RESISTANCE TO EXTINCTION AS A FUNCTION OF THE TYPE OF RESPONSE ELICITED BY FRUSTRATION STIMULATION AND LEVEL OF REINFORCEMENT

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Major professor

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A THESIS

Submitted to the School of Graduate Studies of Michigan State College of Agriculture and Applied Science in partial fulfillment of the requirements for the degree of

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AN ABSTRACT

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The present study was designed primarily to test the hypothesis that the type of response elicited by the frustrating omission of a reward is a significant determinant of the rate of extinction of the original response. Furthermore, this study was formulated to test the rates of learning of a compatible jump response and extinction rates of that response when the learning was elicited by different types of stimulation. Fifty female Hooded rats were employed, with thirty Ss being run in a straight alley with food as a reward. For extinction, they were divided into three groups according to the type of response to be learned to the frustrating state of affairs. During extinction one group learned a compatible jump response from the goal box, while a second group learned a directly incompatible response of recoiling from a goal box. A third group was run according to traditional extinction procedure of confinement in the goal box for a 20-second period after frustration.

Two additional groups of 10 Ss each were run on the learning of the jump response only. The exploratory group was taught the jump response with no reward, whereas, the food group was taught to jump to a food reward.

The results clearly demonstrate that resistance to extinction is a function of the type of response elicited by frustration. A directly incompatible recoil response to frustration produces rapid extinction of an approach response

while a compatible escape response to frustration produces little or no extinction of the original response. Furthermore, the results indicate that the type of stimulation eliciting the jump response is a significant determinant of both the rates of learning of that response, and the asymptote reached in the learning.

The second part of the study was concerned with a determination of the relationship between number of reinforcements and resistance to extinction in the framework employed above.

Thirty female hooded rats were trained as the experimental jump work, although one group received 12 reinforcements, another 24, and the third 36.

The results indicate that the number of reinforcements seem to have an all or none effect upon resistance to extinction. That is, if the habit is of sufficient magnitude to produce frustration stimulation no extinction will take place. On the other hand if the habit is too weak to produce frustration, extinction will rapidly take place.

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INTRODUCTION - PART I

In contemporary psychology the weakening of a conditioned response has been termed inhibition (13), while total elimination of a conditioned response due to the omission of the unconditioned stimulus has been called experimental extinction (10). Although there is a considerable amount of agreement concerning the nature of innibitory phenomena in general, the theoretical explanation of how responses are weakened and finally eliminated has been a major concern of psychological theorists.

Pavlov (10) in 1929 first attempted to give a theoretical account of the nature of the extinctive process by defending the position that inhibitory phenomena are exclusively cortical, cellular, and inherent in any form of conditioned excitation (10). After accusing Pavlov and his associates of taking too many liberties with physiology, many other theorists accounted for the same phenomena by reference to other constructs with variegated conceptual properties. In his 1939 Psychological Review article, Razran (11) reviewed seven explanations of extinction in accordance with the manner in which they handled the facts of extinction. His thoroughgoing analysis also revealed the shortcomings of all the proposed explanations up to that date.

With the recent trend in psychology toward more formalized theoretical structure, new formulations of the extinction

process have arisen. These theories, eschewing the inconsistencies of past formulations, may generally be divided into three types. The first type postulates some state in the organism which develops during extinction and finally produces the cessation of a given response. The second type holds that extinction takes place by the learning of an incompatible response. The third type of theory is a combination of the first two.

The chief protagonists in contemporary psychological theory are those who explain extinction by the type I formulation and those who adhere to the type II position. The latter viewpoint, generally referred to as interference theory, is held by Guthrie (4), Wendt (15), Culler (1), and others (16). In general, this view holds that the omission of the unconditioned stimulus leads to irritation and excitement which in turn elicits new responses. With continuous omission the cues which formerly led to a reward now become elicitors of responses which are incompatible with the on-going response, and thus produce extinction. However, this explanation of the extinction process is of a distinctly ad hoc character, since it is impossible to specify a priori which response will be strengthened to the point of interference with the original response. Thus, with the multiplicity of responses which characteristically occur to the omission of a reward, one cannot understand why one particular response gets strengthened more than another. This would tend to reduce the

interference theories to verbal explanation of the phenomena in question, and therefore would tend to obviate the eventual theoretical significance of such a position.

In a somewhat more systematic fashion, Hull (5), a type I theorist, has attempted to deduce the characteristic extinction phenomena by postulating the development of inhibitory potential. This is assumed to be composed of reactive inhibition, a temporarily labile drive state, and conditioned inhibition which develops upon the reduction of reactive inhibition. Since reactive inhibition develops in reinforced and unreinforced trials alike and dissipates within specified time intervals, it can be used to explain such inhibitory phenomena as spontaneous recovery, reminiscence, and others. True extinction occurs, however, only when conditioned inhibition is generated to the extent that it produces a response which competes with the ongoing excitatory response. Recent studies have shown, however, that the concept of reactive inhibition upon which the concept of conditioned inhibition is based, may be open to considerable doubt as a possible explanation of extinction (7, 9). Since conclusions following from false premises are indeterminate in character, the theoretical significance of the concept of reactive inhibition and the validity of the conclusions drawn therefrom are strongly suspect.

It is evident then, that most theories of inhibition, regardless of the type of explanatory concepts involved, explain experimental extinction as a result of the learning of interfering

responses. These theories do, however, differ as to the origin of the interfering responses, and the principles of learning involved. Hull (5) and Miller and Dollard (8), for example, posit that interfering responses arise from the accumulation of intrinsic inhibition resulting from sheer performance of the learned response. These interfering responses are variously described as resting responses, relaxation responses, response of not responding, etc., and result in the reduction of the accumulated drive state. On the other hand, pure interference theories of extinction as represented by Guthrie (4) and others (1, 15, 16) maintain that any new response which consistently occurs during extinction will be learned and interfere with the original response, since sheer contiguity of stimulus and response are considered sufficient to produce learning. Other theories maintain that interfering responses arise from frustration resulting from removal of the goal object (4, 15). These responses are reinforced and eventually interfere with the original response tendency.

The theoretical orientation of the present study (7) holds that new responses are elicited by frustration stimulation (s_f) arising from the omission of food in a previously rewarded situation. For the purposes of the present study a reinforcement is defined as follows:

"A reinforcement will occur whenever there occurs a stimulus or stimulus complex that elicits a characteristic response (r).

Given the occurrence of a reinforcement, there will result an increment to a tendency ($_{S}H_{R}$) for that complex to evoke a member of that response class (R)."

Frustration stimulation is defined as follows:

"Frustration stimulation (s_f) will occur in a learned sequence whenever the elicitation of a learned response results in the occurrence of a stimulation complex interrupting performance of the learned sequence. s_f will elicit members of a characteristic class of responses (Rs_f)."

It follows from the above definitions that a frustrating state of affairs is a reinforcing state of affairs and that Rs_f will be conditioned to the stimulus complex blocking performance of the original learned response. However, the capacity of these responses to interfere with the original response tendency is dependent upon the type of skeletal response (Rs_f) elicited by s_f. The type of Rs_f elicited will depend upon the possibilities and limitations placed upon responding by the environment. Thus, some situations, such as those involving conventional extinction procedures, can only elicit responses that are incompatible with the original response, e.g., random exploratory behavior in an enclosed goal box.

On the other hand, it also follows that the environment may be manipulated so that it would require an Rs_f which would not eventually interfere with the original response leading to s_f. Thus with continued non-reward, the anticipatory

occurrence of a compatible Rs_f would facilitate or "fixate" the original response instead of resulting in "extinction" or that response. Therefore, within the theoretical position employed, it is entirely possible that non-rewarding learned adient behavior could result in a wide range of behavior ranging from rapid extinction of the response tendency to facilitation or virtual fixation of the response tendency.

Specifically the first section of this study was designed to compare the effects of three types of response to frustration (Rs_f) upon the rate of extinction of a simple running response. A response of jumping from the goal box was considered relatively compatible to the original running response since it could only occur after entering a distinctive goal box. A response of recoiling from the goal box into the alley of the straight alley was considered a directly (directionally) incompatible response since S cannot both approach and recoil from the goal box at the same time. The third type of response to frustration was that produced by the conventional extinction procedure of confining S in the goal box for a specified time. This procedure was assumed to produce emotional behaviors, e.g., face washing, exploration, etc., which would result in some intermediate degree of extinction.

Since, according to the above theoretical position, the elicitation of responses by frustration stimulation (s_f) constitutes a reinforcement, it follows that these newly learned responses should be highly resistant to extinction. Theoretically

the jump response learned to the omission of food in a previously rewarded situation should exhibit little or no extinction unless the response elicited by the frustration stimulation is somehow interfered with. Thus a comparison of the strength of the jump response established by non-reward with the same type of response set up through use of a food reward should reveal differential extinction rates.

