AN EXPERIMENTAL TEST OF THE DIFFERENTIAL EFFECTS OF WORK AND FRUSTRATION UPON LEARNING

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This is to certify that the

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M. Ray Denny
Major professor

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OF WORK AND FRUSTRATION UPON LEARNING

by

Jack Lou Maatsch

AN ABSTRACT

Submitted to the School of Graduate Studies of Michigan
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ABSTRACT

AN EXPERIMENTAL TEST OF THE DIFFERENTIAL EFFECTS OF WORK AND FRUSTRATION UPON LEARNING

Jack L. Maatsch

This study was designed to test two sets of conflicting predictions about the effect of massing and spacing procedures upon learning and inhibition in an infra-human learning situation involving lesser amounts of work. The first set of predictions were drawn from Hull, who assumed that lesser amounts of work resulting from repeated response evocation gives rise to an inhibitory state, reactive (work) inhibition, which dissipates with rest. While it is obvious that excessive and/or prolonged work may fatigue the organism, evidence for the fact that lesser amounts of work encountered in the typical infra-human learning experiment is conflicting and for the most part negative. The second set of predictions, were drawn from an interference theory of inhibition which stressed the cue properties of massing and spacing procedures.

To test these predictions, 16 Ss were given extended training on both spaced and massed trials in a straight alley maze. A test was then performed to determine the amount of inhibition resulting from performance on a single trial. After the test of inhibition, Ss were divided into two equated groups, a work inhibition group and a frustration group. The work inhibition group continued under the same testing sequence to determine the continued effect upon performance of rewarded-spaced, and rewarded-

massed trials. The frustration group experienced rewarded spaced trials but were unrewarded on massed trials during the same test of inhibition procedure received by the work inhibition group. This test determined the effect of associating the massing procedure with non-rewarded trials. A test was then performed to determine if the massing procedure, per se, was the cue which produced inhibition on the subsequent trial.

The results confirmed all the predictions drawn from an interference theory and failed to confirm the major predictions drawn from Hull's theory. The data failed to indicate the presence of any temporary or permanent inhibition resulting from lesser amounts of work involved in a single trial. The massing procedure however, did become a cue eliciting responses which interfere with performance on the following trial if that procedure was followed by an unrewarded trial and the spacing procedure was followed by a rewarded trial.

Since the experimental conditions were optimal for the production of reactive inhibition and yet none was observed, and when non-reward was introduced inhibition did develop, it was suggested that Hull's analysis of inhibitory phenomena is not applicable to infra-human maze learning studies involving lesser amounts of work. The application of interference theory and existing concepts also seems to account for other learning and extinction phenomena previously offered in support of Hull's theoretical analysis.

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INTRODUCTION

In recent years, the variable of work has played an increasingly important role in theoretical interpretations of learning phenomena. In 1941, Miller (10) hypothesized that stimulation arising from the fatigue of responding could motivate an organism to rest. Fatigue stimulation would be reduced during rest; and this reduction of fatigue stimulation could reward the organism for resting. Miller suggested that this formulation could explain the fact that a response undergoes extinction when non-rewarded but then spontaneously recovers after a rest period. In 1943, Mowrer (14) tested a similar hypothesis and seemingly demonstrated that the amount of work involved in responding was an important variable in determining the rate of extinction of a response. This study was to play an important role in Hull's analysis of extinction phenomena.

Hull (5) incorporated the Mowrer-Miller hypothesis in a general theory of behavior and extended the hypothesis to account for such phenomena as disinhibition, reminiscence, the law of least work, and the economy of spaced reinforcement over massed reinforcement in the acquisition process. Of the three treatments of the influence of work upon learning and extinction, Hull's treatment is the most explicit and has been the most influential in stimulating research. Accordingly, we will be particularly concerned with Hull's theoretical treatment of the influence of work upon performance during learning and extinction.

Hull has postulated two related logical constructs which arise from responding and, in turn, affect behavior in various ways. Reactive inhibition (Ir) is defined as, ". . . a condition or state which acts as a primary negative motivation in that it has an innate capacity to produce cessation of the activity which produced the state." (5, p.278). The relationship of Ir to work is defined as follows, "The net amount of functioning inhibitory potential resulting from a sequence of reaction evocations is a positively accelerated function of the amount of the work (W) involved in the performance of the response in question." (5, p.278). Hull states that evidence for the existence of such a relationship between work and the accumulation of Ir is "convincingly demonstrated" (5, p.279) in a study reported by Mowrer and Jones (14). We shall discuss this study in some detail later.

Reactive inhibition has two other important characteristics. Reactive inhibition, ". . . diminishes progressively with the passage of time according to a simple decay or negative growth function." (5, p.281). In other words, like fatigue, Ir is reduced through rest. The other characteristic involves the assumption that lesser amounts of work, not usually thought of as sufficient to produce fatigue or fatigue stimulation, could motivate the organism to stop responding. That is, the accumulation of reactive inhibition would eventually produce "fatigue" or "decrement in action evocation potentiality." (5, p.278). Every response, whether reinforced or not, is assumed to produce some amount of Ir. So conceived, the concept has been applied to such molar responses as locomotion, "right turn," and bar pressing. As such, the concept offers a convenient theoretical explanation of the phenomena of reminiscence, experimental extinction, spontaneous recovery, spontaneous alternation, and other allied inhibitory phenomena in situations where fatigue would not otherwise be considered a relevant variable. This assumption will receive a more critical evaluation later.

The second related logical construct postulated by Hull is conditioned inhibition (sIr). Conditioned inhibition is considered to be a habit resulting from the association of stimuli with resting responses elicited by the accumulation of Ir. (5, p.282). This habit is reinforced by the reduction of Ir resulting from the rest. Thus, after repeated associations with the evocation of resting responses by Ir, previously neutral stimuli are assumed to acquire the power to evoke resting responses.

It should be apparent from the above discussion that the inhibitions produced by Ir and sIr have different characteristics. Reactive inhibition is temporally labile, that is, it builds up during performance of some act, but dissipates relatively rapidly during an ensuing rest period. On the other hand, $_sI_r$ accumulates over a series of trials and does not dissipate. That is $_sI_r$ behaves like a habit, being reinforced at the end of each trial through reduction of I_r, and reinstated by stimuli at the beginning of the next trial. For Hull then, a sequence of reaction evocations will produce both temporary (I_r) and permanent ($_sI_r$) inhibitory effects.

These two types of inhibition, "summate functionally to produce $\dot{I}_r$ as would corresponding amounts of habit strength," (5, p.283). Total inhibitory potential ($\dot{I}_r$) in turn, subtracts from the reaction potential ($_sE_r$) of the original response evoked by the situation. The resulting tendency to respond --- or to rest --- is defined as effective reaction potential ($_s\bar{E}_r$). In short, Hull considers the tendency to respond in a learning situation to be a function of combination of a tendency to respond because of previous learning and a tendency not to respond because of the work involved <u>during</u> the previous learning.

So conceived, the work variable plays an important role in generating a great many diversified hypotheses about learning and extinction phenomena. We shall review some of the predictions drawn from this theoretical treatment shortly; but first let us review critically the experimental evidence bearing upon some of the assumptions of Hull's analysis of learning and extinction phenomena in terms of the effects of the work variable.

