SATIATION LEARNING: ONE TRIAL PER DAY

Thesis for the Degree of M. A.

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ABSTRACT

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The problem which this research was designed to investigate can be stated in two parts: (1) Can stimulus satiation mediate avoidance learning when highly spaced "forced" trials are administered to one side of a T-maze? (2) If so, what is the function which relates the number of forced trials to the learned satiation effect (Ss' preference for the opposite side).

Sixty albino female rats were randomly assigned to five independent groups receiving either 0, 2, 6, 12 or 20 forced reward trials to one side of an enclosed T-maze, with an ITI of 24 hours. One day after the last forced trial a series of 10 free test trials was initiated. On these free trials the reward was on the same side as on the forced trials; the free trials were also administered with an ITI of 24 hours.

A significant persistent preference for the opposite side was found in Groups 6, 12 and 20 on the 10 free trials,

supporting the notion that stimulus satiation can act as a mediator for avoidance learning when highly spaced forced trials are given to one side of the maze. The most persistent preference occurred in the group that received 6 forced trials. In other words, a curvilinear relationship was found between the number of forced trials and the number of visits to the previously unvisited side during free trials.

The learned effect was explained within an elicitation framework which includes a postulate on stimulus satiation. According to this position, responses which are produced by stimulus satiation are contiguously conditioned to the cues at the choice point, mediating an avoidance of the previously experienced cues. The curvilinear effect was attributed to two competing response tendencies (approach and avoidance). On the one hand there is a tendency to avoid the previously visited side as mediated by stimulus satiation. On the other hand there is a tendency to approach the previously visited side resulting from repeated pairings of food with cues in that side of the maze. The tendencies increase at different rates, resulting in the curvilinear function obtained.

Approved M. Ray Denny

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SATIATION LEARNING: ONE TRIAL PER DAY

By

Bruce Thomas Leckart

A THESIS

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To Annette

The Prime Mover

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HISTORY

Tolman (1925) first observed what was later to be called spontaneous alternation. He found that rats run in a T-maze in which both alleys led to the same goal box tended to alternate between paths chosen on successive trials.

In general, there have been two types of theoretical explanations of spontaneous alternation: (a) response-oriented theories and (b) stimulus-oriented theories. The former centers around Hull's (1943) concept of reactive inhibition (I_r). According to this interpretation the occurrence of a response temporarily reduces the probability that the same response will be evoked on a subsequent trial. Stimulus-oriented theories explain spontaneous alternation by hypothesizing that perception of a stimulus reduces the organism's potential reaction to the same stimulus on subsequent trials.

Hull's (1943) Postulate 8 states that: "Whenever a reaction (R) is evoked in an organism there is created as a result a primary drive (D); (a) this has an innate capacity (I_r) to inhibit the reaction potentiality ($_sE_r$) to that response . . ."

Zeaman and House (1951) make three deductions from Postulate 8. They state that alternation tendency will be: "(1) a negatively accelerated decreasing function of the time between responses; (2) a positively accelerated increasing function of the work involved in the execution of the response; and (3) a simple linear increasing function of the number of evocations."

Heathers (1940) presents evidence in support of the first deduction. Assuming that I_r is responsible for spontaneous alternation and that it dissipates with time he hypothesized that the avoidance of repetition of a response would decrease with increases in the time between responses. Subjects were run six trials per day in an elevated T-maze with the ITI varying between 15 and 120 seconds. Evidence was found that the amount of alternation decreased with increases in the ITI thus supporting the conceptualization of I_r as a determinant of spontaneous alternation.

Solomon (1948) tested the second deduction by inclining the arms of a T-maze 16 degrees from the horizontal. Hypothetically this would increase the work involved in making the responses and hence the amount of I_r associated with each response resulting in an increased tendency to alternate. Supporting data in the form of an increase in the percentage of alternation in the tilted alleys as compared

to horizontal alleys was found. However it was also found that increasing the weight that S carried through the maze did not increase the amount of alternation as the theory would predict.

Zeaman and House (1951) tested the third deduction. They hypothesized that increases in the number of trials would increase I_r and the amount of spontaneous alternation. Using an elevated T-maze with one alley removed Ss were forced 10 trials to one side. This procedure was duplicated with forced trials to alternate sides of the maze on successive days until each side was rewarded 100 times. Ten seconds following each block of 10 forced trials a free or alternation trial was given by replacing the missing alley. After the first 100 forced trials 100% alternation was obtained on free trials.

"A series of a smaller number of forced trials was next tried." 1 2 4, or 7 forced trials were administered and a free trial given one hour later. In support of the third deduction it was found that the greater the number of forced trials the greater the likelihood of a visitation to the less frequently visited side. The relationship between the number of forced trials and the percentage of alternation was found to be positive and linear. Evidence was also found to support the first deduction. The percentage of visitations

to the less frequently visited side was shown to decrease with increases in the time between forced and free trials. No significant alternation was found with delays of 18 and 24 hours between forced and free trials.

Dennis (1939) was one of the first investigators to find good evidence for a stimulus interpretation of spontaneous alternation. Using a two unit square maze he found a significant avoidance of repetition of exposure to the same stimuli but no significant avoidance of repetition of the same response. He concludes that there is an avoidance of a specific pathway rather than a specific response. This finding obviously seriously questions the validity of the explanatory concept of I_r in dealing with spontaneous alternation.

Glanzer (1953) has formulated a stimulus satiation postulate to deal with spontaneous alternation. Accordingly, stimulus satiation is an incremental function of the time S perceives the stimulus and a decremental function of the time spent away from the object. Increases of stimulus satiation are hypothesized to bring about a reduction of the Ss tendency to respond to the same stimulus on a subsequent trial. In this framework spontaneous alternation is based upon non-repetition of exposure to a stimulus as opposed to non-repetition of a response.

Glanzer tested his deduction in a cross-shaped maze by starting Ss on opposite ends of the maze on successive trials, thus pitting the stimulus satiation and reactive inhibition explanations against each other. Avoidance of the side previously visited is evidence in support of stimulus satiation whereas avoidance of a previous response is evidence in support of reactive inhibition. The results obtained supported the conception of a stimulus satiation postulate.