METHOD

Apparatus

The apparatus was a conventional straight alley maze. The starting box section was 11 inches square, painted flat gray and covered with a piece of 1/8 inch clear plate glass. The 18 inches long, 5½ inches wide, and 8½ inches high runway was of natural plywood color and covered by 1/4 inch hardware bloth. The goal box section was 11 inches square and 10 inches high, painted black, and covered with a piece of 1/8 inch clear plate glass. A natural plywood guillotine door separated the goal box from the straight alley and a semi-circular piece of black bristol board (11 inches radius) was mounted on top of the goal box on the side facing the alley to prevent Ss viewing the rest of the maze when perched on top of the goal box. A 2 inch black ledge was attached to the top external part of the goal box on the three remaining sides to facilitate perching after S had jumped from the goal box.

Subjects

The subjects were 50 experimentally naive female hooded rats, 90-150 days old, from the colony maintained by the psychology animal laboratory at Michigan State College.

Procedure (Table I)

The Ss were handled for seven days prior to introduction into the maze. During this time they were put on a 23-hour feeding schedule and received an average of 9 grams of Purina Dog Chow checkers daily at the scheduled training time. Throughout the course of the experiment all Ss were individually fed 9 grams ten minutes after the end of the daily run. On day 8, for 3 groups of 10 Ss each, Ss were introduced into the maze and allowed free exploration for a one-hour period. On day 9, acquisition trials began. All Ss were given three spaced (10 minute intertrial interval) trials on the first day, four spaced trials on the second day, and six spaced trials per day for five days thereafter. The time allowed for eating during acquisition was gradually decreased. During the latter phases of acquisition, a 20-second period after entering the goal box was allowed for eating. All Ss ate the 1/5 gram reward pellet within this time interval. Twenty seconds after entering the goal box and securing the reward, Ss were removed to running cages to await the next trial. Thus, each S received a total of 37 spaced acquisition trials prior to extinction. Running times were recorded to the nearest second from the time S was placed into the starting box till S entered the goal box section.

On the following day, Ss were divided into three groups on the basis of their performances on the previous day and given one rewarded warm-up trial to indicate the control of

TABLE I

EXPERIMENTAL DESIGN OF EXTINCTION STUDY

Group	Straight Alley	Goal Box	Extinction Trials	Extinction of Jump Response
Experimental jump	36 trials	20 seconds	30 jump trials	100 trials or 5 min. criterion
Normal extinction	36 trials	20 seconds	confine 20 sec.	None
Recoil	36 trials	20 seconds	recoil 30 trials	None
Control food	None	20 seconds no reward	30 jump trials to food	100 trials or 5 min. criterion
Control exploratory	None	20 seconds no reward	30 jump trials	100 trials or 5 min. criterion

group running times prior to extinction. On the next trial (10 minute intertrial interval), extinction of the running response was begun by removing the reward from the goal box.

The groups were differentiated by the type of response allowed following the frustration resulting from non-reward. For the jump group, the plate glass cover of the goal box was removed to allow access to the ledge on top of the goal box. After S had entered the goal box it was allowed a 5-minute period in which to escape by jumping to the top of the goal box. After jumping, S remained on the ledge for 20 seconds before being returned to the individual running cages. If S did not jump within the 5-minute period, he was aided by E in climbing to the top of the goal box by inserting a hand into the box to serve as a step.

A second group, the normal extinction group, was confined for 20 seconds after entering the goal box and then returned to the running cages. This method is frequently used as an extinction procedure in learning studies in this area.

The third group, the recoil group, was allowed to recoil out of the goal box after frustration by leaving the guillotine door between the alley and the goal box open. Upon re-entering the alley, the door was dropped behind him and 20 seconds later S was removed from the alley or starting box and placed into a running cage. It should be re-emphasized that the groups were differentiated on the basis of the response which occurred

after frustration of the original response and that all Ss were retained in the maze for a period of 20 seconds after the response to frustration had occurred.

The extinction period covered three days of 10 spaced (10 minute intertrial interval) extinction trials per day. If S did not enter the goal box within 120 seconds it was removed. Two successive no response trials were considered as an extinction criterion, even though Ss were given all 30 extinction trials. The running times during extinction were recorded in the same manner as employed during acquisition.

To preclude the possibility that the obtained results could have been due to the consummation of an exploratory drive, a control group of 10 Ss was utilized. During the acquisition phase the exploratory group was put into the enclosed goal box but was never fed therein. All Ss were put into the goal box for the same 20 seconds period as were the other groups and then returned to the running cage to await further trials. For the thirty extinction trials all control Ss were given identical treatment to the experimental jump group.

To show differences in learning and extinction rates between responses elicited by food deprivation and those elicited by frustration stimulation, a control food group was run. The 10 Ss in this group were confined in the goal box for 20 second periods during the 37 training trials, and like the exploratory group received no reward. When the experimental jump group

began extinction trials the control food group was taught the identical compatible response, but was rewarded by the placing of food upon the ledge. Thus a direct comparison of the learning of the jump response by the experimental, exploratory, and food groups was readily forthcoming.

On the day following the 30 trial extinction period, the jump response learned under the various conditions underwent extinction trials. The three groups involved were the experimental jump group, the control exploratory group, and the control food group. The procedure for all the groups was to place each S in the goal box and await the jump. When S had jumped and perched on the ledge for a period of 20 seconds he was picked up and put back into the box. Thus each S was handled in such a manner until he remained in the box for a 5-minute no-jump period, or had gone through one hundred trials. Ss were handled singly until one of the two extinction criteria had been met. Jump times during extinction were recorded in the same manner as employed during acquisition.

RESULTS

The results of extinction of the straight alley response are presented in Figure 1 and a statistical analysis for the 30 trials are presented in Table II. Figure 1 clearly shows that the type of response elicited by frustration stimulation is a significant variable in the extinction of a simple running response. A response to frustration which opposes or is directly incompatible with the original response (recoil) produces very rapid extinction of the original response; and a response which is compatible with the original response (jump) produces little or no effect upon the original response tendency within the limits employed in the present study. Normal extinction procedures result in some intermediate effect upon the original response.

Further evidence to support the differences obtained may be found by an analysis of the number of trials to reach the extinction criterion of two successive 120-second no-response trials. All ten Ss of the recoil group, only four Ss of the normal extinction group, and none of the jump group reached this criterion.

The results of the learning of the compatible jump response for the experimental jump group, the control food, and control exploratory groups, are presented in Figure 2 and a statistical analysis of the 30 trials is presented in Table III.

TABLE II

EXTINCTION OF STRAIGHT ALLEY RESPONSE AS A FUNCTION OF TYPE OF RESPONSE ELICITED BY FRUSTRATION STIMULATION

Group	**Mean of median latency	d-value	Trials to extinction
1. Experimental jump	5.75		30
		$d_{1, 2} = 4.6$*	
2. Normal extinction	47.5	$d_{1, 3} = 5.0$*	26.2
		$d_{2, 3} = 1.3$	
3. Recoil	60.30		16.0

*.01 = 3.40

**Numbers represent the mean latency score of the medians taken from the median latency for blocks of five trials during the thirty-trial extinction period.

TABLE III

LEARNING OF JUMP RESPONSE AS A FUNCTION OF THE TYPE OF STIMULATION ELICITING THE RESPONSE

Group	**Means of median latency	d
1. Experimental jump	4.90	
		$d_{1, 2} = 4.6$
2. Control food	19.60	$d_{1, 3} = 5.0$*
		$d_{2, 3} = 4.7$
3. Control exploratory	168.45	

.01 = 3.40

**Numbers represent the mean jump latency of the medians taken from the median latency for blocks of five trials during the thirty-trial extinction period.