Research bearing on the subject is best characterized as extensive, conflicting, and for the most part inadequate. In 1948, Solomon (16) found some ninety-seven articles relevant to the subject. He concluded that research in this area can be unified by one central theoretical idea, namely, ". . . that response produced effects (kinesthesis or proprioception) can serve both as a drive or motivating stimulation, and as cue stimulation." (16, p.35). In short, the stimulation arising from movement, like any other stimulation, may serve as a distinctive stimulus upon which discrimination learning can be based; and at the same time, if response produced stimulation becomes sufficiently intense, noxious, or painful, it may motivate the organism to cease responding. It is this later characteristic of work which we wish to consider.

There seems to be little question that proprioception arising from response can serve as a cue for discrimination learning. Such cues are used continuously for posturing and bodily orientation in every day life. Furthermore, it seems equally obvious that excessive or prolonged energy expenditure can so fatigue muscle tissue that coordinated movement becomes both impaired and painful. Any one who has mowed the lawn or shoveled snow from the sidewalk knows only too well that excessive work can motivate one to cease responding. However, it seems almost inconceivable that lesser amounts of work involved in traversing a three foot alley, or turning right at a choice point, or pushing a lightly weighted bar, or memorizing a few nonsense syllables, could <u>motivate</u> the organism to cease responding. This would seem to be especially true when the response in question is goal oriented and molar in nature, that is, when the response in question is defined in terms of the accomplishment of some goal or task regardless of <u>how</u> the task is carried out, and the response in question involves the movement of whole organism.

In most infra-human learning studies the task to be performed, or the goal to be achieved, allows for a great deal of variability in the muscle cells utilized in response as well as a great deal of variability in efferent neural innervational patterns utilized in carrying out the <u>sequence</u> of movements. This variability would tend to minimize the effect, whether muscular or neural, of previous responses upon subsequent behavior.

These considerations and others lead Bartley to view fatigue as an outcome of conflict (2, p.54) and to treat <u>fatigue</u> as distinct from <u>impairment</u> of the ability of muscle tissue to perform, (2, p.48). Bartley states that, "<u>Neither fatigue nor impairment can be measured by the work output of the intact organism</u>. Activity may be used as a measure of impairment only when such systems as isolated nerve-muscle preparations are used." (2, p.49). "<u>Fatigue does not crucially depend upon energy expenditure</u>." (2, p.55), and, "<u>Fatigue is</u>

<u>never specific to a given body member</u>," (2, p.55). In short, Bartley's more extensive treatment of the topic of fatigue and impairment contradicts many of the relationships implicitly and explicitly assumed by Hull as necessary to account for a variety of learning and inhibitory phenomena.

Despite the common acceptance and frequent use of reactive inhibition as a theoretical concept, experimental evidence for the existence of a relationship between lesser amounts of work and magnitude of inhibition is slim. Solomon (16) criticized many of the earlier studies for failure to control adequately such variables as delay of reinforcement, habit strength, and complexity of the tasks involved. The Mowrer and Jones study (14) which Hull has offered as a convincing demonstration of the relationship between energy expenditure or work to the accumulation of Ir (5, p.279) has also been sharply criticized. The training schedule employed in the Mowrer and Jones study, in contrast to what Hull reports (5, p.280), resulted in a greater number of reinforcements and a higher rate of responding for a bar requiring little effort to push than for a bar requiring greater effort to push. As a consequence, the results of the study are open to an alternative interpretation, namely, that the obtained differences were due to differences in habit strength of the different bar pressing habits.

Applezweig (1), in attempting to control for habit strength prior to extinction of the bar pressing response, utilized a design that resulted in extreme selection of Ss in some groups.

His design also required the assumption that rats trained to push a lighter bar could be made to push a heavier bar as easily as rats trained to push a heavier bar could push lighter bars. This assumption is not supported by observation, however. Rats trained to push a heavy bar automatically push all lighter bars; but if trained to push a light bar, rats have difficulty in pushing heavier bars. They have to <u>learn</u> to push a heavier bar, and will cease bar pressing altogether if the change in bar weights is not graduated. The results obtained by Applezweig bear out this relationship. When Ss were switched to heavier bars during extinction, resistance to extinction was a decreasing function of the weight of the bar that S was required to press during extinction. For Ss switched to <u>lighter</u> bars during extinction, the data indicated little or no relationship between bar weight and resistance to extinction. When the two halves of the data were combined, however, it <u>appeared</u> that resistance to extinction was a function of amount of effort.

There are at least three additional factors that may influence the results of studies using bar weight as an index of energy expenditure. First of all, the types of response required to depress bars of different weights are different. A rat may slap at a 5 gram bar with one paw while reaching for the food with the other paw, but must drape over or lean against on an 80 gram bar in order to depress it. Secondly, this difference in response may cause a difference in delay in reinforcement. The rat pushing the 5 gram bar may situate himself, and usually does, so as to receive the reward pellet as quickly as possible following bar depression, whereas the 80 gram bar requires the undivided attention of the rat prior to securing the reward pellet. The delay of reinforcement variable clearly favors faster learning and a stronger habit for S's required to press the lighter bar.

The third variable, not previously controlled, concerns a methodological consideration inherent in the bar pressing situation. In the bar pressing situation, the number and rate of bar presses are mechanically or electrically recorded. The criterion for a response is an excursion of the bar which closes a switch. Ordinarily this allows for a precise unbiased measurement of the rate of responding. But when the bars are differentially weighted, the light bar is a very sensitive recorder of tangential, or incidental behavior involving the bar. A movement of the tail of the rat may easily be translated into a bar pressing response. The heavy bar on the other hand is relatively insensitive, registering only the most deliberate and well executed responses. This differential sensitivity of the bar to tangential responses favors the recording of more bar presses during extinction or, in other words, greater resistance to extinction for lighter bar weights.

In this connection it is important to note that <u>all</u> the variables mentioned above are related to <u>work</u> in the bar pressing

situation in such a way as to produce differences in resistance to extinction in the direction obtained by Mowrer and Jones and predicted by reactive inhibition (Hull). The more recent studies proporting to support Hull's analysis in the bar pressing situation (11, 17, 18), are subject to alternative interpretation because of the lack of control of these variables.

Recently Maatsch, Adelman, and Denny (9), in essentially a replication of the Mowrer and Jones study, controlled for habit strength, delay or reinforcement, and bar sensitivity. They found <u>no</u> relationship between amount of work and rate of extinction (amount of inhibition). These findings cast doubt upon Hull's conception of inhibition as due to the lesser amounts of work involved in the typical infra-human learning study and demonstrate that the results obtained by other investigations (11, 17, 18) were more than likely due to the lack of control of one variable or another.

In a previous experiment (7), the writer tried to quantify the amount of Ir generated by a single trial and the rate of its dissipation in a straight alley maze. Here again, no evidence of any inhibitory effect due to responding was found with respect to performance on the following trial, if the inter-trial interval was 20 seconds or longer. Yet the amount of work performed and the inter-trial interval employed was as favorable to the generation of Ir as for a large body of learning and extinction data which have been "explained" in terms of Ir. The failure to demonstrate any measurable effect of Ir in this situation would seem to cast doubt upon the explanatory value of Ir in a straight alley situation.

