THE EFFECTS OF STIMULUS SAMPLING ON THE RETENTION OF AN AVOIDANCE RESPONSE

Thesis for the Degree of Ph. D

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James Henry Reynierse

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ABSTRACT

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by James Henry Reynierse

In the present series of experiments, rats were trained to avoid shock in a one-way shuttlebox to a criterion of two successive avoidances. Subsequent to the acquisition criterion, Ss received either 1, 5, or 20 additional avoidance trials (called sampling trials). In Experiment I, Ss were given sampling trials following an appropriate time-out period. The Ss that received a sampling trial immediately after reaching criterion extinguished rapidly 24 hours later, that is, when the internal stimuli were associated with a relaxed state rather than an emotional state. The other Ss (time-delay groups) received sampling trials approximately 40 min. after reaching criterion when the shock-associated stimuli had dissipated and when the relaxation-associated stimuli that would prevail 24 hours later could be sampled. In contrast to Ss that received the sampling trial when the shock-associated stimuli prevailed, these time-delay Ss were highly resistant to extinction. Furthermore, a single sampling of relaxation-associated stimuli was as effective as 20 sampling trials given over the same time period. This was interpreted as support for a non-incremental learning position.

The retention of an avoidance response was simultaneously investigated for three delay intervals (0 min., 40 min., and 24 hours). A typical retention curve was obtained which was approximately log linear.

In Experiment II, shock-associated stimuli were reinstated after the time-out period by giving S an additional shock in the shock compartment. These Ss were highly resistant to extinction after a delay of 24 hours even though the sampling trial followed the shock within 120 sec. Experiments III and IV were designed to clarify this finding.

In Experiment III, S received an additional shock immediately upon reaching the acquisition criterion. A sampling trial was administered 120 sec. after this shock when the prevailing internal stimuli were associated with shock. These Ss extinguished rapidly after a delay of 24 hours. Experiment III demonstrated that the high resistance to extinction found in Experiment II required the presence of the time-out period and was not due to the additional shock *per se*.

In Experiment IV, shock associated stimuli were reinstated after the time-out period by giving S an additional shock in the shock compartment, as in Experiment II. The sampling trial, however, was administered after only 20 sec. had elapsed, and extinction occurred after a delay of 24 hours. An intermediate level of resistance to extinction was found for these Ss. The results of Experiment IV were consistent with the hypothesis that S may relax within

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120 sec. when the additional shock is preceded by a long time-out period. Thus the results of Experiment II were interpreted by positing that the avoidance response on the sampling trial was actually associated with relaxational stimuli and could thus maintain an avoidance response 24 hours later. The data from Experiments III and IV were most readily interpreted as indicating that a single shock was insufficient to reinstate fully the emotional stimuli of original learning.

In general, the results supported a non-incremental learning position and emphasized the importance of stimulus sampling in avoidance learning.

Approved M. Ray Denny

Committee Chairman

Date Aug 18, '64

THE EFFECTS OF STIMULUS SAMPLING ON THE RETENTION OF AN AVOIDANCE RESPONSE

By

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TO

JAN AND DANNY

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CHAPTER I

INTRODUCTION

Theoretical Considerations

One trial learning theorists such as Guthrie (1952) and Estes (1959) propose that the total stimulus situation to which an organism responds consists of a set of stimulus elements. On successive trials different elements are sampled and associated in full with the responses that immediately follow them.

In simple learning situations the external stimuli to which *S* is responding remain relatively stable over time. Because of this relative constancy, the situational cues can be sampled by the organism in a brief period of time. But, the total stimulus complex which is effective in eliciting a response does not contain external stimulus elements alone. Internal stimuli are also a part of the total stimulus complex. Typically, these internal cues are less stable than the external stimuli and change with the passage of time. Without doubt, the internal stimuli at the beginning of an acquisition session differ considerably from the internal cues which are present after varying degrees of practice. With many trials most stimulus elements resulting from changes in the organism's internal state become associated with the response: therefore, there is little generalization decrement with the passage of time.