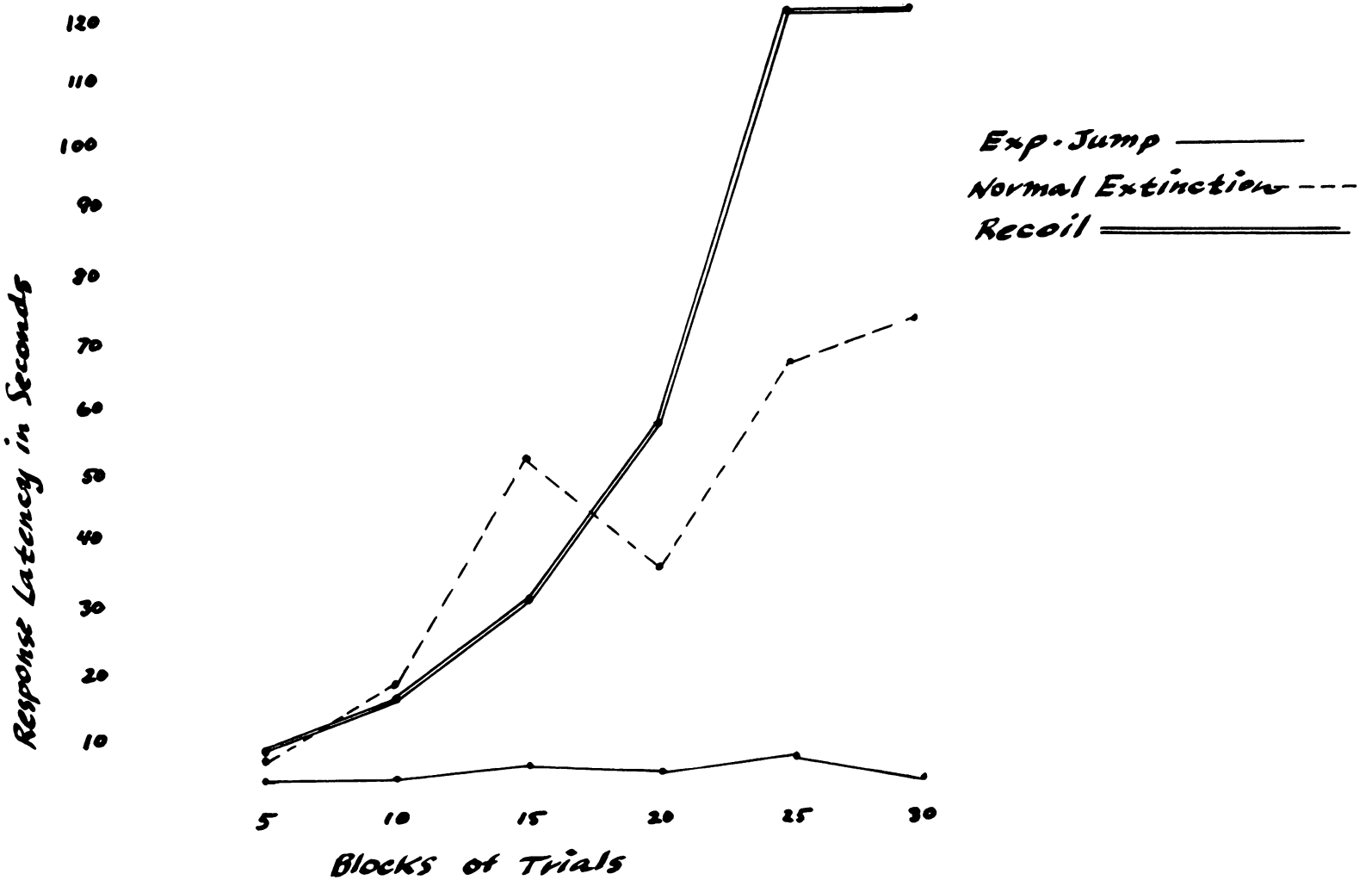

Fig. 1. Extinction of straight alley response. Numbers represent medians for blocks of five trials during 30 trial extinction period.

Figure 2 shows that the type of stimulation eliciting the jump response is a significant determiner of the rate of learning of a jump response, and differential asymptotic rates of responding. Non-parametric statistical analysis in Table III reveals these differences to be significant beyond the .01 level of confidence. It would seem, therefore, a response which is elicited by frustration stimulation produces very rapid learning of a new response; and stimulation resulting from the exploratory drive state produces little or no learning in most cases. Responses produced by stimulation of hunger and rewarded by food are learned significantly slower than a like response produced by omission of food in a previously rewarded situation.

Further evidence to support the differential rates of response learning as a function of different types of stimulation may be found by an analysis of the jump learning data. Eight Ss in the control exploratory group failed to jump spontaneously within the 5-minute period, whereas 7 Ss in the control food group, and only 3 Ss in the experimental jump group failed to negotiate the 10 inch jump within the same specified period. It would seem therefore that the stimulation arising from the omission of food in a previously rewarded situation elicits decidedly different responses initially, than does stimulation arising from other sources.

The results of the extinction of the jump response for the three groups learning this response are presented in

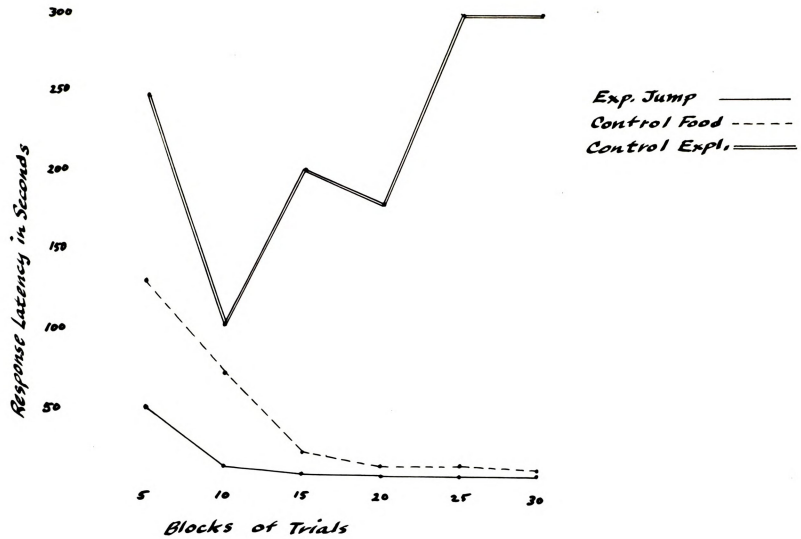

Fig. 2. Learning of jump response as a function of type of stimulation. Numbers plotted on ordinate represent median scores for blocks of five trials.

Figure 3 and a statistical analysis for the 100 trials are presented in Table IV. Figure 3 clearly shows that type of stimulation eliciting a particular response is a significant determiner of the rate of extinction of that response. Since, in the case of the experimental jump group, the jump response to the frustration stimulation was not interfered with, that response shows no decrement in strength as measured by latency of jump. The Ss in the exploratory control group all reached the 5-minute no response criterion within the first 20 trial block which would be an indicator of the relative instability of a jump response elicited by exploratory drive stimulation. The food control group, on the other hand, tended to exhibit an intermediate degree of extinction, and is strictly analagous to the normal extinction group. Thus, this group showed complete extinction when the excitatory potential for a newly learned incompatible response tendency surpassed the strength of the on-going response tendency.

Further evidence to support the latency differences obtained may be found by an analysis of the number of trials before the 5-minute no-response criterion was reached. The control exploratory group responded an average of only 10.5 before complete extinction, whereas the control food jumped an average of 42.5 times. The experimental jump group showed little effects of extinction with an average of 91.1 responses prior to extinction.

TABLE IV

EXTINCTION OF JUMP HABIT AS A FUNCTION OF TYPE OF STIMULATION ELICITING THE RESPONSE

Group	*Means of median latency	d	Trials to extinction
1. Experimental jump	4.78		91.1
		$d_{1,\ 2} = 4.11$	
2. Control food	187.5	$d_{1,\ 3} = 5.0$	42.5
		$d_{2,\ 3} = 3.5$	
3. Control exploratory	271.75		10.5

.01 = 3.40

*Numbers represent the mean jump latency of the medians taken from the median latency for blocks of twenty trials during the 100-trial extinction of jump response period.

