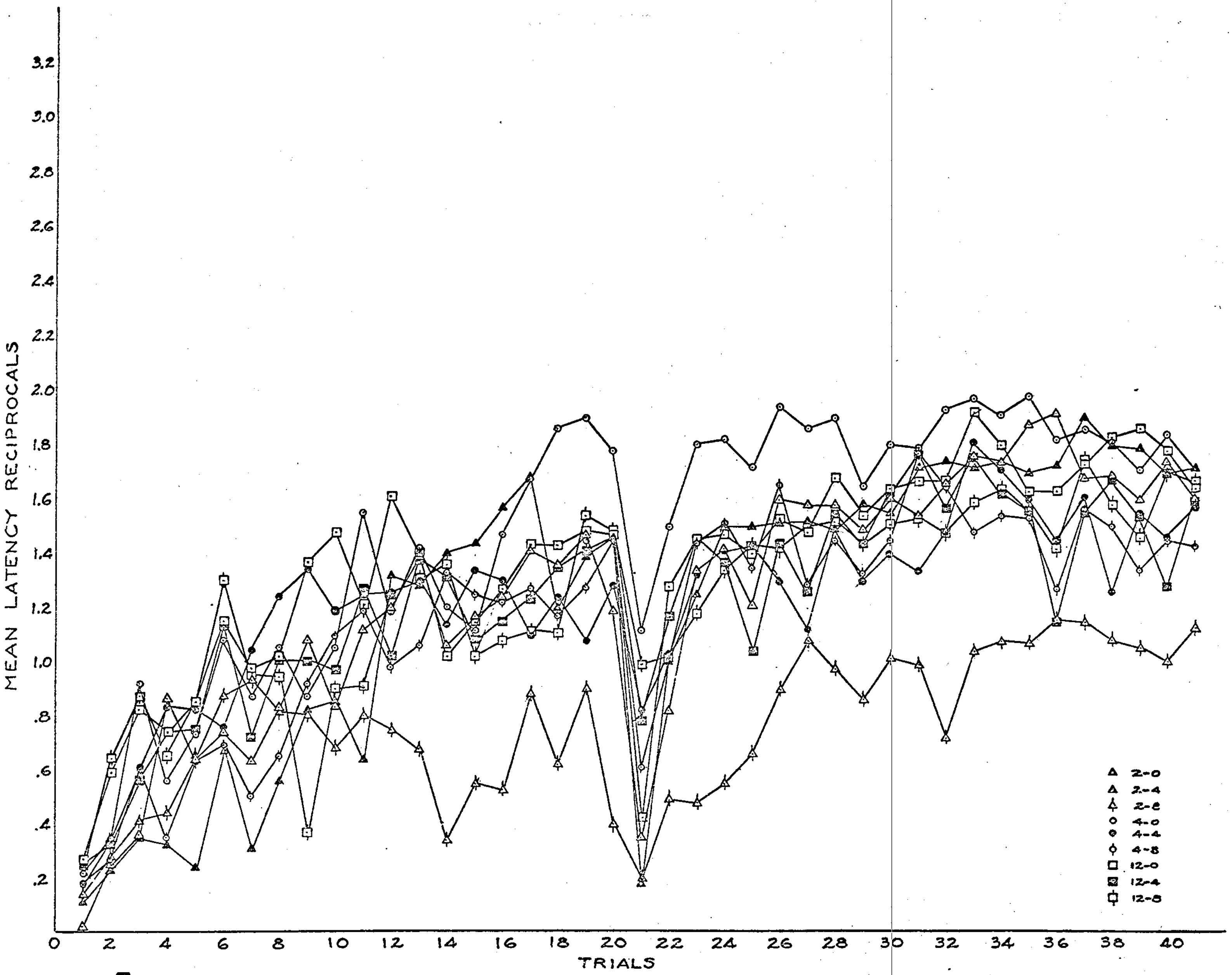

FIG. 5

RECIPROCAL OF MEAN LATENCY FOR RUNWAY TIME IN .01 SECONDS DURING ACQUISITION

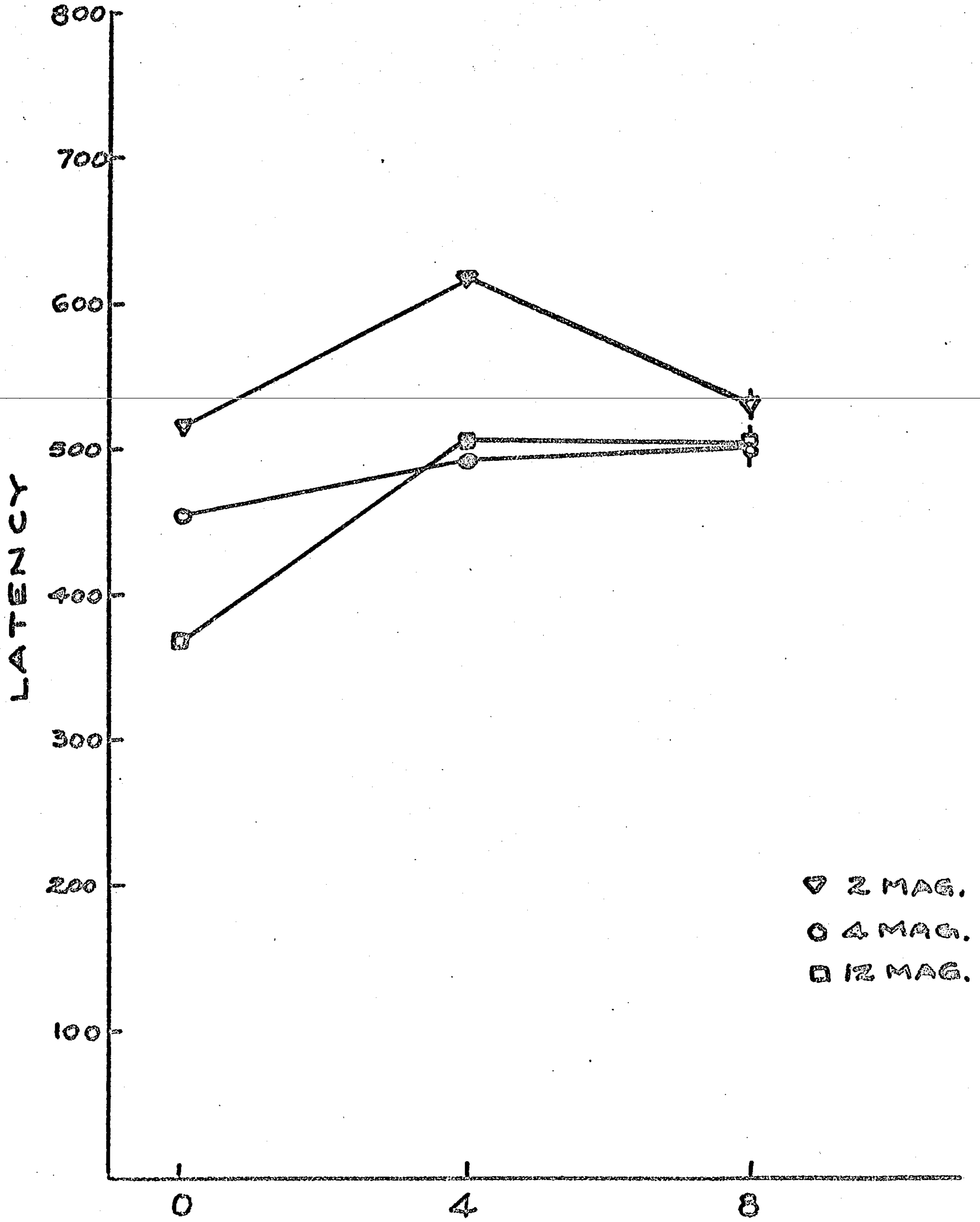

FIG. 6

INTERACTION OF MAGNITUDE AND DELAY OF REWARD DURING EXTINCTION FOR RUNWAY TIME

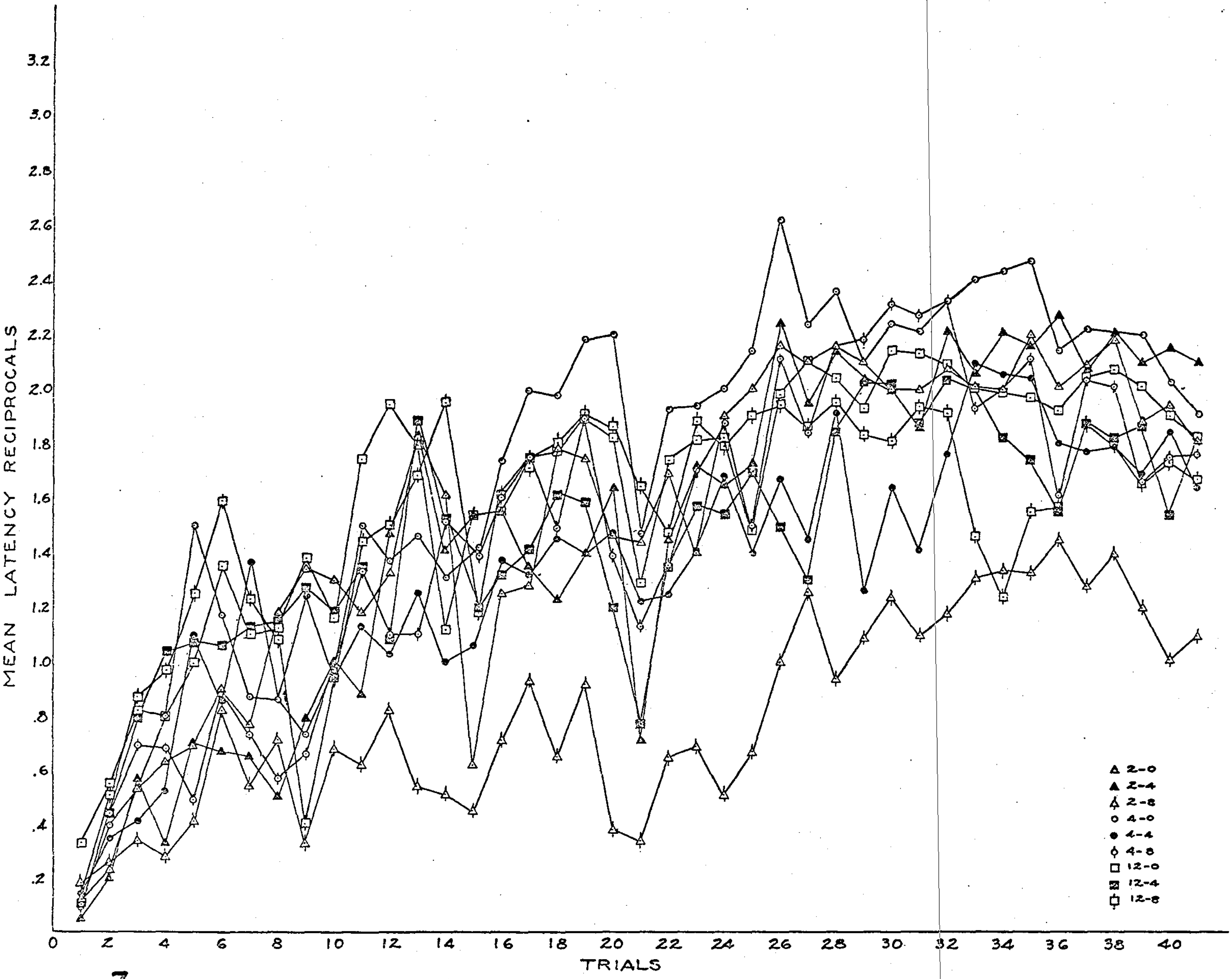