This earlier study has been criticized for the failure to control adequately two variables. The first variable concerns the fact that the test for the inhibitory effect, as produced by a single trial, occurred as the rat was approaching the maximal or asymptotic level of habit strength. Thus, it may be argued that the inhibitory effect of a single trial was offset by the increment in habit strength resulting from reward on that trial. An adequate test of Hull's theory under these circumstances requires that the testing for the inhibitory effect of a single trial occur <u>after</u> the running habit reached a maximum, so that continued reward can have no further effect upon performance.

The second criticism is based upon the fact that the Ss were not given experience with massed[1] trials during the pre-test training. Consequently during the testing procedure, a rewarded <u>massed</u> trial produced a large increment of the habit to run on <u>massed trials</u> thus offsetting any inhibition that might have been displayed on the massed trial. The argument

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1. The term <u>massed</u> will be used to refer to a trial that follows the preceding trial by 30 seconds or less, (5, p.36). The term <u>spaced</u> will be used to refer to a trial that follows the preceding trial by 5 minutes or longer.

is similar to the first criticism except that the criticism is specific to massed trials. Furthermore when there is a sudden shift from spaced trials to unrewarded massed trials it could be the sIr, which is discriminatively attached to the massing cue and which is unopposed by positive reaction potential, which is causing the inhibition and not the omission of reward *per se*.

These two criticisms, while tenuous, were sufficient to question the generality of the findings of the Maatsch study. As a consequence, the following experiment was designed to test for the presence of Ir as resulting from performance on a single trial. This testing will be done *after* all Ss have reached asymptotic levels of performance on both spaced and massed trials. The experiment will also test other predictions stemming from Hull's theory as well as predictions stemming from a different theoretical analysis of the same situation.

Summarizing the discussion so far, it would seem that the effect of excessive and/or prolonged work will produce motivation to rest and that responding *per se* may serve as a distinctive stimulus upon which a discrimination may be based. However, experimental evidence for the fact that *lesser* amounts of work can serve as a source of inhibition in the manner postulated by Hull is inconclusive and for the most part negative. In fact, previous research seems to indicate that when all relevant variables are controlled in a bar pressing situation, there is no relationship between lesser amounts of work and inhibitory effects occuring during the extinction process. Yet Hull's theory is frequently used to explain performance and extinction phenomena in those experiments involving lesser amounts of work.

Predictions From Hull's Theory

Let us now turn our attention to a detailed analysis of a simple learning situation. We shall contrast a Hullian analysis of the effects of massing and spacing with another theoretical analysis of the same situation. The situation involves a sequence of trials in a straight alley as employed in the present experiment. Assume for the moment that the rats have been trained to run down the alley and into the goal box for a pellet of food. Performance has reached a maximal level for trials that are spaced 5 minutes or more apart (spaced) and for trials spaced less than 30 seconds apart (massed). During the 5 minute inter-trial interval, S is returned to a holding cage to await the beginning of the next trial. Within the 30 second period, S is picked out of the goal box and put almost immediately into the starting box for the beginning of the next trial.

Hull would probably conceive of this situation primarily as a sequence of work-rest periods, with the spacing procedure providing a longer rest period than the massing procedure, which provides little or no rest at all.

For Hull, reactive inhibition is generated on the first trial of the day. If the second trial immediately follows the first trial, then some portion of the Ir generated by the first trial should be present at the beginning of the second trial, and should tend to inhibit performance on the second trial. On the other hand, if sufficient rest is allowed between trials, then all the Ir generated by the first trial should have dissipated and there should be no measured inhibition on the second trial. If we subtract the running time on the first trial from the running time on the second trial, the difference between performance on the two trials would constitute a measure of the amount of inhibition which is produced by the running response of the first trial and carried over to the second trial. When the first trial of such a pair of trials is spaced to minimize any residual inhibitory effect of the previous trials and the second trial is massed or immediately follows the first, this difference will be considered a test of the inhibition generated by performance on a single trial. The first trial will be referred to as the "<u>inhibition</u>" trial, and the second trial will be referred to as the <u>test trial</u>. Since this sequence represents a method of measuring the inhibitory effect of Ir generated by a single trial in a straight alley, the Hullian analysis will receive support if inhibition can be detected on the test trial.

Now let us assume that S is given a number of tests of inhibition. According to Hull, the procedure of placing S immediately back into the starting box at the beginning of each test trial is associated with the dissipation of the Ir generated by the first or "inhibition" trial. Thus, the cues of the massing procedure should become conditioned to the resting response-produced by Ir. In other words, the massing cue should come to elicit sIr. This habit to rest when the massing cue is present, should increase with repeated tests. Thus we should expect that the total amount of inhibition ($\dot{I}r$) will increase and that this increase will be due solely to increases in sIr.

From Hull's theory it is possible to predict: (a) A test of inhibition will reveal a measurable amount of inhibition immediately following performance on a single trial, (b) spaced training trials will produce better performance than massed training trials, and (c) performance on spaced trials at the end of training will be better than performance on massed trials. (6, p.37).

These hypotheses stem from the assumption that greater amounts of both Ir and sIr are present on massed trials than spaced trials.

The above predictions refer to a test sequence in which both trials are rewarded. Suppose now the second or massed trial is unrewarded, while the first or spaced trial continues to be rewarded. According to Hullian theory, which interprets inhibition solely in terms of responsed-produced effects, there should be no difference in the amount of inhibition generated by rewarded and unrewarded massed test trials. The inhibition appearing on the test trial results from undissipated

Ir produced by performance on the immediately preceding inhibition trial.

Predictions From An Interference Theory

Let us now analyze the same learning situation from a different theoretical view. This point of view is suggested by a pure interference theory of inhibition which is part of a general theory of learning under development by the writer. This position denies the existence of Ir in situations involving lesser amounts of work, and holds that all inhibitory phenomena may be explained in terms of interference due either to the elicitation or learning of incompatible responses (7) (8).

In contrast to Hull's interpretation that the spacing and massing of trials represent essentially rest periods of different lengths, our position holds that the difference between the two inter-trial procedures is essentially one of cue differences. That is, the spacing procedure gives rise to a stimulus complex different from the massing procedure stimulus complex. We will hereafter refer to the "spacing cue" and "the massing cue" to describe these differences.

The spacing cue and the massing cue, while discriminatively different, are not identical in their effects upon the organism in the usual straight alley situation. It is assumed that the massing cue, which involves the rapid transportation of S from the goal box back into the starting box, is more likely to elicit emotional responses than is the spacing cue. These emotional responses may arise because of the disruption of the eating behavior in the goal box, or they may be due to the abrupt reorientation forced upon S by the procedure, or they may be due simply to an unaccustomed way of being handled. Whatever the case may be, it is assumed that this effect of the massing cue may be adjusted to, or interfered with, i.e., overcome, by new learning.