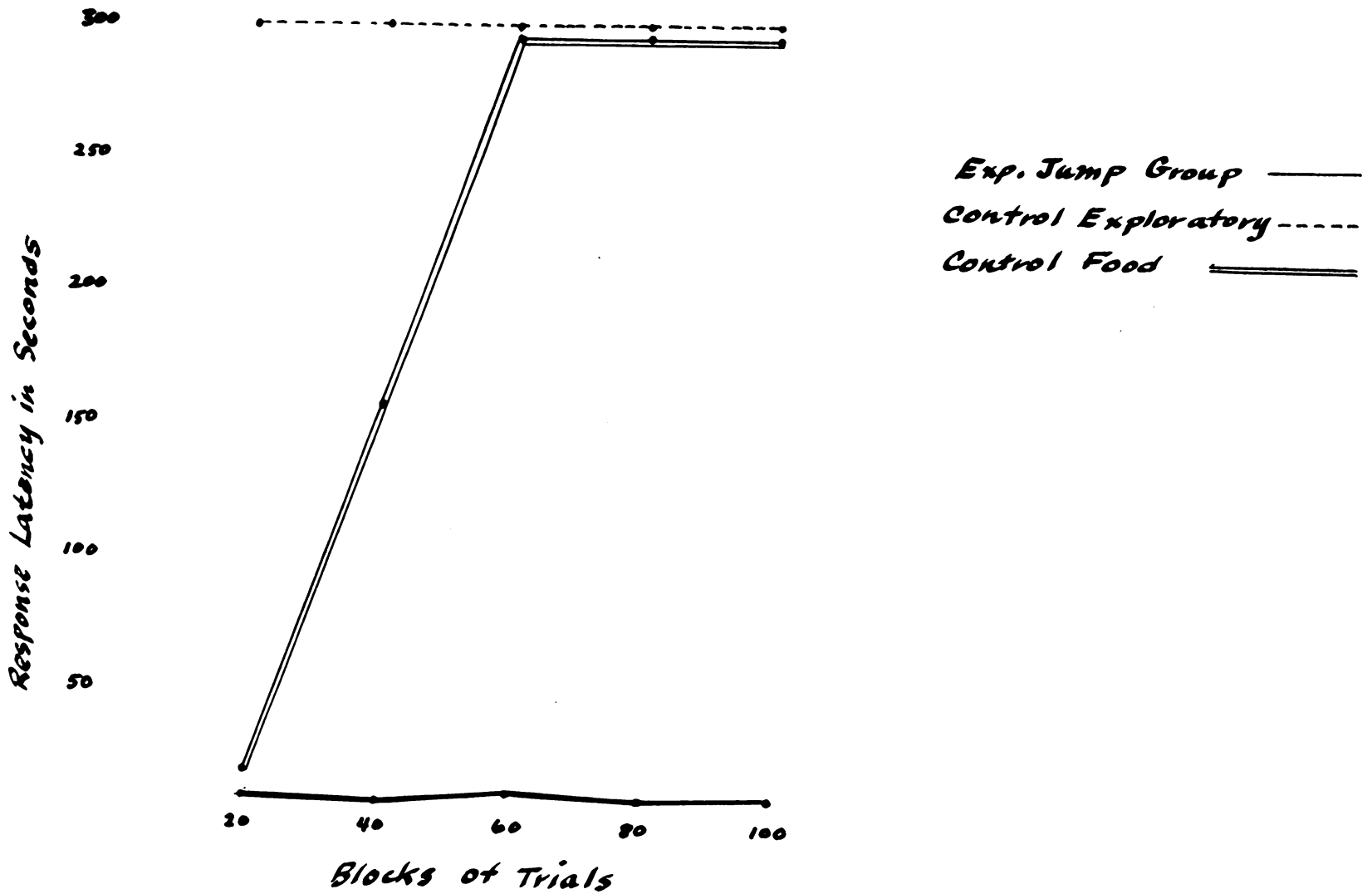

Fig. 3. Extinction of jump habit as a function of the type of stimulation which elicits the response. Plots on ordinate represent the median score for blocks of twenty trials.

DISCUSSION

The striking differences obtained during the extinction of the adient straight alley response tendency would seem to indicate that the type of response which the experimental situation allows to be elicited by frustration stimulation is an important variable in the extinction process. The results suggest that the extinction process is one of competition between the original response tendency and the new response tendency which is specified by the experimental procedure and reinforced through continued frustration during the performance of the original response sequence.

An alternative explanation might be that the differences obtained were due to a differential delay in secondary reinforcement through return to the running cages. However, the use of a constant 20-second interval between the occurrence of the response to frustration (Rs_f) and return to the running cages controlled the effects of this variable.

It should also be pointed out that both the jump and recoil groups were required to learn specific responses with respect to the non-reward state of affairs (s_f). Therefore, both groups remained in the frustrating situation for longer periods of time in the initial stages of extinction than did the normal extinction group. However, in the latter stages of extinction, since learning of the response to frustration

progressed with continued extinction, these groups spent less time in the goal box as compared with the normal group. These results tend to indicate that length of time in the goal box per se did not produce the obtained differences.

The highly mechanistic hypothesis employed, and the results obtained therefrom, would seem to be at odds with conventional purposive or adaptive theories of the extinction process. Tolman (14), for example, describes extinction as a relearning of a sign-significate expectation. During extinction the maze (sign) comes to elicit an expectancy of non-reward (significate). Since, in the present study the expectancy of non-reward was constant for all groups, and since marked differences in resistance to extinction of the straight alley response did occur, it would seem that expectancy of a particular goal is not the essential variable governing behavior in the extinction process.

This position may also be contrasted with the theory of inhibition which posits intrinsic inhibitory states that produce inhibition of the original response independent of subsequent learning. Hull (5), for example, posits that reactive inhibition (I_R) is generated by repetition of the original response and the amount of effort involved in the performance of that response. The generation of I_R during extinction in turn produces conditioned inhibition ($_SI_R$) which in turn serves to bring about the cessation of the original response.

In the present study the responses of the jump group clearly involved the greater amount of effort in performance, since the Ss had to negotiate a 10-inch jump in addition to the learned instrumental sequence. The fact that this group exhibited little or no decrement in response strength within the confines of the number of extinction trials employed is contradictory to and unexplainable by Hull's theory.

However, Guthrie's interference theory (4) can handle the extinction results of the present study, albeit by means of ad hoc formulations. Guthrie holds that by taking the animal out of the situation following the performance of an instrumental response, one insures the strengthening and stability of the instrumental responses leading to the goal. Thus, in the present study, the jump response learned by the experimental jump group, served to withdraw the animal from the situation in such a manner that the whole instrumental action sequence was left intact. Therefore, little or no extinction should take place. The precise ordering of the remaining groups follow directly from the learning of incompatible response hypothesis, and needs no reinterpretation and/or extension.

From the present theoretical position, extinction data for the recoil group may also serve as a learning curve of avoidance of a frustrating state of affairs (s_f) in the face of a strong competing approach response. This relatively

rapid learning is in accord with the results obtained which demonstrates, among other things, that the learning to escape a non-reward situation (s_f) where there is no competition from the original response, proceeds very rapidly, significantly faster in fact, than learning through the use of a food reward for hungry Ss not previously subject to frustration stimulation. Thus, the fact that the jump group revealed more spontaneous jumps, significantly faster learning of the jump response, and a higher asymptotic rate of responding than did either the food or exploratory groups, would tend to indicate both the operation of different stimulation variables and the viewpoint that the omission of reward in a previously rewarded situation attains the properties of an unconditioned stimulus.

Further evidence of the acquisition of unconditioned stimulus properties by cues previously associated with reward is revealed by extinction of the jump response results. The jump group showed practically no decrement in response strength, as measured by latency of jump, throughout the course of extinction, whereas the remaining groups did tend to extinguish. It would seem therefore, that omission of food took on properties characteristic of, for example, cues associated with shocking S in an enclosed area where a jump response was the only escape response possible. Thus so long as no interference to the performance of Rs_f occurred, theoretically, the animal should show relatively little decrement in

response strength with continuing "extinction" trials. Therefore, although somewhat elliptical, the present study also provided a test for the definitions of reinforcement and frustration stimulation.

INTRODUCTION - PART II

Studies in the area of instrumental conditioning have demonstrated that the resistance to extinction of instrumental act sequences is proportional to the number of previously reinforced responses, the conditions under which reinforcement occurs, and the drive state of the organism (5). According to this formulation individuals should tend to exhibit differential tendencies to sustain instrumental goal seeking behavior in accordance with the number and nature of their previous successful experiences with particular instrumental action sequences, and in accordance with their respective states of drive. However, as far as present determinations are concerned, these formulations may only be applicable to the highly artificial situations which were referred to as normal extinction procedures in the preceding section of this paper.

The dependence of experimental results upon the structure of a standard situation has been unequivocally demonstrated in the first section of this paper. It has been shown that when the environment is so manipulated as to allow more than one type of elicited response, extinction scores will vary from extremely rapid cessation of learned responses on the one hand to virtually no extinction tendencies on the other.

Thus, failure on the part of many psychological theorists to take into account responses made before and after the standard experimental situation represents a serious control omission. In keeping with the foregoing, the precise lawful relationship between such variables as number of reinforcement and resistance to extinction may only refer to certain circumscribed areas, and any application value of these results to more complex situations would be mere speculation, or, more exactly, empirical questions.

The lawful relationship between the independent variable, number of reinforcements, and the dependent variable, resistance to extinction, in more complex situations is not determinable within the bounds of any major contemporary theory of behavior. Even in the interference theory herein employed this relationship is not explicitly stated. Therefore, an investigation of these variables must of necessity take on the character of a phenomenal or pure empirical study. However, a brief recapitulation of the theory which lay behind the results predicted in the first section of this study may serve to give us a set of predictive possibilities for the forthcoming investigation.

As previously mentioned all contemporary theories of extinction are in the last analysis interference positions. Extinction takes place when responses learned to non-reinforcing states of affairs become stronger than the ongoing response tendency and, if sufficiently incompatible, produce a cessation

of that response tendency. However, from the interference position employed in the present studies, and in conjunction with the Elicitation Hypothesis of reinforcement, the exact manner in which any given response is selected and strengthened may be treated on a molecular level. By dealing with the theoretical structure of the process of response specification it becomes possible to arrive at predictions concerning the effect of habit strength (number of reinforcements) on resistance to extinction.

A straight alley paradigm would be of considerable heuristic value at this point for the understanding of how extinction takes place. First of all, the rat runs down the alley and is reinforced by food reward in the goal box. When the habit is sufficiently strong to elicit dominant approach tendencies the reward is omitted. When the animal next runs down the alley his responses do not lead him to former discriminable elements (food) and frustration stimulation arises. The characteristic class of responses elicited by the frustration stimulation are reinforced, and upon successive elicitations become the dominant response to the total stimulus complex. Thus, the cues of the starting box which were once signals for approach responses now become signals for avoidance responses, and extinction becomes complete.

However, as was demonstrated in the prior study, the type of response to frustration stimulation may be experimentally manipulated. In the ideal case this response may be

so manipulated as to allow strengthening without the incompatibility so necessary if extinction is to take place. In such a case the cues of the starting box become signals to the dominant compatible response, and no weakening of the straight alley response is readily discernible. Thus, the generic term extinction would seem to be nothing more than an artifact of some experimental situation in which the environment is so structured as to obtain extinction. In the cases where the anticipatory occurrence of a response to frustration stimulation is compatible with the original instrumental action sequence little or no extinction should result.