FIG. 7

RECIPROCAL OF MEAN LATENCY FOR GOAL BOX TIME IN .01 SECONDS DURING ACQUISITION

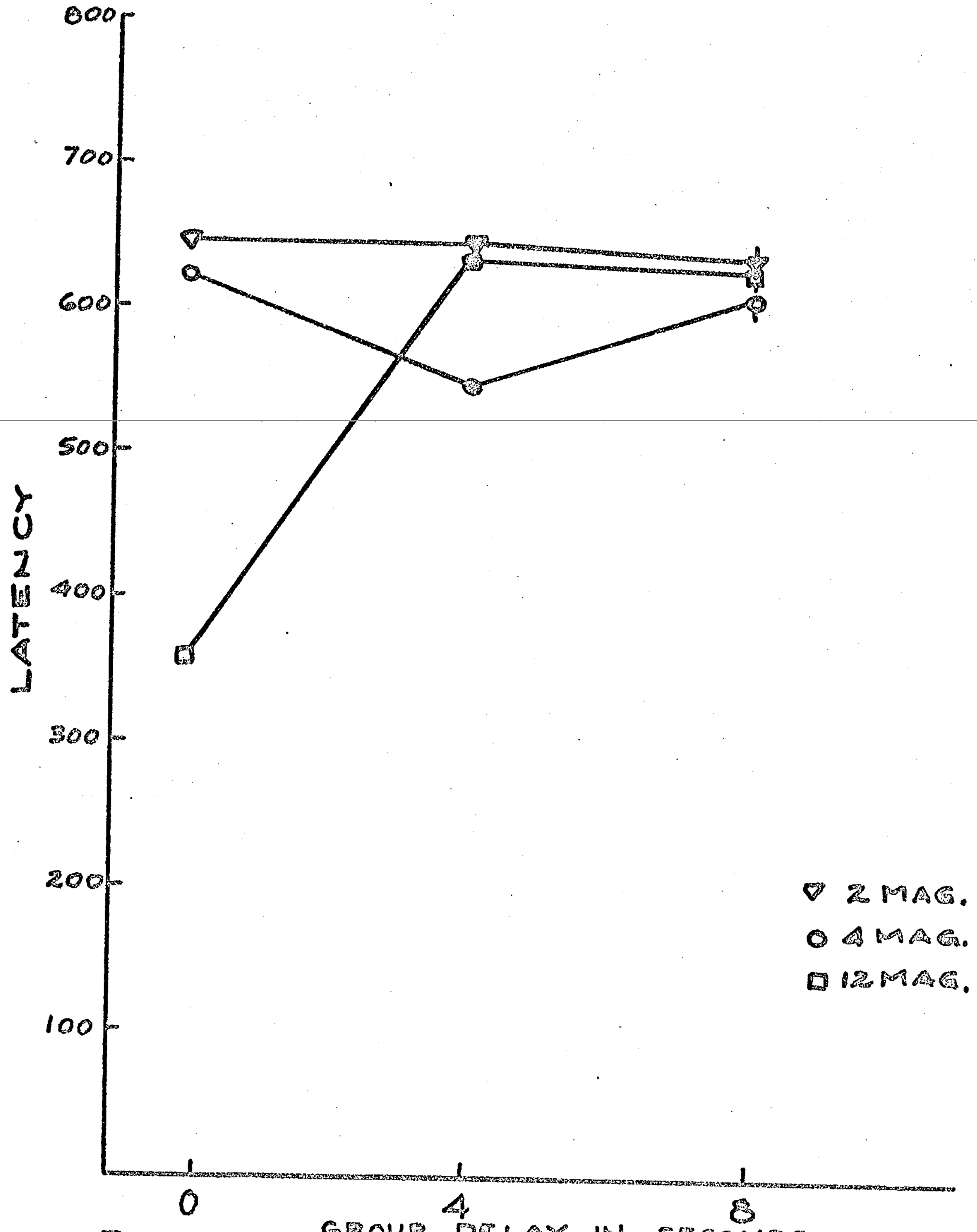

FIG. 8

INTERACTION OF MAGNITUDE AND DELAY OF REWARD DURING EXTINCTION FOR GOAL BOX TIME

Extinction. Figure 9 represents the latency response curves for extinction.

Through analysis of variance, there appeared to be no significant difference among the groups across trials. Although there was no statistical significance, through visual inspection of the curves, Group II appeared to interact with both Groups I and III. Group II appeared to be more resistant at a delay of 8 seconds than either Group I or III, yet slower and less resistant at delays of 0 and 4 seconds. Generally, Group I was less resistant than Group III; however, at delays of 8 seconds, Group III was much more resistant to extinction than at a delay of 0 or 4 seconds.