In an escape-avoidance learning situation, many of the internal stimuli are response produced stimuli which are related to the response to shock (emotional responses) rather than to the response being learned. Thus, as training progresses, the internal state of the organism and the internal stimuli to which S is responding should change over time. According to elicitation theory (Denny and Adelman, 1955) S begins to relax after shock termination or after removal of the cues associated with shock. Thus, stimuli associated with relaxation are present on later trials. Indirect evidence for the occurrence of relaxation in avoidance learning is present in studies by Knapp (in press), Reynierse, Weisman and Denny (1963) and Denny and Weisman (in press).

At the beginning of acquisition, stimuli associated with emotional responses constitute a sizable proportion of the stimuli for eliciting the learned avoidance response. With the passage of time, however, these stimuli presumably disappear as S relaxes. During avoidance learning, unless S samples the stimuli associated with relaxation, S will not learn to respond when these stimuli prevail. Presumably sampling of the major portion of these relaxation produced stimuli can occur either with a series of successful avoidance trials frequently presented or with a single trial that follows a non-shock period of comparable length.

A pilot study[1] showed that a series of successful avoidance trials administered after reaching the acquisition criterion

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[1] Independent pilot work by Robert K. Knapp yielded the same finding.

(typically 3-8 trials) markedly increased resistance to extinction 24 hours later. This contrasted with low resistance to extinction when no further trials were given after the criterion was reached. But the pilot work did not separate the effects of stimulus sampling from those of total trials. The implication from an incremental learning position is that the additional trials strengthen the habit. The implication from a non-incremental position is that the relaxation-associated stimuli sampled during the extra trials (early extinction) become associated with the avoidance response and thereby elicit and maintain the response on subsequent occasions.

General Design

The present study tests an incremental versus a non-incremental interpretation of an avoidance learning situation. Specifically, the question is whether a single sampling of the new internal stimuli strengthens an avoidance habit as well as many additional avoidance trials. According to the non-incremental position, there is an all-or-none association between the response and the new stimulus complex; thus, a single sampling of the new stimuli should maintain the avoidance response.

According to the incremental position, the associative strength between a stimulus and a response increases gradually (Underwood and Keppel, 1962). Additional trials should therefore maintain the avoidance response better than a single trial.

Should *S*'s internal state change without administering a series of successful avoidance trials, then a test of the one-trial position is possible. The test depends upon giving S the opportunity to make the avoidance response after the internal stimuli associated with shock have dissipated, so that new, internal stimuli which occur with relaxation can become associated with the avoidance response. If Ss under these conditions do not differ significantly in resistance to extinction from Ss given a series of successive avoidance trials, then a non-incremental position is supported. On the other hand, if Ss given additional trials are more resistant to extinction, then an incremental position is supported. In addition, a non-incremental position requires that Ss responding once in a relaxed state be more resistant to extinction than Ss which have not had the opportunity to do so.

Another approach to the incremental versus non-incremental question involves reinstating shock-cues after relaxation takes place, then giving S an additional trial (sampling trial), and then extinguishing the avoidance response after 24 hours. The non-incremental position would predict that extinction should be rapid after 24 hours since the additional shock should eliminate or decisively attenuate, the relaxation-cue on the subsequent sampling trial.

The present study also deals with the retention of an avoidance response as a function of delay interval. Moyer (1958) found essentially no differences in resistance to extinction between groups which had variable amounts of delay between acquisition and extinction. He used a lengthy acquisition session (30 trials), however. Thus, relaxational stimuli may have become the cues for eliciting and maintaining avoidance responding even after long retention intervals. The present study provides information about retention over a limited range of delay periods, introduced after the criterion had been attained.

Experiments I and II were run simultaneously. Experiments III and IV were begun after the trends from Experiment II were established and were designed to identify the processes underlying the effects found in Experiment II. The running of the Ss overlapped in time, in all experiments.