It seems to follow from the above that the crucial factors in extinction studies are: 1) a habit strength of sufficient intensity to produce frustration stimulation upon a change in complex; 2) frustration stimulation with definite elicited response; and 3) opportunities afforded by the environment for responses of varying degrees of compatibility. From various interactions of these three factors one may obtain the wide differences in extinction scores mentioned above.

However, the first factor, a strong habit strength, seems to imply that there is an optimal habit beyond which frustration stimulation will arise and below which it will fail to arise. With strong habit strength in a situation which provides for a compatible response to frustration stimulation, the anticipatory R_{sf} should chain, or link, with the

original response and thus produce little decrement in recorded response strength. In the cases where habit strength is too weak to allow frustration stimulation to arise, the result will be a lack of chaining of the on-going sequence with the R_{sf} and extinction of the instrumental responses. Statistically stated in terms of the apparatus utilized in the first study with the compatible jump response group, if a high correlation is obtained between the running response and jump response no extinction will be evident; if the correlation is low there will result rapid extinction of the original response.

Specifically, the present section of the study will be concerned with an investigation of the effect of three levels of habit strength upon resistance to extinction of a straight alley response. It is hypothesized that the effect of habit strength will be an all or none effect rather than a negatively accelerated function as found by Hull. If enough habit strength is present to insure the linkage of the on-going with the compatible responses no extinction should take place. If it is too weak to permit linkage extinction will rapidly take place.

METHOD

Apparatus

The apparatus utilized was identical to that used for the initial study in this series of investigations.

Subjects

The subjects were 30 experimentally naive female rats, 90-150 days old, from the colony maintained by the psychology animal laboratory at Michigan State College.

Procedure

The procedure utilized in the present section of the study exactly duplicates that used for the experimental jump group in the first study, with one exception. Three groups of 10 Ss each had different numbers of reinforcements upon the straight alley running response prior to the onset of the extinction trials. The low habit group had 12 reinforcements, the medium habit group had 24 reinforcements, while the strong habit group had 36 reinforcements.

In the case of all three groups two successive non-response trials on the straight alley was considered the extinction criterion. If any S reached this criterion he was no longer run in the straight alley, but was placed in the goal box for his jump trials. The jump trials were thus carried on in

keeping with the procedure outlined for the experimental jump group, or until the jump extinction criterion of one five-minute no-jump response was met. Thus, the results of this section are directly comparable with those of the first study.

RESULTS

The result which best indicates the prevalence of linkage of the ongoing response with the compatible jump response is the correlation between performance times. The coefficient of correlation between the median running times on the original response and the median jump latency of the response to frustration stimulation for the high and medium habit groups was .90. The coefficient of correlation between those two variables for the low habit group was .21. Since there was no appreciable decrement in response strength for the former, and complete extinction for the latter, the hypothesis that linkage must take p lace prior to having an effect upon extinction tendencies is supported. Therefore, it would seem that anticipatory occurrences of the compatible jump response must completely generalize to the starting box for the chaining of response tendencies to take place prior to the interference from the generalization of some incompatible response tendency.

An alternative interpretation for the significant correlation might be that we are dealing with but one variable in the two groups, namely, speed of performance. That this interpretation is omnipresent with utilization of the correlation coefficient as a measure of relationship can scarcely be denied.

However, the theoretical structure from which predictions are generated is the sole determinant of the manner in which such measures are to be interpreted. Therefore, the only valid criticism of the above interpretation from a logical point of view is that of poor translation from the theoretical structure into an empirical system. The only caution to be observed, in this connection, is that utilized measures be interpreted consistently throughout the complete system.

The results of extinction of the straight alley response are presented in Figure 4 and a statistical analysis for the 30 trials is presented in Table V. These results are presented in conjunction with the figures from the normal extinction group and recoil group of the prior study in order to facilitate comparisons. Figure 4 clearly shows that the strong and medium habit groups exhibited no decrement in response strength or, if any trend is present, it seems to be in the facilitative direction. However, the data for the low habit group show that by the 15th trial extinction of the straight alley response was complete. Thus, the point at which habit strength gains sufficient intensity to produce frustration stimulation seems to vary somewhere between twelve and twenty-four reinforcements. When the habit strength is not sufficient to produce a generalizing response it would seem that extinction takes place very rapidly.

Further evidence to support these results comes from observations of runway behavior. The rats in the high and

TABLE V

EXTINCTION OF STRAIGHT ALLEY RESPONSE AS A FUNCTION OF THREE LEVELS OF HABIT STRENGTH

Group	**Mean of median latency	d-Value	
1. Strong habit	5.75	$d_{1, 2}$ = .44	$d_{2, 5}$ = 5.5
2. Medium habit	3.28	$d_{1, 3}$ = 5.0	$d_{3, 5}$ = 4.8
3. Weak habit	117.75	$d_{2, 3}$ = 5.5	
4. Normal extinction	47.5	$d_{2, 4}$ = 5.5	
5. Recoil	60.30	$d_{3, 4}$ = 5.0	

.01 = 3.40

**Numbers represent the mean latency score of the medians taken from the median latency for blocks of five trials during the thirty trial extinction period.

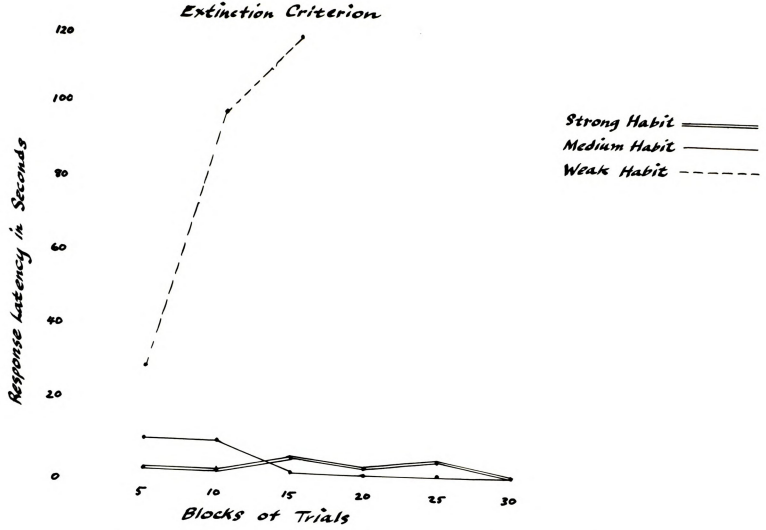

Fig. 4. Effect of three levels of habit strength upon extinction of straight alley response. Numbers represent medians for blocks of five trials during 30 trial extinction period.

medium habit groups exhibited abortive jumping movements from as far from the appropriate place as the starting box. The glass cover on the starting box was utilized to prevent any jump completions. However, the rats in the low habit group extinguished before this response had generalized backward and, therefore, showed little or no incipient jump responses.

The significant difference between the medium habit group and both the recoil and normal extinction group provides evidence for the assertion that resistance to extinction is not a linear function of habit strength. Since the medium habit group had but 24 reinforcements whereas the other two had 36, the conclusion follows that the type of response elicited by frustration stimulation is the important determinant of resistance to extinction. Thus, the application of laws of habit strength to more complex situations demands the support of careful research, before utilization may be unequivocally accepted.

The results of the learning of the compatible jump response for each habit strength group are presented in Figure 5, and a statistical analysis of this data combined with the results of the control food and control exploratory groups are presented in Table VI. Figure 5 reveals no differences between the three main groups in the learning of the jump response to frustration stimulation. However, these three groups show significant departures from the means of both type of control

TABLE VI

LEARNING OF JUMP RESPONSE AS A FUNCTION OF THREE LEVELS OF HABIT STRENGTH

Group	**Mean of median latency	d-Value
1. Strong habit	4.90	$d_{1, 2} = .1$
		$d_{1, 3} = .1$
2. Medium habit	6.50	$d_{2, 3} = 2.5$
3. Weak habit	11.61	$d_{2, 4} = 3.78$
		$d_{2, 5} = 5.0$
4. Control food	19.60	$d_{3, 4} = 2.44$
5. Control exploratory	168.45	$d_{3, 5} = 5.0$

.01 = 3.40

.05 = 2.60

**Numbers represent the mean jump latency of the medians taken from the median latency for blocks of five trials during the thirty trial extinction period.