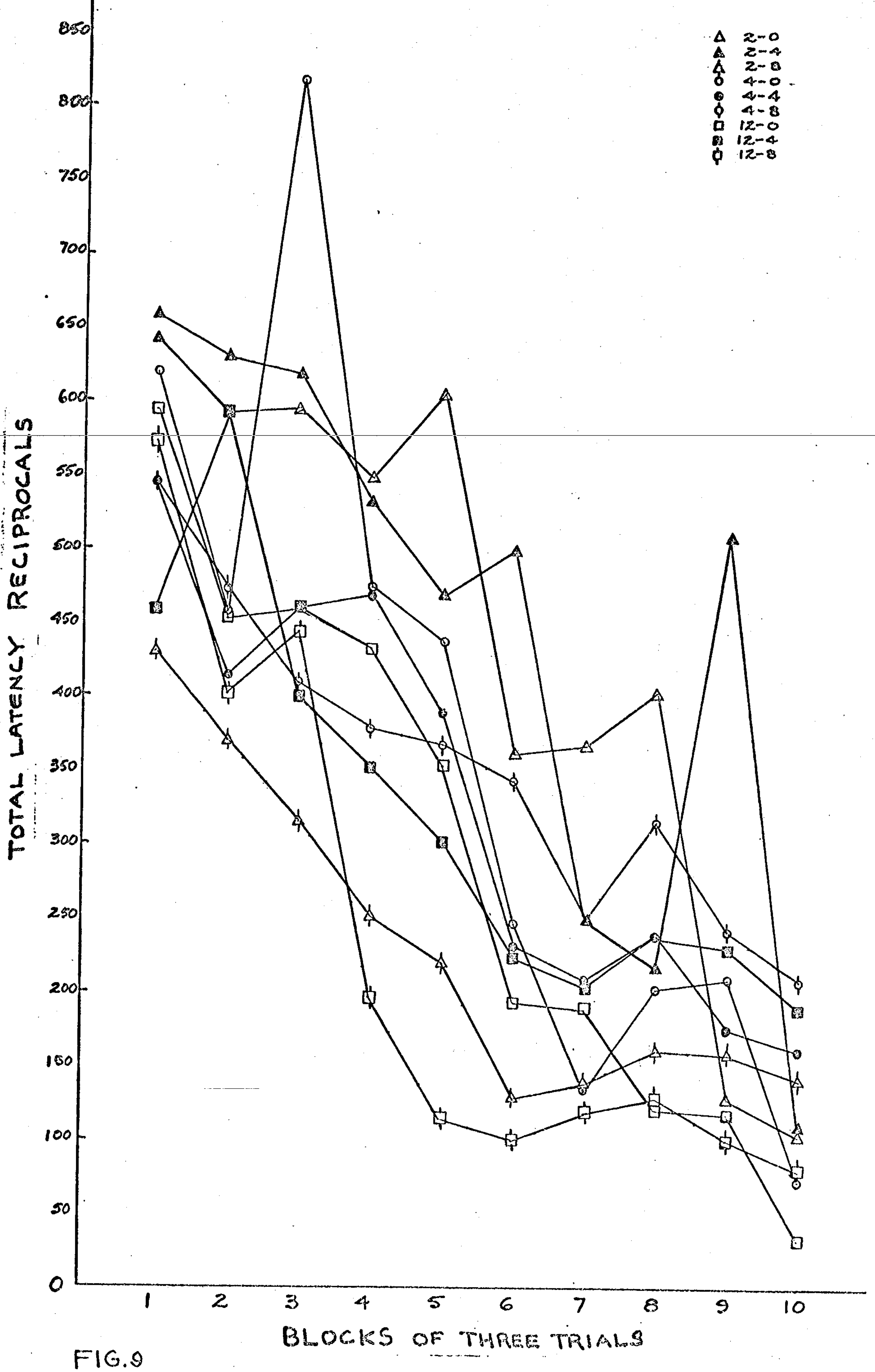

FIG.9
RECIPROCAL OF MEAN LATENCY FOR TOTAL TIME IN .01
SECONDS DURING EXTINCTION

IV. Discussion

The main point indicated by the present results is that when delay of reward varies (either increased or decreased) in the same direction as magnitude of reward a balance of performance level should be reached. Davenport (1962) showed that "equal reinforcement contours indicated that to balance a unit increased in delay of reward in a two-choice spatial discrimination task, there should be a log unit increase in magnitude of reward." However, in the apparatus that measures latency times as performance levels (present study) rather than choices, Davenport's results become inapplicable. It was found that Logan's (1960, pp. 251-253) "relative quantification" applies much more adequately to the present results. Logan's "relative quantification" deals with the increased ratios of delay and magnitude variables. The important balance point in Logan's results (1965) was in the delay range of 5 to 15 seconds and magnitude of one to three Noyes pellets. In this study the important values seemed to be both the 12 magnitude, 4 and 8 second delay groups, and the 4 magnitude, 4 and 8 second delay groups.

Admittedly, delay is a much more complex variable than magnitude and similarly has a much more serious effect on performance than magnitude. The data from the start box latency show that the 4 magnitude group at 8 seconds delay is superior in performance to the 12 magnitude group for the same delay. It appears that waiting 8 seconds for 12 pellets is less rewarding than waiting 8 seconds for 4 pellets.

There are also similar results (although not quite as striking as the start box data) for the goal box latency. These data seem to be contrary to what Thorndike's law of effect predicts and what common sense would expect. To explain this discrepancy, secondary reinforcement enters into the discussion.

On each trial there are stimuli associated with running down the runway and either being rewarded immediately or having to wait for the prescribed delay for the reward which enter into the store of associated stimuli. The normal stimuli such as color, smell, and the feel of the runway are soon associated with the runway and its reward. There are also sensations which can be referred to as negative stimuli, namely confinement (Hulse, 1958). The confinement of the goal box can be considered as negative stimuli which would become associated with the goal box upon leaving the start box and entering the goal box. Referring back to the graphs in the results, the performance of the 12 