Now let us analyze the first of the experimental test situations. This situation, it will be remembered, involved the test of inhibition at the end of maximal training on both spaced and massed trials. From the interference position, this means that the reaction potential to both the spacing and massing cue are at maximal levels. Thus we may predict: (a) A test of inhibition after extensive training on both spaced and massed trials will not reveal a measurable amount of inhibition resulting from performance on a single trial.

If we apply the interference position to a training situation, it is apparent that in the initial stages of learning, the massing cue may produce emotional responses that interfere with running response being learned. However, after the reaction potential of the running response becomes stronger it will interfere with or "override" the competing emotional responses produced by the massing cue. Thus we may predict: (b) Spaced training trials will produce better performance than massed training trials in the initial stages of learning, and, (c) Performance on massed trials at the end of training will be as good as performance on spaced trials.

The third situation involved the removal of reward on the second or massed trial. From Hull's theory it was predicted that no change in the amount of inhibition manifested on the massed test trial should occur. However a different hypothesis results from the application of the interference theory to this situation. The removal of reward in a learned situation gives rise to frustration stimulation (Sf) which in turn elicits emotional responses (Rsf) capable of interfering with original running response (8). The unrewarded massed trials constitute a relearning or extinction situation, and S would soon learn to react emotionally and avoid running to the goal box. This learning will cause "inhibition" of the running response on massed trials. But at the same time that the maze cues are being unrewarded on the massed trials, these same cues are being rewarded on the spaced trials. In other words, the only stimulus complex consistently correlated with the frustration of unrewarded massed trials, and not at the same time correlated with the rewarded space trials, is the unique stimulus components of the massing cue. For S the massing cue will always be paired with frustration produced by an unrewarded trial. The spacing cue, on the other hand, will always be paired with a rewarded trial.

This situation is favorable for the development of a learned discrimination, and the massing cue will become a discriminative cue (CS) capable of eliciting interfering emotional responses (UR) originally elicited by frustration stimulation (US). In anthropromorphic terms, the massing cue serves to warn S that frustration is coming, while the spacing cue indicates to S that food reward is coming. Therefore we may expect, if food reward is removed from the second or test trial of the test pair during a sequence of tests of inhibition, that discrimination learning will occur. At first no differences will occur in the behavior of S on the second or test trial; but gradually S will begin to show inhibition on the running response, that is, the massing cue will begin to elicit interfering emotional responses on the massed trials. This discrimination will be manifested in the gradual increase in the obtained measure of inhibition, which was defined as the <u>difference</u> between the running times on the spaced inhibition trial and massed test trial. It follows that: The removal of reward on the test trial will produce a gradual increase in the amount of inhibition present on this trial.

In summary, we have drawn four predictions from Hull's theory and four predictions from an interference theory about behavior in a straight alley situation. Three of the four predictions drawn from one position contradict the corresponding predictions drawn from the other position. The following experiment is an attempt to test each of the four predictions to determine which of the two theories, Hull's or an interference theory, most adequately accounts for the obtained data.

STATEMENT OF PROBLEM

The present study was undertaken to test empirically Hull's interpretation of the effects of massing and spacing of trials on the performance of infra-human subjects in a maze learning situation. The study also will test conflicting predictions drawn from an interference theory of inhibition.

The predictions drawn from Hull's interpretation that spacing and massing of trials are essentially rest periods of different lengths are as follows:

H-1. Spaced training trials will produce better performance than massed training trials.

H-2. Performance on spaced trials at the end of training will be better than performance on massed trials.

H-3. A test of inhibition after extensive training on both spaced and massed trials will reveal a measureable amount of inhibition immediately following performance on a single trial.

H-4. The removal of reward on the test trial will produce no significant increase in inhibition on this trial.

The predictions drawn from an interference theory that holds that the spacing and massing of trials serve essentially as discriminable cues are as follows:

I-1. Spaced training trials will produce better performance than massed training trials in the initial stages of learning.[1]

I-2. Performance on massed trials at the end of training will be as fast as performance on spaced trials.

I-3. A test of inhibition will not reveal a measurable amount of inhibition immediately following performance on a single trial.

I-4. The removal of reward on the test trial will produce a gradual increase in the amount of inhibition present on this trial.

1. To determine the extent to which the prediction drawn from the two theoretical analysis conflict, compare the corresponding numbers, i.e., H-1 with I-1, H-2 with I-2, H-3 with I-3, and H-4 with I-4.

PROCEDURE

Subjects. Fourteen male and two female hooded rats approximately 130-180 days old at the beginning of the experiment from the colony maintained by the Department of Psychology at Michigan State College were used initially. However, because of the death of one of the male hooded rats, it was necessary to substitute one male albino rat of the Wister strain. Neither strain nor sex of the subjects had any observable effect upon performance in the present study.

Apparatus. A straight alley constructed of 3/4" white pine board was used. The starting box was 12 in. long, 11 5/8 in. high, and 10 in. wide at the back. The sides narrowed to the 4 1/2 in. wide alley adjoining the front of the starting box. The alley was 25 in. long, 11 5/8 in. high, and 4 1/2 in. wide. The adjoining goal box was 15 in. long, 11 5/8 in. high, and 10 in. wide. A guillotine door separated the alley from the goal box and was used to prevent S from re-entering the alley after entering the goal box. Beneath the door, a black criterion line was painted. In the rear right hand corner of the goal box, a one in. high barrier isolated the food dish from view of S as he entered the goal box. The maze was painted a dark grey throughout and was dimly lit by a 40 watt bulb in a frosted glass globe hanging near the goal box. The maze was uncovered to allow easy access to S.

Preliminary Training. All Ss were placed on a 9 gm.-22 hr. hunger drive in individual home cages for nine days prior to the beginning of experiment. Water was available at all times. During the first five days, Ss were handled for 5 min. periods daily.

On the next two days, Ss were placed into the maze in groups of eight. Their standard diet, Purina Dog Checkers, was scattered throughout the maze. While Ss explored the maze and ate, E picked them up, placed them to his chest momentarily, and then replaced them in some other location in the maze. This procedure was designed to adapt them to one of the handling procedures to be utilized in the experiment, i.e., the massing procedure.

During the next two days the procedure was the same except that instead of dog checkers being scattered throughout the maze, the reward pellets subsequently used in the experiment were scattered in the goal box and particularly around the food dish area. This procedure was designed to adjust S to eating the reward pellet in the goal box and to search for the pellet in the food dish area. This procedure was necessary in order to secure a brief time interval between running responses.

At the end of preliminary training all Ss were reasonably well adjusted to the maze and to the two distinctly different handling procedures, i.e., massing and spacing procedures.

They would approach and quickly eat the reward pellet, 5-25 sec. after entering the goal box.

The reward pellet used in the experiment was one Cheerios, a standard breakfast food. This particular reward was used because it was easily seen, quickly eaten, light in weight, and yet eagerly sought by Ss.

Training Series. At the end of preliminary training, the experiment began. All Ss were given 6 rewarded trials daily. Three of the trials were massed and three were spaced. A massed trial was defined as a trial that succeeded the previous trial by 30 sec. or less. A spaced trial was one that succeeded the previous trial by 5 min. or longer. As was pointed out previously, the handling procedure for a massed trial involved picking S up immediately after eating the reward pellet, placing S momentarily to E's chest, and then placing him quickly into the starting box for the beginning of the next trial. The spacing procedure involved removing S immediately after eating, placing S on E's chest, transporting him to the holding cage, where S waited for 5 min. before being returned to the starting box for the next trial.