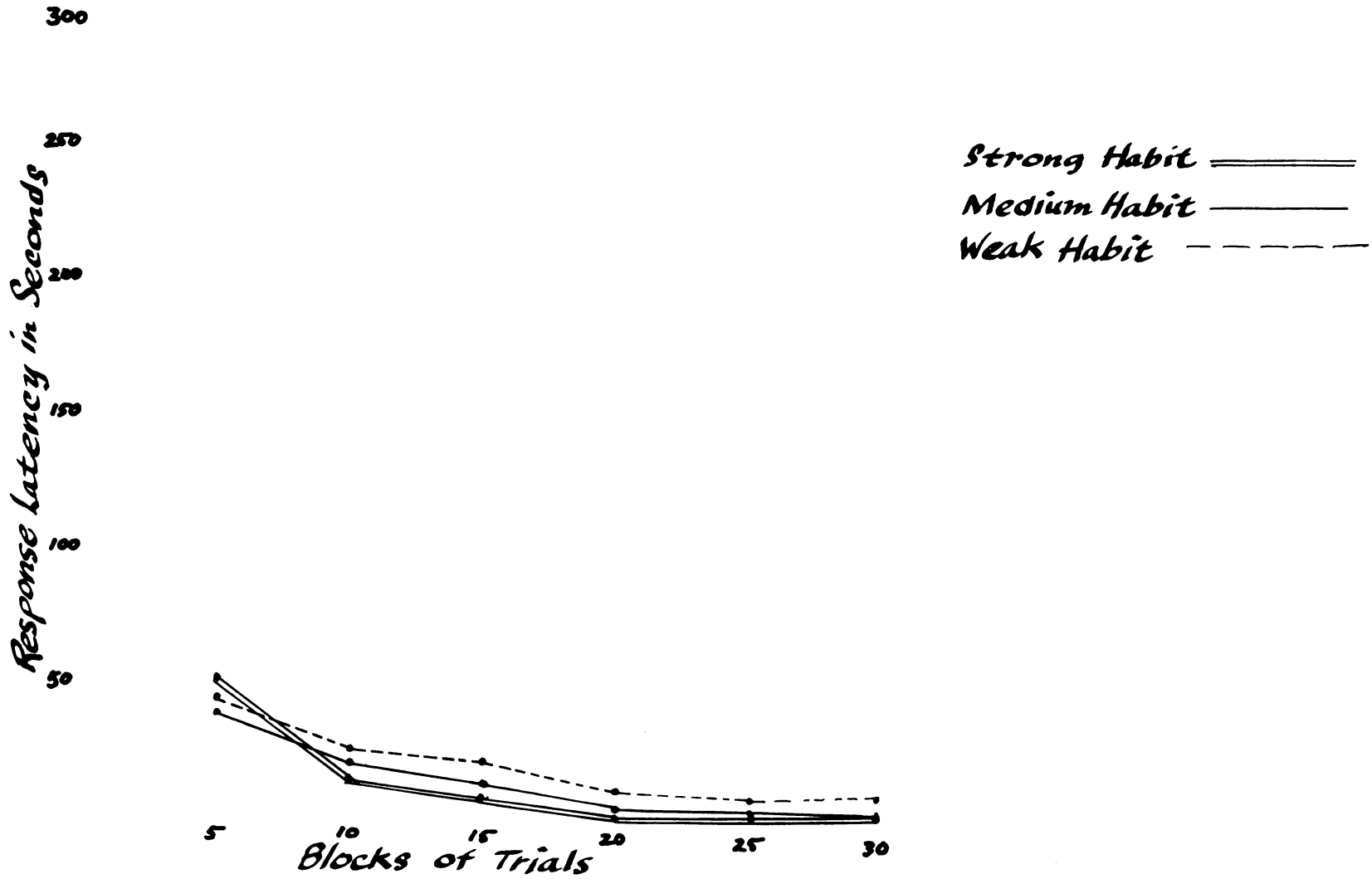

Fig. 5. Effect of three levels of habit strength upon learning of jump response. Numbers plotted on ordinate represent median scores for blocks of five trials.

groups. The weak habit group falls slightly shy of the 5 percent level of confidence in a comparison with the food group, but all other comparisons reveal significant differences. It would seem from the above that frustration stimulation may be set up strongly by utilizing any of the habit levels used in the present experiment, but that the type of stimulation eliciting the jump response is the significant determiner of the speed of learning of the jump response.

One question remains unanswered in this connection. If the weak habit group rapidly learned to negotiate the jump under elicitation by frustration stimulation, why did not this variable have an effect upon the extinction of straight alley response? One possible explanation, although speculative, is that in the case of the weak habit group, interference by incompatible responses produced extinction before the compatible response could generalize backward. Thus the compatible jump response became slowly strengthened through elicitation, but only after extinction had already taken place, and thereby prevented anticipatory occurrences of the jump response from chaining with the original response. The level of habit strength, then, seems to affect the speed of generalization of the incipient compatible response to starting box cues more than affecting the production of frustration stimulation. An alternative interpretation may be that sufficient habit strength must be present to insure stability of the

original response so that enough trials can be run to permit chaining of the two responses. However, since the evidence points to almost instantaneous chaining by the high and medium habit groups the previous explanation seems to be the more strongly borne out by the empirical findings.

The results of the effect of three levels of habit strength upon the extinction of the jump response are presented in Figure 6 and a statistical analysis is presented in Table VII. Again in this case results from the control food and exploratory groups are presented to facilitate comparisons. As can be seen from Table VI there are no statistically significant differences between any of the three groups in speed of reaction throughout the course of the 100 extinction trials. Thus, it would seem that within the habit strength levels employed in the present experiment there is no systematic contribution of number of reinforcements to resistance to extinction of R_{sf}. The important contributory variable seems rather to have been the number of elicitations of the response; so that if the cues of the goal box have been sufficiently reinforced to produce response elicitation the major requirements for learning have been met.

However, analysis of Table VI reveals significant differences to exist between each of the habit groups and both the food and exploratory groups in resistance to extinction of the jump response. All three habit groups show significantly

TABLE VII

EXTINCTION OF JUMP HABIT AS A FUNCTION OF THREE LEVELS OF HABIT STRENGTH

Group	**Means of median latency	d-Value	Trials to extinction
1. Strong habit	4.78	$d_{1, 2} = 1.5$	91.11
2. Medium habit	2.28	$d_{1, 3} = 1.67$ $d_{2, 3} = .83$	100.00
3. Weak habit	3.06	$d_{2, 4} = 4.0$	96.7
4. Control food	187.5	$d_{2, 5} = 5.0$ $d_{3, 4} = 3.0$	42.5
5. Control exploratory	271.75	$d_{3, 5} = 5.0$	10.5

.01 = 3.40
.05 = 2.60

**Numbers represent the mean jump latency of the medians taken from the median latency for blocks of twenty trials during the 100-trial extinction of jump response period.