Walker, Dember, Earl and Karoly (1955) extended the work of Glanzer in determining what stimulus class the organism responds to when spontaneously alternating. By rotating a cross-shaped maze 180° between trials they succeeded in pitting stimulus, response, and place against each other as determinants of alternation. First, they found that Ss alternate on the basis of intra-maze stimuli as opposed to responses. Second, evidence was found supporting the hypothesis that Ss also alternate with respect to place (extra-maze stimuli in the experimental setting). The results lend themselves to a stimulus satiation interpretation, relevant stimuli being both intra and extra-maze in nature. They conclude that intra-maze cues (stimuli), extra-maze cues (place) and responses are, respectively, the most important determinants of alternation.

Rothkopf and Zeaman (1952) varying the number of forced trials in an elevated T-maze found evidence for an increase in alternation with increases in the number of forced trials to one side of the maze. They also found evidence for a learning effect, alternation increasing with practice in alternating. They postulate a two-factor theory, including concepts of both stimulus satiation and reactive inhibition, in dealing with the data. First, there is an adaptation to external cues (stimuli) during traversing of the maze which results in a preference to respond to the less adapted stimuli. And second, making a response leads to a fatigue like state (I_r) which inhibits the repetition of that response and results in a preference of the organism for the less fatigued response.

Denny (1957) has offered evidence that stimulus satiation may act as a mediator of avoidance learning. Accordingly, satiation with stimuli in one alley of a T-maze leads to avoidance of those stimuli on succeeding trials. Two trials were given per day with an ITI of thirty minutes. Forced and free trials were interspersed and controlled by the experimenter so that one side was visited twice as often as the other. A significant tendency for Ss to visit the less frequently visited side on free trials was found. Evidence suggesting that this preference was learned is supported

by three empirical observations. (1) The preference develops along the lines of a typical learning curve. (2) After initial training Ss continued to visit the less frequently visited side on successive free trials. (3) There was retention of the preference for at least a week.

Denny's results were interpreted with the Elicitation Theory (1955) framework which includes a postulate of stimulus satiation. Accordingly, satiation with cues in one arm of the maze elicits an avoidance response with respect to those cues. This avoidance reaction is assumed to be contiguously conditioned to these cues.

Finally, Hill, Cotton and Clayton (1963) using a forced trial technique have found no preference for one side of a T-maze that was rewarded twice as often as the other. They also found evidence that Ss visiting one arm but not the other showed more of a tendency to visit the non-experienced arm than those Ss that had previously experienced it. They interpret their results as evidence against a frequency of reward theory of learning and as support for Denny's findings.

THE PROBLEM

The present research is related to the work done on spontaneous alternation, Heathers (1940), Solomon (1948), Dennis (1939), Glanzer (1953), and Walker et al. (1955), but unlike the typical studies done in this area the Ss are not always permitted to respond freely. The present method, first used by Zeaman and House (1951), consists of giving a series of forced rewarded trials to one side of a T-maze followed by a free trial or a series of free trials. Zeaman and House and Rothkopf and Zeaman (1952) applied this method in an elevated maze and found clear evidence for an increased alternation effect with forced trials to one side though after 24 hours the effect was gone. The latter investigators, however, found a suspicion of a learned alternation effect. Since this time many investigators, Glanzer (1953), Dember and Earl (1957), Montgomery (1952), and Walker et al. (1955), have obtained evidence that alternation, regardless of procedure used, seems to be a stimulus satiation effect rather than a response produced effect (reactive inhibition) as assumed by Zeaman and associates.

In the past five years one published study (Denny, 1957) and a number of other studies have been conducted by Denny and associates which indicate that when the Zeaman and House technique is used in an enclosed maze, rather than an open elevated maze, the stimulus satiation effect as revealed by a preference for the non-visited side is long lasting or seemingly learned. This particular series of researches culminates with an as yet unpublished study by Denny and Leckart (1962) and the present master's research.

The problem which this research was designed to investigate can be stated in two parts: (1) Can stimulus satiation mediate avoidance learning when highly spaced "forced" trials are administered to one side of a T-maze? (2) If so, what is the function which relates the number of forced trials to the learned satiation effect (Ss' preference for the opposite side).

The possibility of a learned effect has been evaluated by Denny and Leckart by using 10 free trials spaced 24 hours apart. This method virtually eliminates from the test trials any immediate non-learned stimulus satiation effects which could result from a single trial or any accumulation of such effects. In the present research not only are the free trials separated by 24 hours but the original forced trials are also separated by 24 hours. Thus it is possible to see whether

discrete, noncumulative stimulus satiation effects can mediate avoidance learning (according to the elicitation framework this is entirely conceivable). Given this procedure, the present study involves varying the number of forced trials which independent groups receive and evaluating the effects with 10 spaced free trials.

APPARATUS

The apparatus was an enclosed T-maze constructed of unpainted wood shown diagrammatically in Figure 1. The overall dimensions of the arms and stem were 28" and 16" respectively. The goal boxes and the starting box were 12" long. The alleys and goal boxes were 4" wide and 6" high and covered with hardware cloth. The start box was covered with unpainted wood. To provide differential intra-maze cues, on each wall of the right arm, 2" from the bottom, and down the center of the floor of the right arm there were full length strips of 3/4" black electrical tape. The laboratory situation was such as to provide a wealth of differential extra-maze cues. Opaque guillotine doors were located at the entrance to the stem, and at the entrance to each arm and goal box. These doors were closed behind S as he traversed the maze to preclude retracing.