magnitude, 4 delay group is superior to either the 12 magnitude, 8 delay and 4 magnitude, 4 delay groups; they are sufficiently rewarded to offset the confinement of the goal box. Yet when the delay is increased to 8 seconds for the 12 magnitude group, the performance falls; the 4 magnitude, 8 delay group performance is superior. It can be explained by the negative effect of the total time of confinement in the goal box (to wait 8 seconds and eat twelve pellets as opposed to eating only four pellets). The 4 magnitude, 8 delay group spends the same amount of time waiting in the goal box but does not develop these negative secondary reinforcers. The reward magnitude of 4 does not require the same confinement time as the 12 magnitude reward group for eating.

Extinction data follow along according to theory and the results of other studies, except for the 4 magnitude, 8 delay group (refer to Figure 9). The results indicated that the 4 magnitude, 8 delay group is more resistant to extinction than the 12 magnitude, 8 delay group and the 2 magnitude, 8 delay group. Again, we can use the idea of secondary reinforcement to explain the results. The 4 magnitude, 8 delay group spends less total time in the goal box confinement than the 12 magnitude, 8 delay group and is also more greatly rewarded for its confinement than the 2 magnitude, 8 delay group; therefore, the 4 magnitude, 8 delay group does not have as great a negative secondary reinforcement associated with the goal box.

The next step in this exploration of the interaction of delay and magnitude of reward on learning (acquisition and extinction) is to again limit the variables around Logan's prescribed values of "relative quantification" in order to better predict the interactive relationship of these two variables.

Summary

A three by three factorial study involving three levels of reward and three levels of delay was performed in order to describe the interactive effects of magnitude and delay of reward. Using a straight alley runway in order to measure latency performance, forty-five Sprague-Dawley rats were given forty-one acquisition trials and thirty extinction trials. The most significant difference occurred within the group receiving the largest reward magnitude at 4 and 8 seconds delay. In addition, it was noted that the group receiving the smallest reward magnitude performed at slower latencies than either of the other two groups. The results are explained through the concept of negative secondary reinforcement, namely confinement within the goal box which served to increase latencies.

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