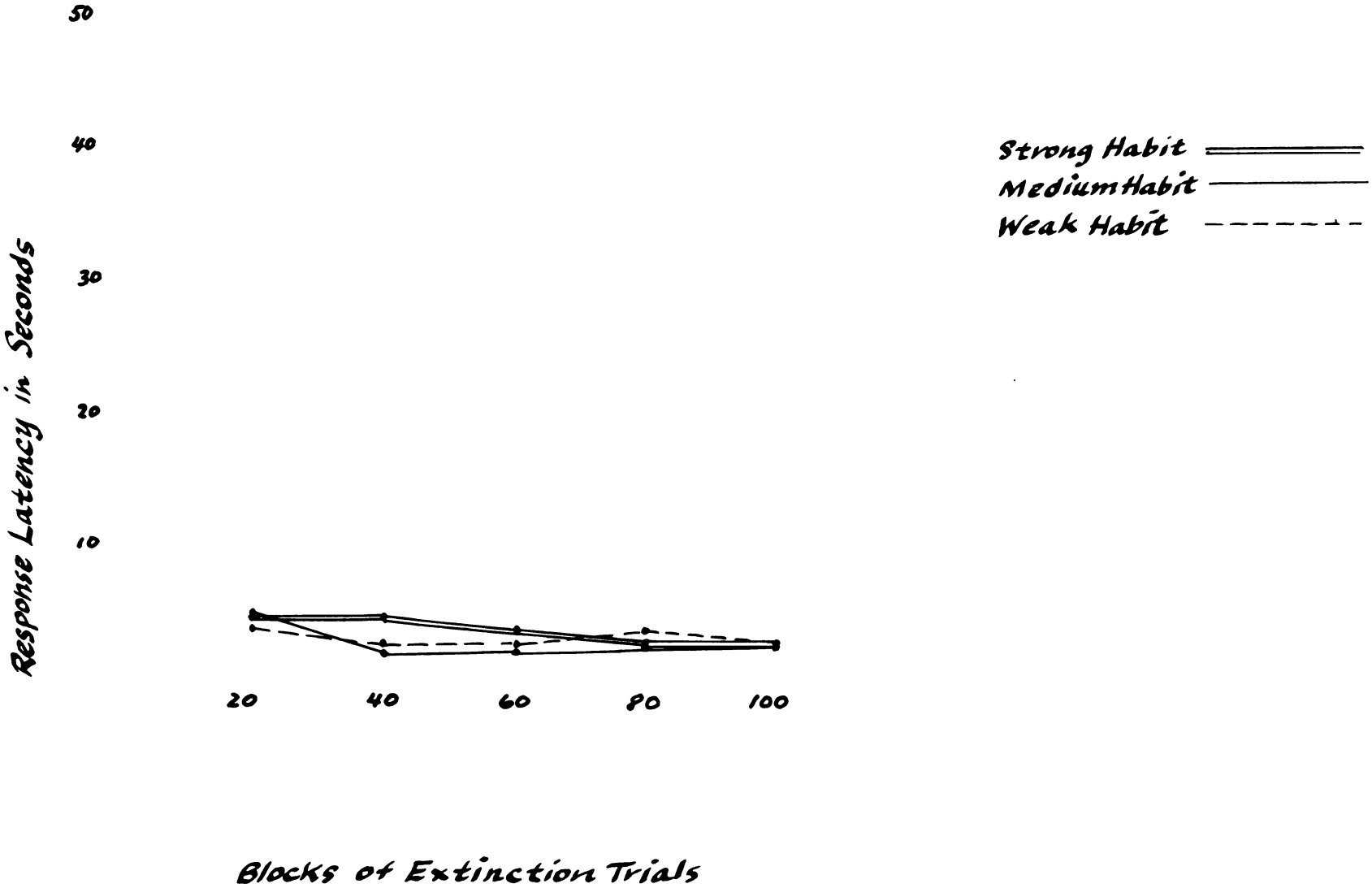

Fig. 6. Effect of three levels of habit strength upon extinction of the jump response. Plots on the ordinate represent the median score for blocks of twenty extinction trials.

faster jump reactions than either of the controls. Therefore, within the confines of the groups employed, the type of eliciting stimulus seems to be the most important variable in the determination of resistance to extinction scores. Since the habit groups performed their response under frustration stimulation, while one control jumped to food and the other to novel stimuli, omission of food in a previously rewarded situation presents more powerful stimulating conditions than do either hunger or exploratory stimulation. This conclusion is also supported by data concerned with speed of learning as a function of the type of eliciting stimulus in the prior study.

The trials to extinction data of Table VI supports the above contention. The three habit groups all revealed over 90 trials before extinction, whereas the two control groups fell somewhere between 10 and 45 trials. Furthermore, observations by the writer suggest that when the three habit groups ceased jumping it might have been more due to sheer exhaustion than for any fact of theoretical significance to the present study. After Ss had extinguished they were given a short respite and then re-run. In most cases Ss began jumping once more and continued for 100 more trials.

DISCUSSION

The differences obtained during the extinction of the adient straight alley response tendency would seem to indicate that the magnitude of habit strength is an important variable in the extinction process. However, the results obtained by analysis of simple experimental situations cannot be utilized in explaining these more complex results. The results suggest rather, habit strength to be an all or none determinant of the resistance to extinction of any response. If a habit magnitude of sufficient intensity is present to insure stability of the original response until generalization of the compatible response takes place, then little or no extinction occurs. Further, if the habit strength is so weak as to allow the specification of an incompatible response prior to the complete learning and generalization of the compatible response extinction will take place fairly rapidly.

The above results likewise lend credence to the suggestion that the extinction process may be fully explained by an interference position, which holds that phenomenal extinction takes place through response competition, which is specified by experimental environmental manipulation, and which is reinforced by elicitation through frustration

stimulation during performance of the original instrumental action sequence. This, of course, obviates the necessity for positing an internally labile drive state such as I_R, and is, in general, a more parsimonious explanation of inhibitory phenomena.

Latency of jump response data for all groups may also serve as an indicator of the unreliability of this measure of response tendency as a determinant of magnitude of habit strength. Since there was no significance between the three habit strength groups in response latency, and since the number of reinforcements Ss received varied from 12 to 36, the relationship of number of reinforcements to latency of response as set forth by Hull (5) does not seem to be supported. An alternative explanation may be that in the present study we were working on the asymptotic portions of the habit strength curve, and that should we reduce the number of employed reinforcements we would obtain the predicted latency differences. However, in view of the extremely small number of reinforcements employed, and in view of Hullian data which indicates an asymptote to the acquisition of habit strength curve at around 30 reinforcements, the latter interpretation would seem to be at once tenuous and strongly suspect. Therefore, these studies, among other things, demonstrate that traditional measures of habit strength may not be unqualifiedly applied to more complex situations, and are further arguments for a

re-examination of the extremely limited traditional approaches as to their former unquestioned importance.

The above studies suggest that adaptive, adjustive, or purpose theories purporting to explain behavior are very little removed from the descriptive level. Such a statement as Dallenbach's (2) "humans do not adapt to painful stimuli because of its anti-survival value" is an extreme case in point. Likewise, psychological concepts such as "adaptation", "adjustment", or "extinction", are prime examples of the fallacy of Darwinian thinking. It is true that these concepts are of didactic, heuristic, or descriptive importance; but their theoretical significance is open to considerable doubt. Within the mechanistic theory employed we have seen that environmental conditions may be so manipulated as to obtain little extinction or adaptation. In a similar manner we must work on the other adjustive concepts to determine their parameters and conditions of operations. In short, we need empirical laws and the specification of operations by which we can define concepts rather than the promiscuous use of "common sense" data.

The Application of the Theory of Extinction to Simple Learning, and the Emergence of Discrimination as a Basic Concept in all Learning

The following theoretical description of the role of extinction in learning would be considerably enhanced by reference to some standard experimental situation such as a conventional T-maze. Let us assume that we are trying to teach a group of rats to turn right into Arm A. Utilizing conventional break-in procedures, we begin by placing S into the starting box. An approach response will soon be elicited under stimulation of the situational novel cues, and the rat will eventually end up in Arm A where he will be fed a pellet. It is at this point that generalization will take place to Arm B at a magnitude and rate corresponding to the stimulus elements the two arms have in common. Now let us suppose that on a succeeding trial the animal blunders into Arm B. Since there has been some generalization of the approach response tendency to that arm, the animal will now have commerce with cues unlike those of Arm A (food, eating, etc.). Therefore, the conditions for the arousal of frustration stimulation will have been met and, since there is opportunity for only a recoil type response, that response will takeplace. According to the elicitation hypothesis, the recoil response to the frustration stimulation is reinforced, and the cues antecedent in time attain the capacity to elicit those responses.

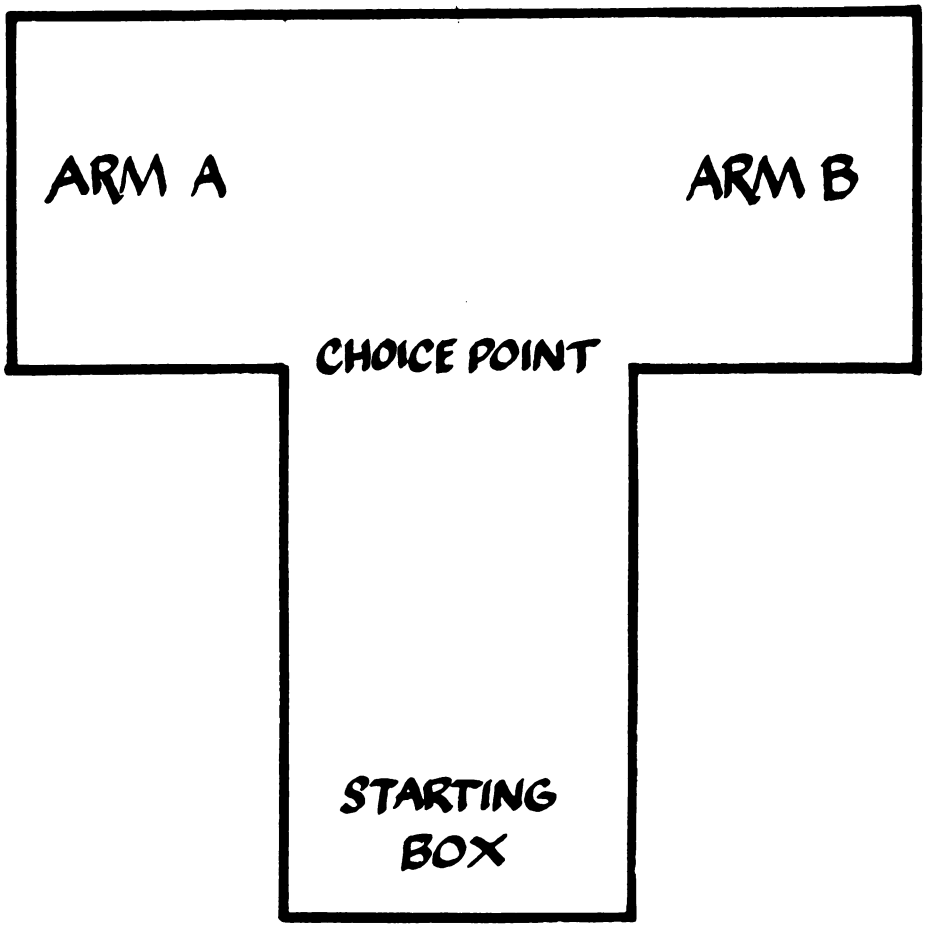

Fig. 7. A conventional T-maze.