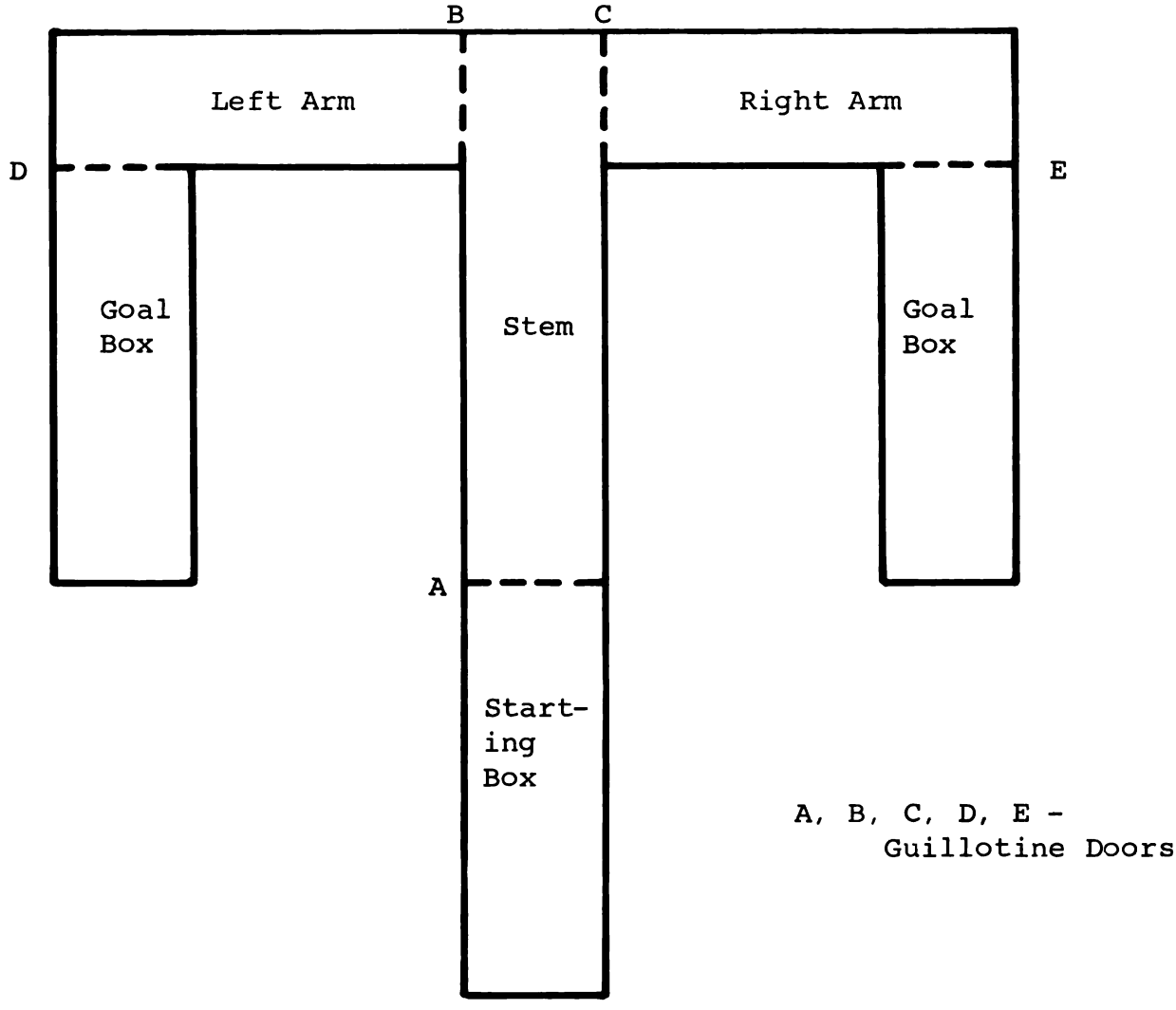

Figure 1. Diagrammatic drawing of T-maze

SUBJECTS

The subjects used in the present study were 61 experimentally naive female albino rats selected from the colony maintained by the department of psychology at Michigan State University. One animal was discarded for failing to reach an habituation criterion. All animals ranged in age from 90 to 120 days at the beginning of the experiment.

PROCEDURE

Pretraining

All Ss were given 12 days of habituation. On each of these days S was first handled for two minutes and then allowed to eat Lab Blox for one hour. All Ss were under a 23 hour food deprivation schedule throughout the experiment. Water was ad lib at all times except in the maze.

On Day 9, immediately after handling, each S was placed first in one goal box and then in the other for food-association trials. On each of these "visits" six 45 mg. P. J. Noyes reward pellets were available in the goal cup. The S was allowed to remain in each goal box until it had eaten all of the pellets or until three minutes had elapsed. The usual one hour feeding followed the last visit. Because many Ss did not eat during this first period, 12 hours after the morning handling the Ss were given additional food familiarization trials. At this time they were twice placed in either one of two clear plastic boxes with two reward pellets in the food cup and were allowed to remain there until they had consumed both pellets or for a maximum of three minutes. These same procedures were duplicated on Days 10-

12 with visits to each goal box and each plastic box counterbalanced. One S failed to meet the habituation criterion by not eating any of the pellets and was discarded.

Acquisition

The subjects were randomly assigned to five independent groups (0, 2, 6, 12, and 20). The numbers correspond to the number of forced trials that each group received during acquisition. A forced trial consisted of denying access to one side of the maze by closing the door leading to that alley. Prior to all trials each S was given thirty seconds of handling. S was then placed in the start box for 10 seconds at the end of which time the door leading to the stem was opened. On all trials, as S traversed the maze the guillotine doors were closed behind him, as all but his tail traversed the door jamb, to preclude retracing. Each of these forced trials was rewarded by one 45 mg. P. J. Noyes reward pellet placed in the goal box where S was allowed to remain until the pellet was consumed. All forced trials for a particular S were to the same side of the maze, and the ITI was always 24 hours. One half of the Ss within each group were forced to the right and the other half were forced to the left. The time between leaving the start box and entering the goal box was recorded for all trials (running

time). This was accomplished by starting a stopwatch as S entered the stem and stopping it as the door to the goal box began to close. The order of running within each home cage was randomly determined each day to preclude the possibility of daily feedings reinforcing turning behavior in a non-random fashion.

Test Trials

One day after the last forced trial ten free trials were administered with an ITI of 24 hours. The free trial procedure remained the same as the procedure during acquisition with the exception that access was no longer denied to the previously unvisited side; both choice point doors were open. All visits to the previously non-experienced side were non-rewarded whereas visits to the previously experienced side continued to be reinforced. Group O, the control group was given free trials 24 hours after the last day of the habituation procedure. The side visited as well as the running time was recorded for each trial.

Forty-eight hours after the last free trial a series of massed free trials was administered with an ITI of 10 seconds. These trials continued until S had made two consecutive visits to the reinforced side (extinction criterion for the satiation habit). The number of trials to criterion was

recorded for each animal as well as running time and side visited.

RESULTS

Acquisition

The mean running times on forced trials are presented for all groups in Figure 2. With an increase in the number of trials the running times decrease as expected, though prior research (Leckart and Denny, 1962) has shown an increase after 5 or 6 forced trials when the forced trials are massed (when cumulative satiation effects are possible).