It is important to note that the 30 sec. inter-trial interval was defined as extending from the time S entered the goal box on the preceding trial to the time S was placed in the starting box for the next trial. The procedure was to place S into the starting box immediately after finishing the reward on the previous trial. The time taken to finish the food after entering the goal box in most all cases was between 10-20 sec. and placing S into the starting box for the next trial consumed about 5 sec. Thus, the total time elapsing between the end of the previous run and the beginning of the next run was 15-25 sec. with an average time lapse of approximately 20 sec. In only a few cases in the initial stages of learning did the inter-trial interval extend beyond 30 sec. This was due to the delay in approaching and eating the food on the previous trial.

By conventional definitions of inter-trial interval, i.e., time lapse between removal from the goal box and return to the starting box, the massed inter-trial interval was approximately 5 sec. or less than 10 sec. in every case.

The first two of the six daily trials were considered "warm up" trials and although times were recorded, these measures do not enter into any further analysis. Since the first trial of each day was obviously a spaced trial, the second trial of each day was massed. On the last four trials of each day, two trials were spaced and two massed.

A series of four days of six trials each was designated a block of trials. Each block contained equal numbers of massed and spaced trials and the four orders of trials used on the last four trials of each day were SMSM, MSMS, SSMM, and MMSS.

On the first day, 1/4 of the Ss began with each combination. The block design is presented in Table 1.

Four blocks, a total of 96 trials in all, were given during the training series.

Test for Inhibition. A test of inhibition immediately followed the training sequence. This test consisted of six rewarded trials per day on two successive days. The six trials were presented as follows: trial 1, spaced (22 hours), trial 2, spaced; trial 3, massed; trial 4, spaced; trial 5, spaced; and trial 6, massed.

Trials 2 and 3 and trials 5 and 6 constitute two independent tests of inhibition. Trials 3 and 6 were test trials immediately following "inhibition" trials 2 and 5. The running time on trial 3 minus the running time on trial 2, and the running time on trial 6 minus the running time on trial 5 yielded two measures of the inhibition which could be produced by the running response on a single trial (trial 2 or 5).

Testing Series. After the test for inhibition, the Ss were divided into two groups of eight, a work inhibition group and a frustration group, and equated for the amount of inhibition shown on the preceding test. The same daily pattern of trials was continued as given in the above test for both groups. The groups differed only with respect to the presence of reward on test trials 3 and 6. For the work inhibition group, all trials including trials 3 and 6 were rewarded. For the frustration

TABLE 1

THE ORDER OF SPACED AND MASSED TRIALS
WITHIN A BLOCK OF TRAINING TRIALS

N	Trial	Day 1	2	3	4
4	3	S	M	S	M
	4	M	S	S	M
	5	S	M	M	S
	6	M	S	M	S
4	3	M	S	M	S
	4	S	S	M	M
	5	M	M	S	S
	6	S	M	S	M
4	3	S	M	S	M
	4	S	M	M	S
	5	M	S	S	M
	6	M	S	M	S
4	3	M	S	M	S
	4	M	M	S	S
	5	S	S	M	M
	6	S	M	S	M
16	S	8	8	8	8
	M	8	8	8	8

group, all trials except trials 3 and 6 were rewarded. In other words, both massed and spaced trials were rewarded in the work inhibition group; but in the frustration group spaced trials were rewarded and massed trials were unrewarded. In the frustration group, it was possible for the massing procedure to serve as a cue for anticipating the frustration resulting from non-reward; and the spacing procedure could serve as a cue for reward. Each group received 12 days of this procedure, or 24 tests of inhibition under their respective conditions.

Following this treatment, the frustration group received two days of testing designed to determine whether the inhibition produced on trial 3 and 6 during the test series was elicited by the massing cue or whether the inhibition manifested on trials 3 and 6 of the daily series was somehow specific to these trials.

The test involved reversing the inter-trial interval on trials 2 and 3, and 5 and 6. Instead of spacing trial 2 (5) and massing trial 3 (6) as in the testing series, trial 2 (5) was massed and trial 3 (6) was spaced. On the following day, the intervals were switched back to the original test procedure. If the massing cue elicited the inhibition, then running time on trial 2 (5) should be greater than trial 3 (6) and of the same order of magnitude as trial 3 (6) on the last day of the testing series. Running times on each trial were recorded to the nearest .5 sec. from the time S was placed into the starting box at the beginning of the trial until S crossed the criterion line separating the alley from the goal box.

In summary, the experimental design was divided into four parts: 1) the training sequence, 2) a test for inhibition resulting from performance on a single trial, 3) a testing series to compare the efficacy of work and frustration in producing inhibition when associated with the massing cue, and 4) a test of the assumption that the massing procedure was the critical cue in eliciting the interfering (inhibition) response. The experimental design provided a test of all the predictions drawn from both theoretical positions.

RESULTS

The data related to hypotheses 1 and 2 of both theoretical analyses are summarized in Figure 1. Hull's theory predicts that spaced training trials will produce faster learning than massed training trials (H-1), and at the end of training, that performance on spaced trials will be better than performance on massed trials (H-2). On the other hand, the interference theory predicts that the superiority of spaced trials will exist initially (I-1) but that the difference between performance on spaced and massed trials will disappear in the latter stages of training (I-2). The data confirm hypotheses I-1, I-2, and H-1, but not H-2. There seems to be no difference in performance on spaced and massed trials at the end of training.

The statistical analyses[1] of the training data are presented in Table 2. The difference between performance on spaced and massed trials in the initial stages of learning (Day 1) is statistically significant at the .10 level of confidence. The differences in the latter stages of learning (Day 16) are not statistically significant.

At the end of training, a test of the amount of inhibition produced by a single trial was performed to test H-3 and I-3.

1. All statistical analyses of running times were performed upon the reciprocals of the running time scores following Edwards formulas for a test with independent and correlated measures. (3). In all cases of graphical presentation, median scores represented the most descriptive untransformed measure of central tendency.