We have seen that by allowing the animal a recoil response to frustration stimulation very rapid extinction takes place. Accordingly, the tendency to enter Arm B will rapidly extinguish.

With continued reinforcement the cues at the choice point become elicitors of both recoil to B and approach to A responses. Thus the animal operates on a discriminative cue basis, which directs him away from one arm and toward another. Therefore, the emergence of discriminative elements seems to take place through the interaction of frustration and positive stimulation.

One of the implications of the above position is that by positively reinforcing a habit which is later to become negative we enhance the learning of a discrimination. Goer (3) tested this position and, in general, his data support the above contention, although his results held up only within certain limits. It was found that if the magnitude of the positive habit structure to the negative side is too great discrimination becomes very difficult.

This theoretical structure also explains simply the more rapid learning of discrimination under the corrective technique of learning as against the same problem learned under non-corrective techniques. By allowing the animal a recoil response we insure more rapid learning of the recoil response and the subsequent more rapid emergence of discriminable elements. Thus, the primary difference between the two techniques seems to be a manipulation of the degree of compatibility of

responses allowed to frustration stimulation. By experimenting with the limits of manipulatory possibilities we theoretically should be able to obtain results which vary from very rapid learning at one extreme to no learning at all at the other.

There are those who feel that by making a theoretical explanation of behavior extremely mechanistic one destroys all the value and individual experiential content of living. For this reason theorists seem to have a marked proclivity for introducing theoretical concepts such as pain, hot, etc., to connote certain feelings which cannot be scientifically analyzable. However, just as in theoretical physics, explaining light in terms of waves does not make us less able to see, and explaining heat theoretically does not make a radiator less hot, so explaining behavior molecularly does not make life less worth living. The purpose of the extreme mechanism in behavior is to limit conceptualization to constructs by which we can best understand behavior, while concomitantly limiting ghost-like conceptions. The humorous jingle of Bertrand Russell (12) best epitomizes the influence of mechanism upon human thought:

> There was a young man who said damn
> I find with regret that I am
> a creature which moves
> in predestinate grooves
> in short, not a bus, but a tram.

Thus, by employing a pure mechanistic philosophy we can reanalyze widespread use of phenomenological constructs as theoretical conceptions and work out the limits of stimulus

parameters as affecting response parameters. Toward this end the above conceptualization of extinction may serve as a first step.

SUMMARY - PART I

The present study was designed primarily to test the hypothesis that the type of response elicited by the frustrating omission of reward is a significant determinant of the rate of extinction of the original response. Furthermore, this study was formulated to test the rates of learning of the compatible jump response and extinction rates of that response, when the learning was elicited by different types of stimulation. Fifty female hooded rats were employed, with thirty Ss being run in a straight alley with food as a reward. For extinction, they were divided into three groups according to the type of response to be learned to the frustrating state of affairs (non-reward). During extinction one group learned a compatible escape response of jumping from the goal box, while a second group learned a directly incompatible response of recoiling from the goal box. A third group was run according to the traditional extinction period of confinement in the goal box for a 20-second period after frustration.

The results clearly demonstrate that resistance to extinction is a function of the type of response elicited by frustration. A directly incompatible recoil response to frustration produces rapid extinction of an approach response while a compatible escape response to frustration produces little or no extinction of the original response.

Two additional groups of 10 Ss each were run on the learning of the jump response only. The exploratory group was taught the jump with no reward, whereas the food group was taught to jump to a food reward. The results indicate that the type of stimulation eliciting the jump response is a significant determinant of both the rates of learning of that response, and the asymptote reached in the learning. Extinction scores for the jump response also revealed significant differences between groups, and tended to indicate differential rates of extinction to be a function of differential stimulation.

SUMMARY - PART II

The second study was designed primarily as a pure empirical research to discover the relationship between number of reinforcements and resistance to extinctions. All determinations of this functional relationship were made in a more complex situation, as distinguished from the traditional approach. Specifically, this study compared the resistance to extinction of a straight alley response by Ss with three levels of habit strength, when the type of response elicited by cues associated with the omission of food was a compatible jump response.

Thirty female hooded rats were run down a straight alley with food as a reward. One group of 10 Ss were given 12 reinforcements, the second 24 reinforcements, and the third 36 reinforcements. For extinction all groups were treated exactly as the experimental jump group of the prior study.

The results demonstrate that the low habit group (12 reinforcements) reached the extinction criterion for the straight alley response fairly rapidly. Neither of the other two groups revealed decrements in response tendency within the number of extinction trials employed. However, since there were no significant differences between groups in either learning of the jump response, or resistance to extinction of that response,

it would seem that even 12 reinforcements creates a habit of sufficient intensity to elicit compatible responses. Therefore, the interpretation was made that the magnitude of habit strength affects the speed of generalization, so that if the generalization of incipient compatible responses is retarded, extinction will take place.

The results also lend additional support to the assertion that frustration stimulation is a more powerful elicitor than either hunger or situational novel cues. Extinction scores between the habit strength groups and the two control groups revealed significant differences, and tended to indicate the prevalence of differential stability of responses as a function of the differential stimulation.

Learning in a simple T-maze situation was used as a simple paradigm to demonstrate the role of extinction in learning. Learning was described theoretically as an interaction between positive reinforcement and frustration stimulation, with the emergence of discrimination as the basic process in all instrumental learning.

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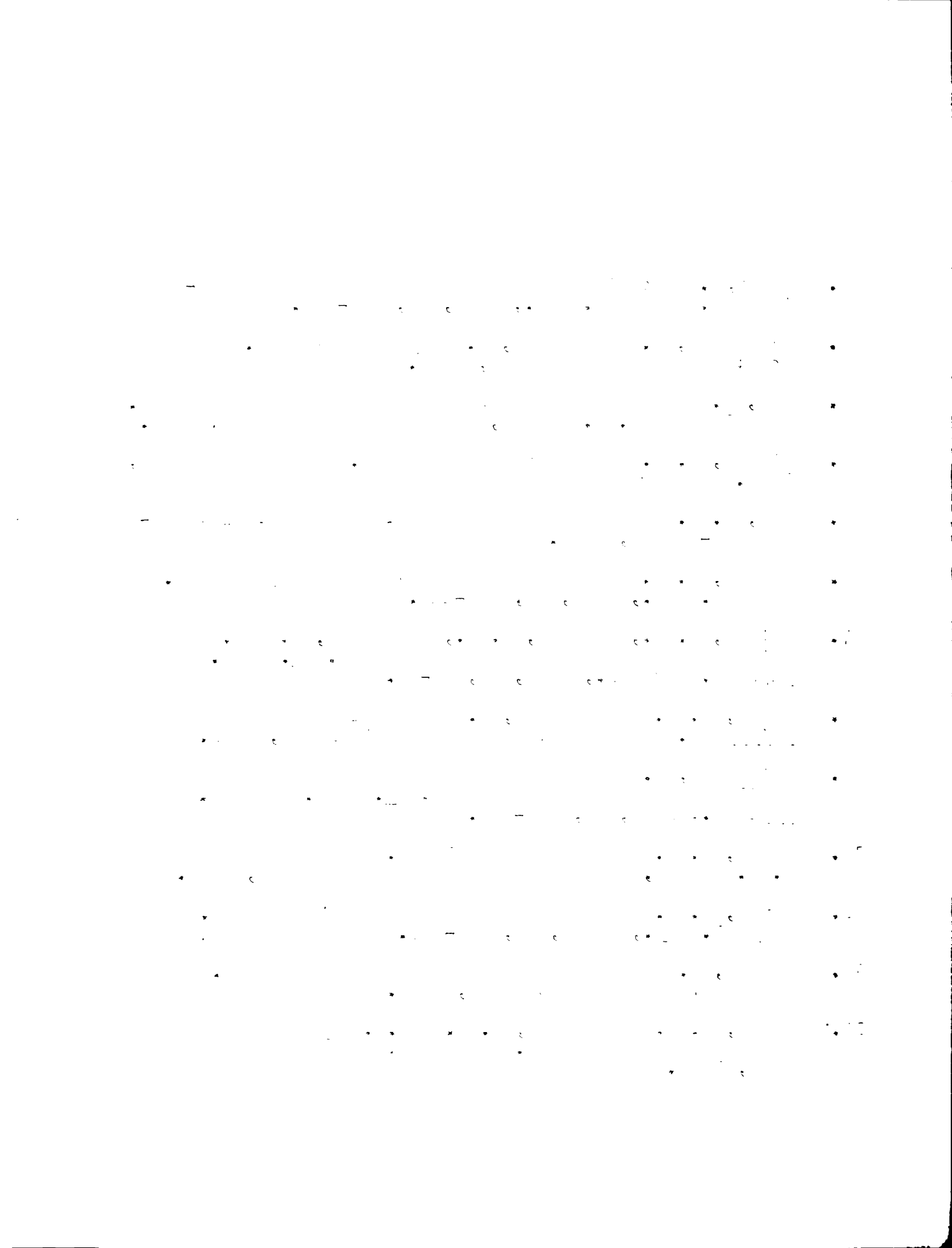

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