Test Trials

The mean number of visits, during spaced free trials, to the side opposite the side to which the Ss were forced are presented for each group in Figure 3. Here we see a curvilinear relationship between the number of forced trials and the number of visits to the opposite side.

An analysis of variance was performed on these data, comparing the five groups on the number of responses made to the opposite side during the first ten free trials. An F value of 6.538 was obtained, with 4 and 55 df's, which is significant at the .01 level of confidence. Tukeys test (Edwards, 1961) for a significant gap between group means was

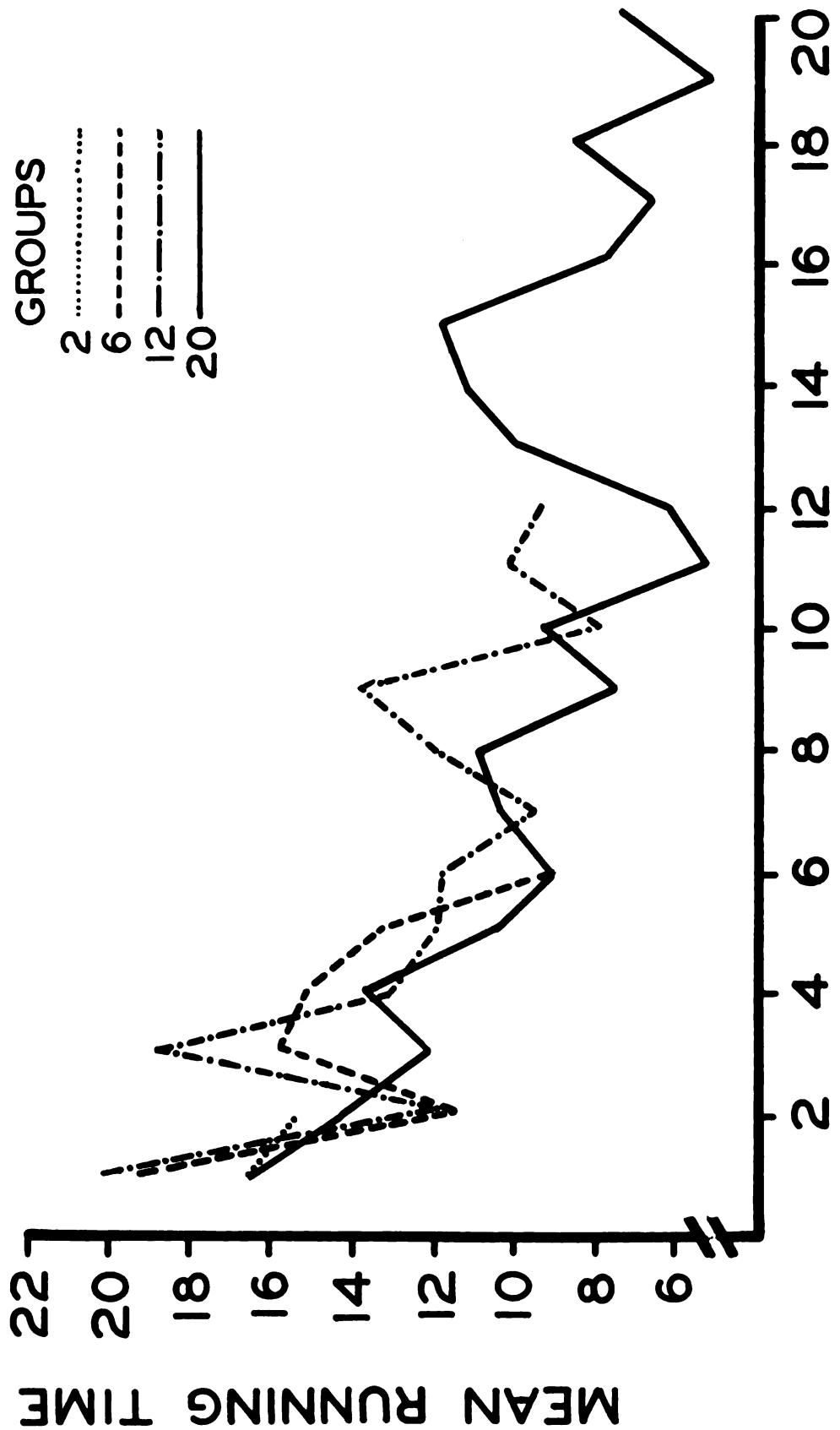

Figure 2. Mean running times during forced trials for all groups.