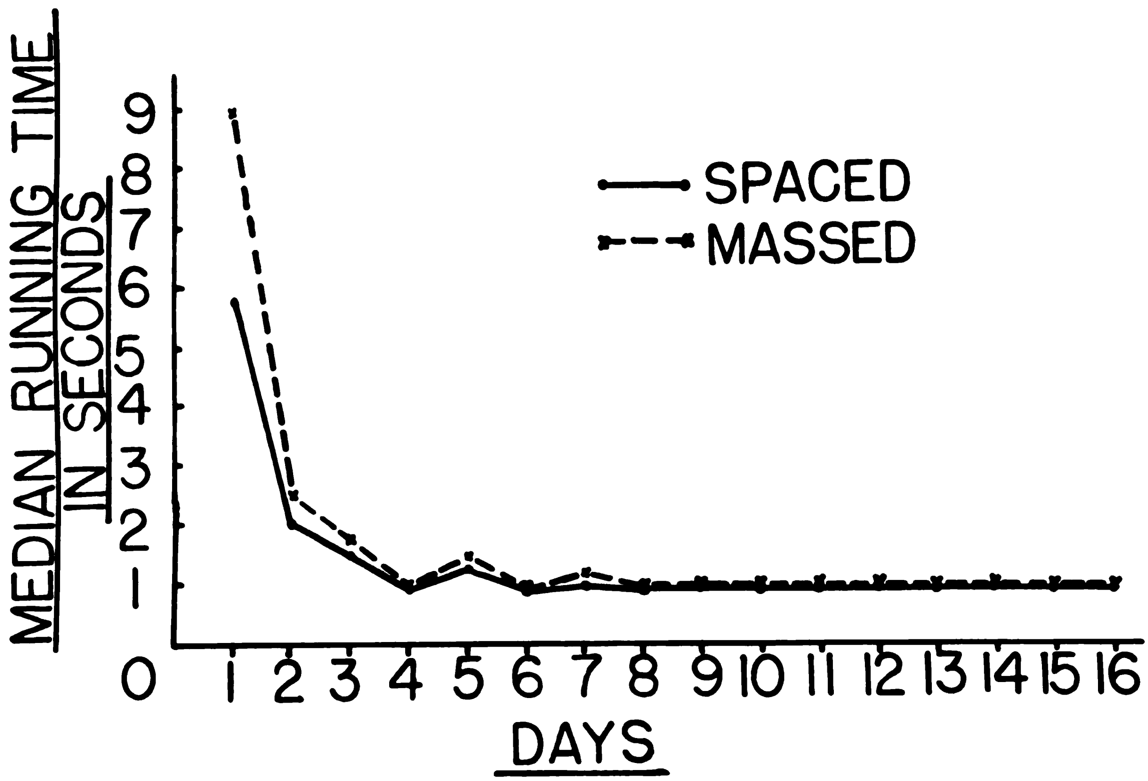

Figure 1. A comparison of running times on spaced and massed trials during training.

TABLE 2

A COMPARISON OF PERFORMANCE ON SPACED AND MASSED TRIALS DURING THE INITIAL AND TERMINAL STAGES OF TRAINING

Comparison	Mdn. (Sec.)	M[1]	S.D.	t	d.f.	Level of Confidence
1. Day 1.						
a. Spaced trials	5.75	.200	.125	1.750	15	.10[2]
b. Massed trials	9	.149	.106			
2. Day 16.						
a. Spaced trials	1	1.062	.234	.138	15	--
b. Massed trials	1	.988	.389			

1. Mean of the reciprocals of running times

2. Two-tailed test of significance

The median amount of inhibition produced by a single trial was 0. Of the 64 measures of inhibition obtained (16 Ss, 2 tests per day for 2 days), 48 were 0 sec., 6 were -.5 sec., 6 were .5 sec., and 4 were larger than .5 sec. A more sensitive measure was obtained by comparing the means of the reciprocals of the running times on the inhibition (spaced) and the test (massed) trial of the test pair. The data are summarized in Table 3. Here we see a slight but statistically insignificant difference favoring the inhibition (spaced) trials. This analysis supports I-3, but fails to confirm H-3.

On the basis of this test of inhibition, two groups were equated and the test sequence continued. The work inhibition group continued under this same procedure of rewarding both the inhibition and test trials. The frustration group, on the other hand, received reward on the inhibition (spaced) trials but no reward on the test (massed) trials. The effect of these two procedures are presented in Table 4. The work inhibition group continues to manifest no inhibition and the running times on the inhibition and test trials remain constant. For example, on the last day (Day 12), 16 measures of inhibition were obtained on the 8 Ss in the work inhibition group. Eleven were 0 sec., 4 were -.5 sec., 1 was 5 sec., and 1 was 1 sec. A more sensitive measure consists of comparing the means of reciprocals of the running times on the inhibition and test trials on the last day of the test series. These data are summarized in Table 5. The

TABLE 3

A COMPARISON OF PERFORMANCE ON INHIBITION (SPACED) AND TEST (MASSED TRIALS AT THE END OF TRAINING

Comparison	Mdn. (Sec.)	M[1]	S.D.	t	d.f.	Level of Confidence
1. Inhibition Trial	1	1.113	.267	.252	15	
2. Test Trial	1	1.053	.272			

1. Mean of the reciprocals of running times.

TABLE 4

A COMPARISON OF THE WORK INHIBITION AND FRUSTRATION GROUPS DURING TESTING

	GROUP					
	WORK INHIBITION			FRUSTRATION		
Day	Inhibition Trial	Test Trial	I*	Inhibition Trial	Test Trial	I*
1	1**	1	0	1	1	0
2	1	1	0	1	1	0
3	1	1	0	1	1.5	.5
4	1	1	0	1	1.5	.5
5	1	1	0	1	2.5	.5
6	1	1	0	1	2	1.25
7	1	1	0	1	5	4.25
8	1	1	0	1	4.5	3.5
9	1	1	0	1	6	4.75
10	1	1	0	1	5.5	4.5
11	1	1	0	1	9.25	8.25
12	1	1	0	1	8.25	7.25

* Inhibition measures are the medians of differences resulting from subtracting the running time on trial 2 (5) from the running time on trial 3 (6) for each subject.

** Median running time in seconds.

TABLE 5

A COMPARISON OF THE PERFORMANCE OF THE WORK INHIBITION GROUP ON THE INHIBITION AND TEST TRIALS ON THE LAST DAY OF THE TEST SERIES.

Comparison	Mdn. (Sec.)	M^1	S.E. diff	t	d.f.	Level of Confidence
1. Inhibition Trial	1	.979				
			.181	.403	7	--
2. Test Trial	1	.906				

1. Mean of the reciprocals of running times.

data summarized in Table 6 also indicates that there is no real difference in the first and last days of the test series, i.e. there is no cumulative effect produced by the test series.

The fourth set of predictions concerns the inhibition manifested by the frustration group on the test series. Table 4 indicates that removal of reward on the test trial has no immediate effect upon inhibition, but that there is a gradual increase in the amount of inhibition during the test series. We may test the hypothesis that there was an increase in the amount of inhibition manifested by the frustration group, by comparing the frustration group with the work inhibition group on the last day of the test series (Table 7) or by comparing the inhibition manifested by the frustration group on the first and last day of the test series. This latter comparison is summarized in Table 8.

There is a significant increase in the amount of inhibition in the frustration group during the testing series. Accordingly I-4 is clearly confirmed. H-4 which predicted no change in the amount of inhibition manifested when reward is removed from the test trial (Table 7) Day 1, frustration group vs work inhibition group is also confirmed.

At the end of the test series, a test was performed on the frustration group to see if the massing procedure had actually been the discriminative stimulus as assumed by the interference analysis. During the test series the test trials (trials 3 and 6) were always massed and the "inhibition" trials were always

TABLE 6

A COMPARISON OF THE INHIBITION MANIFESTED BY THE WORK INHIBITION GROUP ON THE FIRST AND LAST DAYS OF THE TEST SERIES.