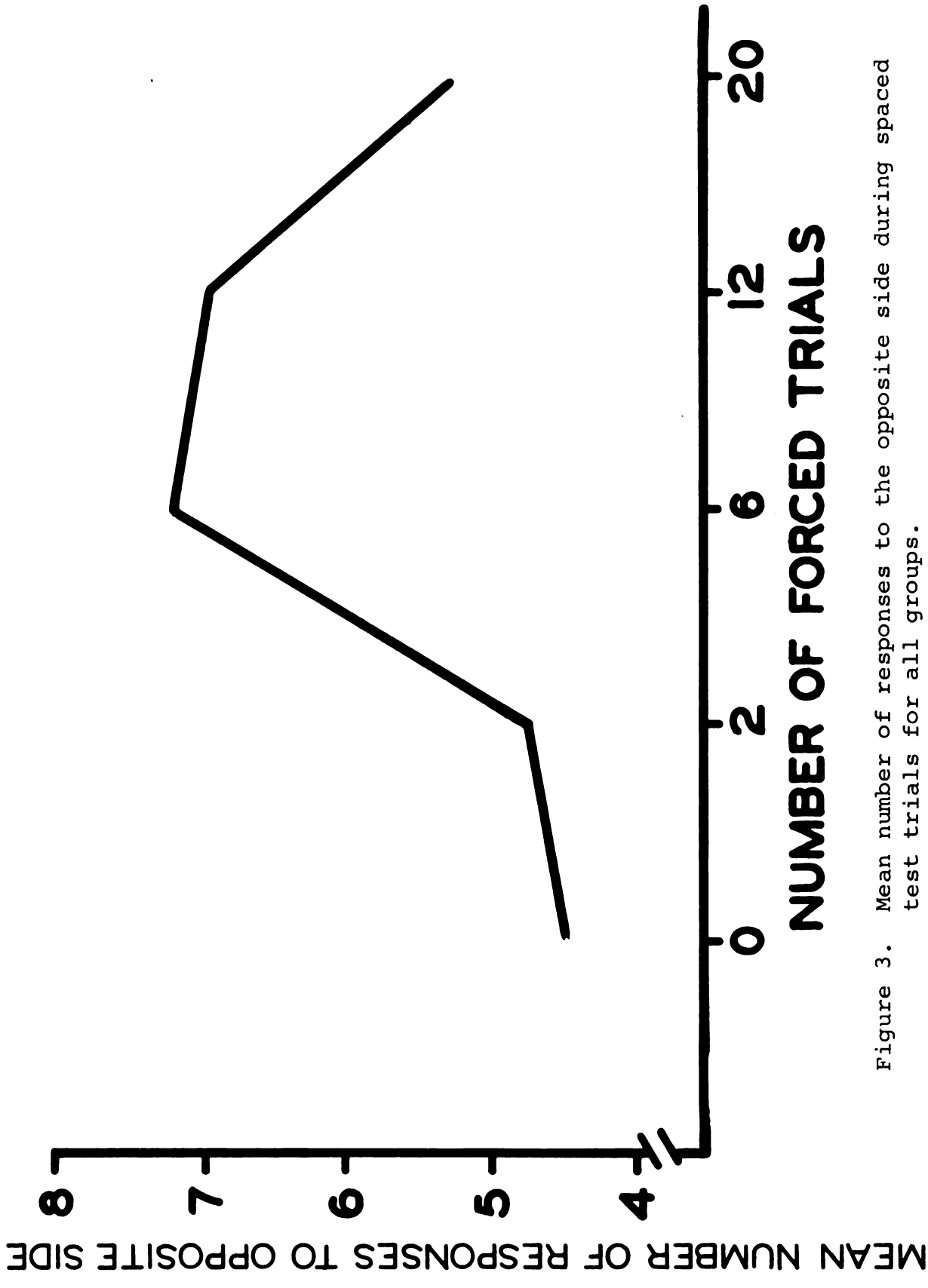

Figure 3. Mean number of responses to the opposite side during spaced test trials for all groups.

performed. The differences between Groups 2 and 6, and Groups 12 and 20 are significant ($P < .01$ and $P < .05$, respectively). No significant differences exist between Groups 0 and 2 and Groups 6 and 12. The extension of the median test, a nonparametric specified by Siegel (1956) was performed on the same data. A X^2 value of 21.953 was obtained, with 4 df's, which is significant at the .01 level of confidence ($P < .001$). Selected median tests were performed to determine the locus of the significant differences between groups. The following differences are significant: (1) Group 2 vs Group 6 ($P < .01$), (2) Group 6 vs Group 20 ($P < .05$), (3) Groups 0 and 2 combined vs Groups 6 and 12 combined ($P < .001$), (4) Groups 6 and 12 vs Group 20 ($P = .039$). The differences between Groups 0 and 2, 6 and 12, and 12 and 20 are not statistically significant. The data for Groups 6 and 12 were therefore combined and are graphically compared, individually, with Groups 0, 2, and 20 on the number of responses to the opposite side over the course of the ten free trials (Figures 4, 5, and 6).

In order to test the persistence of the learned effect the 10 free trials were divided into three blocks (Trials 1-3, 4-6 and 7-10) and the Z approximation of the binomial was utilized to test for significant tendencies to visit the sides of the maze. The results are summarized in Table 1.

Table 1.--Alley preference during spaced free trials by blocks for all groups.

Groups	Trials by Blocks (1-3)	(4-6)	(7-10)
0	No significant preference	No significant preference	Significant preference for the rewarded side ($P < .05$)
2	Significant preference for the opposite side ($P < .05$)	No significant preference	Significant preference for the rewarded side ($P < .01$)
6	Significant preference for the opposite side ($P < .01$)	Significant preference for the opposite side ($P < .01$)	No significant preference
12	Significant preference for the opposite side ($P < .01$)	Significant preference for the opposite side ($P < .05$)	No significant preference
20	Significant preference for the opposite side ($P < .01$)	No significant preference	Significant preference for the rewarded side ($P < .01$)