Comparison	Mdn. (Sec.)	M	S.E. diff	t	d.f.	Level of Confidence
1. First Day	0	.44	.386	.984	7	--
2. Last Day	0	.06				

TABLE 7

A COMPARISON OF THE INHIBITION MANIFESTED BY THE WORK INHIBITION AND FRUSTRATION GROUPS ON THE FIRST AND LAST DAY OF THE TEST SERIES.

Comparison	Mdn. (Sec.)	M	S.D.	t	d.f.	Level of Confidence
1. Day 1						
a. Work inhibition group	0	.44	1.19	.419	15	--
b. Frustration group	0	.22	.89			
2. Day 12						
a. Work inhibition group	0	.06	.59	4.656	15	.01
b. Frustration group	8.25	11.56	6.98			

TABLE 8

A COMPARISON OF THE INHIBITION MANIFESTED BY THE FRUSTRATION GROUP ON THE FIRST AND LAST DAY OF THE TEST SERIES.

Comparison	Mdn. (Sec.)	M	S.E. diff	t	d.f.	Level of Confidence
1. Day 1	0	.22	2.560	4.429	7	.01
2. Day 12	8.25	11.56				

spaced. From Table 4, it is apparent that inhibition occurred on the test trial (the third and sixth trial of a day) but is the inhibition manifested on the test trials due to the massing cue or is it specific to the third and sixth trial of the daily sequence? To answer this question, involved massing trials 2 and 5 and spacing trials 3 and 6 on day 13, and then changing back to the procedure followed previously. If the inhibition were elicited by the massing cue, then inhibition should occur on trials 2 and 5 on day 13, and on trials 3 and 6 on day 14. If the inhibition were specific to trials 3 and 6, then this procedure should have no effect upon the inhibition shown on trials 3 and 6. The data are summarized in Table 9 and analysized statistically in Table 10. Inspecting Table 9 and Table 10, we find that the massing procedure produces inhibition regardless of the position of the massed trial. It is apparent that the massing procedure was a cue for ensuing non-reward as assumed by the interference analysis.

In this connection, it is important to note that the massing cue was potentially associated with the presence of Ir and its subsequent reduction. The work inhibition group had 76 associations of the massing cue with the reduction of work inhibition and yet failed to show any sign of conditioned inhibition (sIr) when the massing cue was presented (Table 4). On the other hand, it took only 10-12 such associations between the massing cue and the frustration resulting from non-reward before the presence of

TABLE 9

A COMPARISON OF THE EFFECT OF REVERSING THE MASSING AND SPACING CUE WITH RESPECT TO RUNNING TIMES ON THE INHIBITION AND TEST TRIALS.

Comparison	DAYS	Test of Massing Cue 13	14
1. Inhibition Trials (2 & 5)	1[2] (S)[3]	9 (M)	1 (S)
2. Test Trials (3 & 6)	8.25 (M)	1 (S)	8.25 (M)
3. Inhibition (3-2 & 6-5)	7.25	-8	7.25

1. The last day of the test of inhibition series.

2. Median running time in seconds.

3. The notation (S) indicates a spaced trial and (M) indicates massed trials.

TABLE 10

AN ANALYSIS OF THE EFFECT OF REVERSING THE MASSING AND SPACING CUE WITH RESPECT TO THE INHIBITION AND TEST TRIALS. (DAYS 13 and 14)

Comparison	Mdn. (Sec.)	M[1]	S.D.	t	d.f.	Level of Confidence
1. Trials 2 & 5						
a. Day 13 (M)	9	.149	.073	8.38	7	.01
b. Day 14 (S)	1	.962	.262			
2. Trials 3 & 6						
a. Day 13 (S)	1	.986	.259	9.82	7	.01
b. Day 14 (M)	8.25	.153	.063			
3. Massing Cue						
a. Trials 2 & 5 (13)	9	.149	.073	.1	7	--
b. Trials 3 & 6 (14)	8.25	.153	.063			
4. Spacing Cue						
a. Trials 2 & 5 (14)	1	.962	.262	.07	7	--
b. Trials 3 & 6 (13)	1	.986	.259			

1. Mean of the reciprocals of running times.

the cue produced inhibition on the ensuing trial. In other words, 10-12 massing cue-frustration associations were sufficient to produce observed inhibition, despite the fact that the massing cue had been previously associated with <u>reward</u> 52 times. Any learning mediated by work inhibition would not seem to be very important when compared with the learning produced by the frustrating omission of non-reward.

DISCUSSION

The results confirm all the predictions drawn from an interference theory and confirm only the one prediction drawn from a Hullian analysis of inhibition which was identical to the one derived from the interference theory. In general, the results indicate that Hull's theoretical analysis of inhibition in terms of Ir and related concepts is not applicable to infra-human maze studies involving lesser amounts of work. On the other hand, the results support the analysis of the effect of massing and spacing procedures upon learning and inhibition in terms of the cue properties of the two procedures.

As pointed out in the introduction, Hull was careful to distinguish the concept of Ir from fatigue. It would seem that this distinction was made in order to justify the application of the "fatigue like" concept of Ir to situations where fatigue would not be considered an important variable. However, the failure to support the Hullian-type formulation and application of Ir does not in any way reflect upon the importance of the effect of <u>fatigue</u> upon behavior. The results of the study suggest only that lesser amounts of work do not produce a state capable of producing inhibition of a learned response.

Bartley (2) makes a distinction between fatigue and impairment. <u>Fatigue</u> is an experience produced primarily by conflict and disorganization within the organism, whereas <u>impairment</u> refers

to the inhibition of responding because of specific physiological changes in tissue condition due to work out-put. Bartley points out that neither fatigue nor impairment, which is similar to the notion of Ir, can be measured directly in terms of work output of an intact organism. Such a relationship can only exist when working with an isolated nerve muscle preparation.

The failure of this study and others (7,9) to demonstrate a consistent relationship between work out-put and inhibition of response in infra-human maze studies involving intact organisms would tend to confirm Bartley's treatment of impairment. The organism must be taxed beyond the normal capacity of the musculature to respond before impairment occurs. Furthermore, the failure to find any observable inhibitory effect that could be attributed to Ir would suggest that, with lesser amounts of work, the impairment of the ability to perform is negligable or non-existent. In other words, reactive inhibition appears to be unimportant in accounting for learning and extinction phenomena in the conventional infra-human learning study.

On the other hand, if the interference analysis of inhibitory phenomena in this situation is correct, then the study of the effect of massing and spacing of learning in maze situations possesses new theoretical import. Knowledge of the inhibitory effects of these procedures no longer serves to support theoretical concept like Ir. Rather, this study, in addition to testing predictions from an interference theory, serves to demonstrate the cue properties inherent in the massing and spacing procedures. The study also emphasizes the importance of handling procedures. The massing procedure differs from the spacing procedure in that massing probably produces interfering emotional responses because initially it may tend to disorient and disorganize the animal. This difference in the properties of the two cues would seem to account for the difference in performance on spaced and massed trials at the very beginning of learning. The consistent association of this procedure with reward, however, will produce learning (adjustment) to the procedure so that in the later stages of learning the interfering emotional responses elicited by the massing procedure are obscured or minimized.