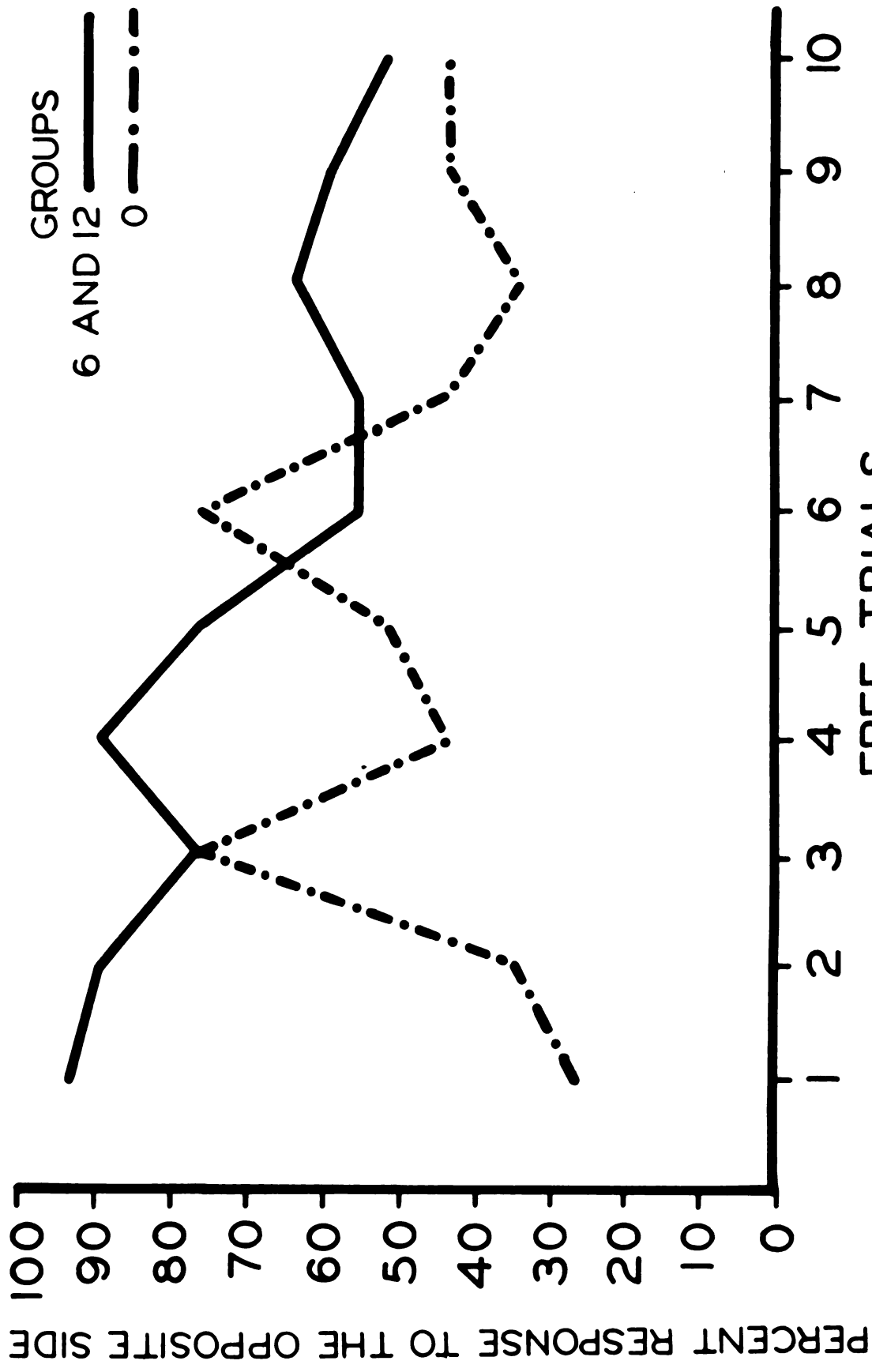

Figure 4. Percentage of responses to the opposite side during spaced free trials for Groups 6 and 12 combined and Group 0.

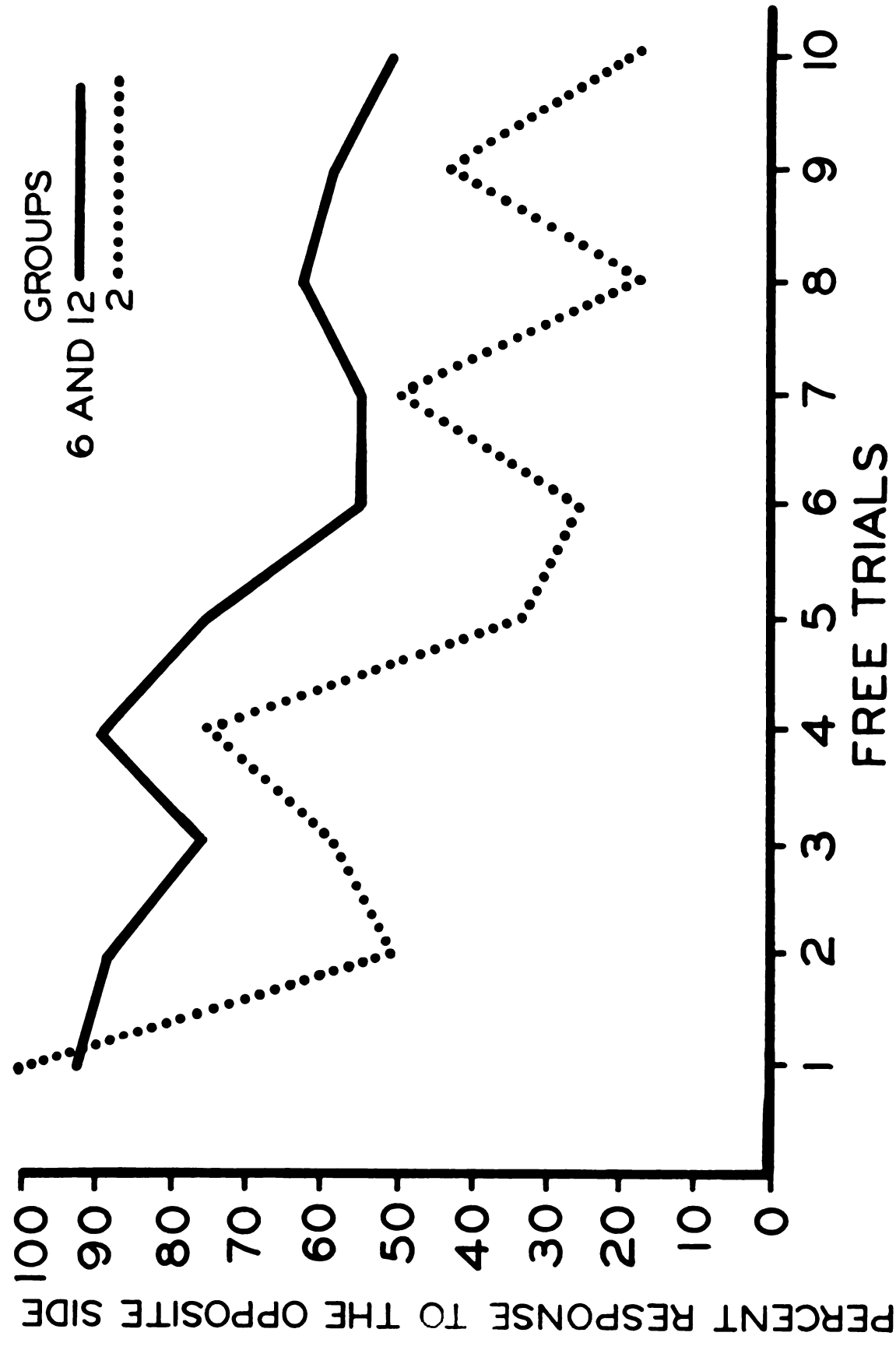

Figure 5. Percentage of responses to the opposite side during spaced free trials for Groups 6 and 12 combined and Group 2.