The theoretical treatment of the massing and spacing procedures as cues may help explain other infra-human inhibitory phenomena previously offered as evidence for the work inhibition interpretation of inhibition. These phenomena fall into six major groupings. They are: (1) The effect of massing and spacing procedures upon the rate of learning, (2) The effect of work upon "spontaneous" alternation, (3) The fact that response extinguishes with non-reward, (4) The fact that massed evocation of a response produces faster extinction than spaced evocation, (5) The "spontaneous" recovery of unextinguished response after rest, and (6) The fact that massed extinction tends to produce a greater amount of "spontaneous" recovery after a rest period than spaced extinction. These relationships represent the core phenomena that the notion of Ir was designed to account for. If these phenomena can be adequately explained by other concepts, then the work inhibition interpretation of inhibition will have lost its unique function, namely, that of unifying diversified inhibitory phenomena.

The following explanations are offered as a way in which these phenomena may be explained by an interference theory of inhibition.

1. <u>The Effect of Massing and Spacing Upon Learning</u>.

   As discussed above, the massing procedure elicits interfering emotional and orientation responses which initially interfere with acquisition of adient responses. The spacing procedure does not tend to produce disorientation, hence learning under spaced conditions proceeds without interference.

2. <u>The Effect of Work Upon Spontaneous Alternation</u>.

   Predictions stemming from Hull's system have been found not to provide a satisfactory explanation of spontaneous recovery. Montgomery (12, 13), Glanzer (4), and more recently Walker, <u>et al</u> (19) have found spontaneous alternation in the albino rat to be a function of several variables <u>other</u> than the amount of work involved in the previous response. Walker states, "Increasing the work or effort involved in making the response did not lead to an increase in the tendency to alternate, as would be expected from Hull's concept of reactive inhibition. What effect there was of increased work was in the reverse direction - increases in the tendency to repeat the response." (19, P. 85). The research of these authors indicates that behavior variability is a function of a number of stimulus and response variables and should best be thought of as fundamental to behavior in learning situations and not as a phenomenon to be predicted by a learning theory.

3. The Fact That a Response Extinguishes With Non-Reward.

An explanation of experimental extinction has been suggested elsewhere (8) and applied above in accounting for the inhibition resulting from the association of the massing cue with the frustrating omission of reward. In general, extinction of a response results from the learning of interfering habits. These interfering habits may be based upon the elicitation of new responses by frustration stimulation which results from non-reward in a previously learned situation; or they may result from the introduction of some new US in the situation. For a more detailed explanation see (8).

4. <u>The Fact That Massed Evocation of a Response Produces Faster Extinction Than Spaced Evocation of Response.</u>

In studies involving a comparison between massed and spaced extinction trials, the original learning is usually spaced. Within the Hullian system, spaced learning trials were thought to eliminate the inhibitory effects of Ir and sIr and faster learning occurred. For Hull, this original learning had little effect upon subsequent extinction phenomena. However, within the present system, learning under spaced conditions is tantamount to associating the spacing cue with reward. During extinction, the massed group is provided with a new massing cue which is followed by non-reward. The spaced extinction group is provided with no such distinctive cue. Thus, the massed extinction group which can distinguish between the learning and extinction series on the basis of the massing

cue, extinguishes more rapidly than the spaced extinction group which must re-associate the previously learned spacing cue with non-reward. However the advantages of massing and spacing of extinction trials will depend upon the degree of similarity between the two cues, the amount of emotional behavior generated by the massing procedure itself, and upon learning conditions prior to extinction. Sheffield (15) obtained conflicting results and in a review of the literature reports that uniformly clear cut evidence for the superiority of massed trials in producing extinction does not exist. Since the factors mentioned above have never been adequately controlled, we might expect a diversity of results. In any event, if the above analysis is essentially correct, then the whole problem of massing and spacing of trials during learning and extinction has acquired new theoretical importance.

5. Spontaneous Recovery of an Extinguished Response After Rest.

Spontaneous recovery within this system is considered to be primarily a function of the reinstatement of cues previously associated with reward. Since extinction is described as an unstable equilibrium of competing or interfering response tendencies any partial reinstatement of cues which were discriminately associated with reward may be expected to elicit the original response and result in "spontaneous recovery".

For example, when learning is spaced and extinction is massed, the rest period after extinction which was thought to allow dissipation of Ir actually involves a reinstatement of the spaced trial conditions that obtained during learning. "Spontaneous recovery" then is a measure of the degree of discrimination between the massing and spacing procedures produced during spaced learning and massed extinction trials.

6. Massed Extinction Tends to Produce a Greater Amount of Spontaneous Recovery than Spaced Extinction.

Explanation of this phenomena is related to the above analysis. If learning is spaced and extinction massed, then the degree of discrimination between learning and extinction would be greater than if both learning and extinction are spaced.

Thus, with the reinstatement of the spacing cue (rest) the massed extinction group should spontaneously recover and the spaced extinction group should not. The differences in amount of spontaneous recovery would depend upon the amount of difference and, type of difference between learning and extinction situations.

The above explanations are offered to suggest that the phenomena previously thought to be best accounted for by Hull's interpretation of inhibitory phenomena may be adequately explained within an interference theory of inhibition. The use of the massing and spacing cues as demonstrated in this study may play an important role in understanding the effect of massing and spacing procedures upon rate of learning, rate of extinction, and spontaneous recovery. This analysis, is of course, restricted to infra-human maze studies involving lesser amounts of work.

SUMMARY

This study was designed to test two sets of conflicting predictions about the effect of massing and spacing procedures upon learning and inhibition in an infra-human learning situation involving lesser amounts of work. Four predictions were drawn from Hull's reactive (work) inhibition theory which stressed the inhibitory effect of massing, per se, and four predictions were drawn from an interference theory which stressed the cue properties of massing.

To test these predictions, 16 Ss were given extended training on both spaced and massed trials in a straight alley maze. A test was then performed to determine the amount of inhibition resulting from performance on a single trial. After the test of inhibition, Ss were divided into two equated groups, a work inhibition group and a frustration group. The work inhibition group continued under the same testing sequence to determine the continued effect upon performance of rewarded-spaced, and rewarded-massed trials. The frustration group experienced rewarded spaced trials but were unrewarded on massed trials during the same test of inhibition procedure received by the work inhibition group. This test determined the effect of associating the massing procedure with non-rewarded trials. A test was then performed to determine if the massing procedure, per se, was the cue which produced inhibition on the subsequent trial.

The results confirmed all the predictions drawn from an

interference theory and failed to confirm the major predictions drawn from Hull's theory. The data failed to indicate the presence of any temporary or permanent inhibition resulting from lesser amounts involved in a single trial. The massing procedure however, did become a cue eliciting responses which interfere with performance on the following trial if that procedure was followed by an unrewarded trial and the spacing procedure was followed by a rewarded trial.

Since the experimental conditions were optimal for the production of reactive inhibition and yet none was observed, and when non-reward was introduced inhibition did develop, it was suggested that Hull's analysis of inhibitory phenomena is not applicable to infra-human maze learning studies involving lesser amounts of work. The application of interference theory and existing concepts also seems to account for other learning and extinction phenomena previously offered in support of Hull's theoretical analysis.

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