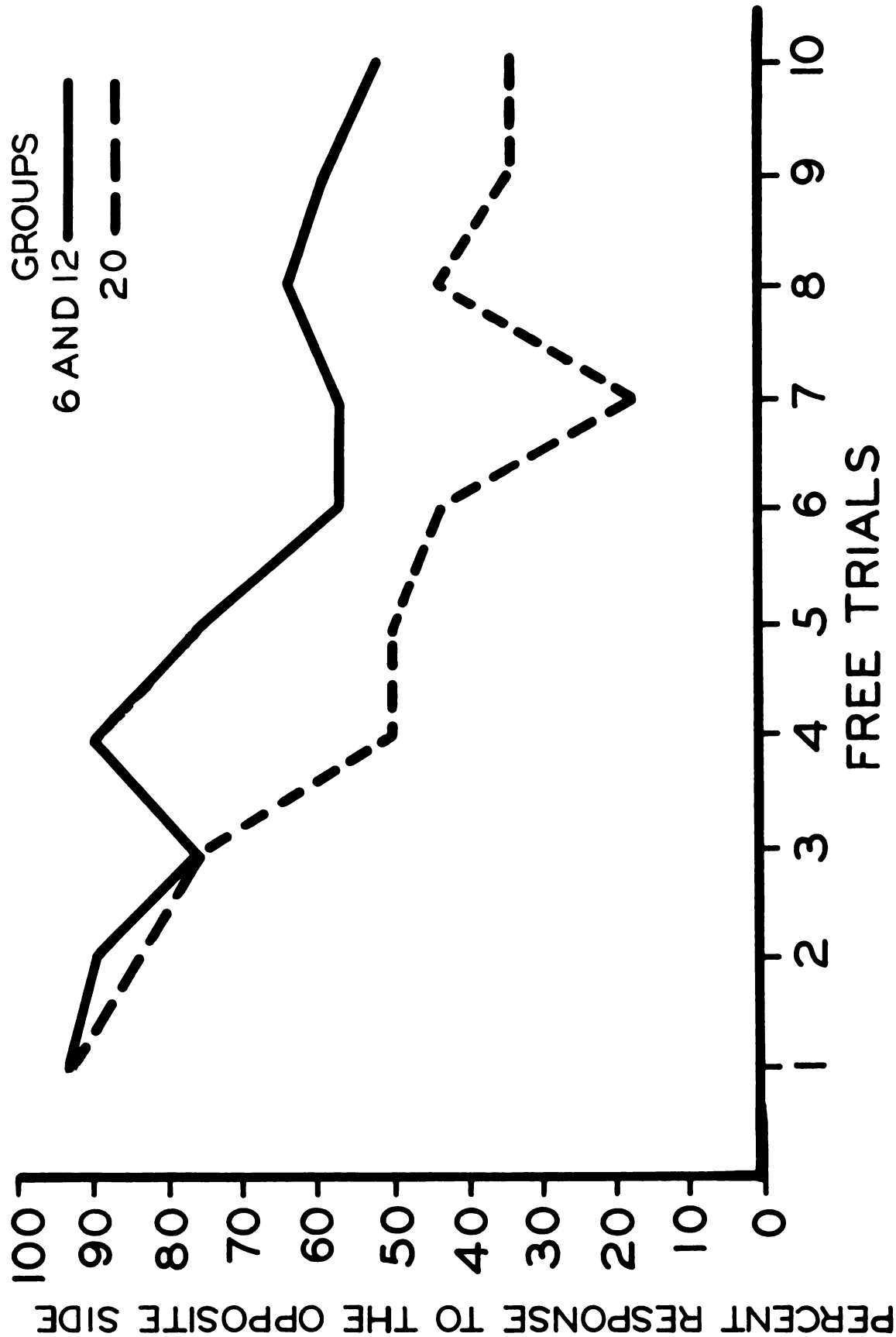

Figure 6. Percentage of responses to the opposite side during spaced free trials for Groups 6 and 12 combined and Group 20.

Significant preferences for the opposite side are found in all four experimental groups for the first three trials. The most persistent preferences are found in Groups 6, 12, 20 and 2, respectively. In all four groups the preference decreases below the level needed for significance with further trials. Groups 2 and 20 after showing no significant preference for either side on trials 4 thru 6 show strong preferences for the rewarded side on the last four free trials.

An analysis of variance was also performed on the number of massed extinction trials to criterion. The data is shown in Figure 7. An F value of 1.50 was obtained, with 4 and 55 df's, which was not significant. The nonparametric extension of the median test on the same data yielded a X^2 of 5.118 which was also non-significant. Multiple comparisons utilizing the Tukey procedure, Scheffe's test (Edwards, 1962), median tests and the Mann-Whitney U (Siegel, 1956) were made. No significant differences of experimental interest between the groups exist. However, the trends were in close agreement with the data collected from the spaced free trials, Groups 6, 2, 0, 12, and 20 respectively taking the most trials to reach criterion.

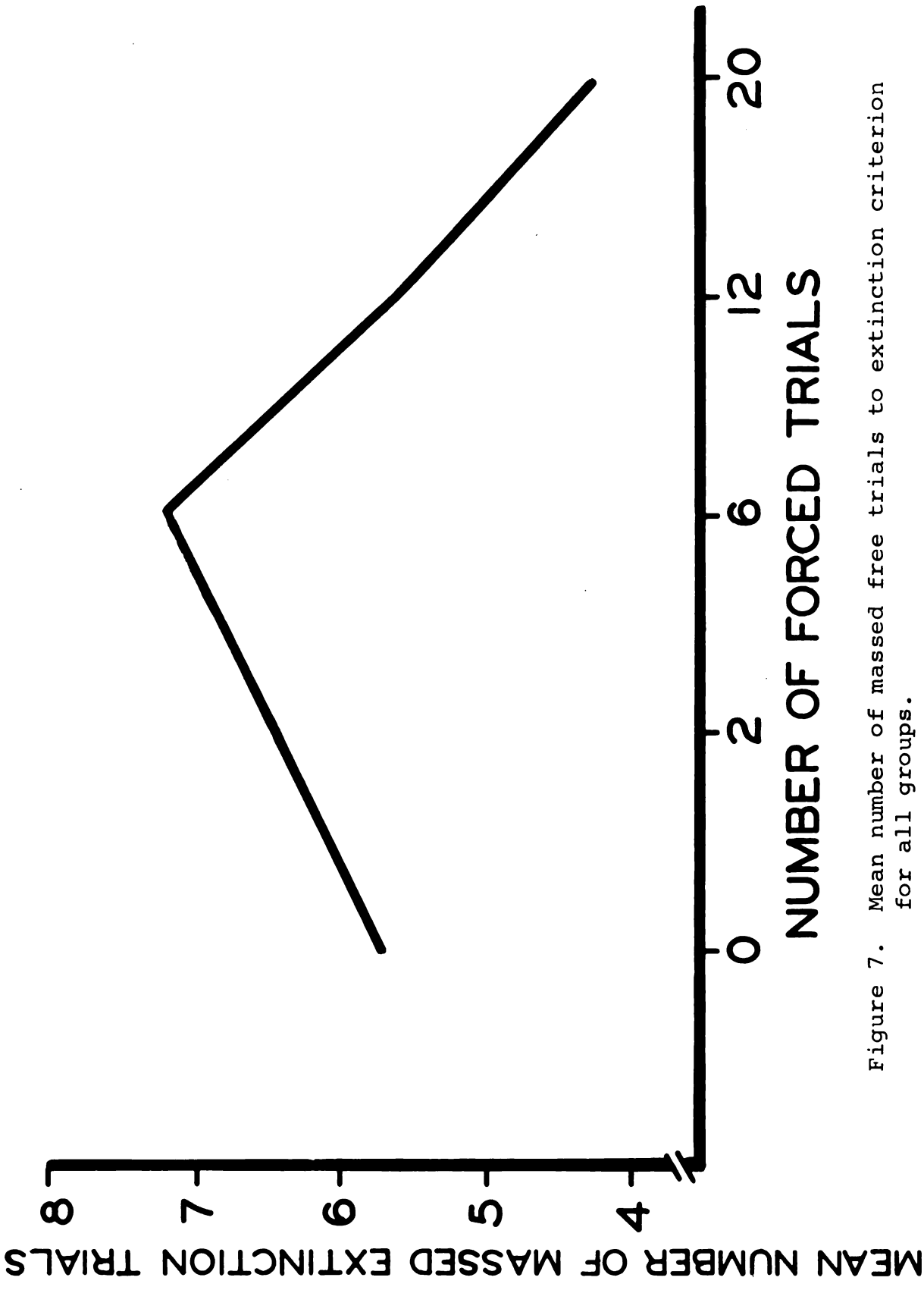

Figure 7. Mean number of massed free trials to extinction criterion for all groups.

DISCUSSION

The results of the present study nicely confirm the hypothesis that stimulus satiation can mediate avoidance learning when highly spaced forced trials are administered to one side of a T-maze. Support for this hypothesis is evident in the persistent preference of Groups 6, 12, and 20 for the previously non-visited and non-reinforced side of the maze. Were stimulus satiation alone producing the effects we would expect the subjects to alternate on successive free trials. Such a tendency was slight and was found only in Groups 0 and 2.

These results are difficult to explain within most traditional theoretical frameworks. However, it is possible to handle them within the elicitation framework, which includes a postulate on stimulus satiation. According to this position, an exposure to one side of a maze results in the satiation of the stimuli in that alley (loss of approach value). This results in the eliciting of responses away from these cues, in short, the eliciting of avoidance or escape-type responses to these cues. These responses are thereby classically conditioned to the associated stimulus situation;

and with repeated exposures the avoidance tendency is further strengthened. Thus anytime later when S is presented with a free choice between visiting the experienced side and non-experienced side, it goes to the novel stimuli.

Support was also found for the second part of the hypothesis, namely the curvilinear relationship between the number of forced trials and the number of visits to the previously unvisited side during free trials. With increases in the number of forced trials there is at first an increase and then a decrease in the tendency to visit the previously non-experienced side. Of the four experimental groups which were given forced trials, no learned satiation effect was found in Group 2, a maximum observable effect occurred in Group 6, and a significantly weaker effect was found in Group 20. That Group 2 showed no learned effect is attributed to the small number of acquisition trials.

The less persistent effect in Group 20 is presumably the result of two competing response tendencies (approach and avoidance). On the one hand there is a tendency to avoid the previously visited side as mediated by stimulus satiation. On the other hand there is a tendency to approach the previously visited side as a result of repeated pairings of food with the cues in that side of the maze. These tendencies increase at different rates, resulting in the curvilinear

function. The avoidance tendency builds up faster because it is assumed to be directly elicited by stimuli near the choice point and directly conditioned to this region. The approach response to food, on the other hand, is first conditioned to the goal region and must chain back to the choice point areas. Further evidence for the curvilinear relationship comes from the massed free trial data. The most persistent learned effect is still found in Group 6, and Group 20 shows the least tendency to visit the opposite side.

In conclusion, the writer wishes to point out the importance of these findings with respect to behavioral phenomena in general. In most any task there is a stimulus satiation component which may result in the learning of competing responses which can subtract from the amount of learning evident in performance. Further investigation is needed to determine how and under what conditions this as yet unrecognized variable affects behavior.

SUMMARY

The problem which this research was designed to investigate can be stated in two parts: (1) Can stimulus satiation mediate avoidance learning when highly spaced "forced" trials are administered to one side of a T-maze? (2) If so, what is the function which relates the number of forced trials to the learned satiation effect (Ss' preference for the opposite side).

Sixty albino female rats were randomly assigned to five independent groups receiving either 0, 2, 6, 12 or 20 forced rewarded trials to one side of an enclosed T-maze, with an ITI of 24 hours. One day after the last forced trial a series of 10 free test trials was initiated. On these free trials the reward was on the same side as on the forced trials; the free trials were also administered with an ITI of 24 hours.

A significant persistent preference for the opposite side was found in Groups 6, 12 and 20 on the 10 free trials, supporting the notion that stimulus satiation can act as a mediator for avoidance learning when highly spaced forced trials are given to one side of the maze. The most persistent

preference occurred in the group that received 6 forced trials. In other words, a curvilinear relationship was found between the number of forced trials and the number of visits to the previously unvisited side during free trials.

The learned effect was explained within an elicitation framework which includes a postulate on stimulus satiation. According to this position, responses which are produced by stimulus satiation are contiguously conditioned to the cues at the choice point, mediating an avoidance of the previously experienced cues. The curvilinear effect was attributed to two competing response tendencies (approach and avoidance). On the one hand there is a tendency to avoid the previously visited side as mediated by stimulus satiation. On the other hand there is a tendency to approach the previously visited side resulting from repeated pairings of food with cues in that side of the maze. The tendencies increase at different rates, resulting in the curvilinear function obtained.

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ADDENDUM

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