The present series of experiments could have been combined into one experiment containing eleven experimental groups. For expository purposes, however, the present format was considered preferable. Therefore, cross-experimental comparisons were considered to be legitimate whenever such comparisons were necessary.

CHAPTER II

EXPERIMENT I

Method

Subjects.--The Ss were 70 experimentally naive, male Sprague-Dawley albino rats from the colony maintained by the Psychology Department at Michigan State University. All were between 90 and 130 days old at the beginning of training. The Ss were maintained in social cages with food and water always available. Ss were assigned at random to seven experimental groups of 10 Ss each.

Procedure.--The apparatus consisted of a one-way shuttle-box having two discriminable compartments separated by a manually operated guillotine door. Each compartment was 18 in. long, 4 in. wide, and 14 in. high. The shock compartment was painted flat black and had a grid floor consisting of 1/8 in. stainless steel grids spaced 5/8 in. apart, center to center. The grids were charged independently through a grid scrambler with a current of 1.1 ma. supplied by a C. J. Applegate stimulator, Model 228. The non-shock compartment was painted white and had a wooden floor. A 50 db transistorized buzzer (Malis and Curran, 1960) and the raising of the guillotine door served as the CS. A speaker mounted on the plexiglass top of the shock compartment delivered the auditory CS directly into the shock compartment.

For all Ss in all groups the intertrial interval was fixed at 120 sec. with S remaining for 100 sec. in the non-shock compartment prior to being placed in the shock compartment for 20 sec. The CS-US interval was 5 sec., both CS and US being response terminated when S crossed to the non-shock compartment. All Ss ran initially to a criterion of two successive avoidances. After S reached criterion, the shock stimulator was disconnected, so that on subsequent trials all responses became, in effect, avoidance responses.

The seven groups used in the experiment are described at length below. Summary information describing these groups appear in Table I.

20-trial group.--After reaching criterion, S received 20 additional acquisition trials. In order to prevent additional escape trials from strengthening the habit after criterion was reached and to insure further the development of a relaxed state, the shock stimulator was disconnected upon reaching criterion. Thus, all responses, whether they occurred before or after the CS-US interval used in training, were avoidances. Such a procedure permitted the shock-associated stimuli present during acquisition to dissipate and be replaced by relaxation-associated stimuli. Extinction began after a delay of 24 hours.

General Time-out Conditions

The purpose of the various time-out conditions was to permit the shock-associated stimuli present during acquisition to

TABLE 1

DIFFERENTIATION OF GROUPS AS TO LOCUS OF SAMPLING TRIAL, SHOCK-CUE, AND EXTINCTION

Group	Reinstated Shock-Cue	Locus of Sampling trial After Criterion Or Shock-Cue	Extinction
	Experiment I		
20-trials	none	trials 1-20	24 hour delay
Time-out-in-home-cage	none	40 min.	24 hour delay
Time-out-in-non-shock-compartment	none	40 min.	24 hour delay
Time-out-five-sampling-trials	none	34-44 min.	24 hour delay
24-hour-retention	none	immediate	24 hour delay
40-minute-retention	none	none	40 min. delay
0-minute-retention	none	none	immediate
	Experiment II		
Shock-cue-immediate-extinction	after 40 minutes	immediate	immediate
Shock-cue-delayed extinction	after 40 minutes	immediate with 120 sec. ITI	24 hour delay
	Experiment III		
Immediate-shock-cue	immediate	immediate	24 hour delay
	Experiment IV		
Shock-cue-20 sec. ITI (delayed extinction)	after 40 minutes	immediate with 20 sec. ITI	24 hour delay

dissipate, independent of total number of avoidance trials. The time-out period for the various time-out conditions typically included the following sequence. After criterion was reached, S remained for 100 sec. in the non-shock compartment, 36 min. in the home cage, 100 sec. in the non-shock compartment, and 20 sec. in the shock compartment. This sequence was immediately followed by a sampling trial that permitted S to respond to the presumptive relaxational stimuli (the shock stimulator was disconnected). A sampling trial was an avoidance response under the relaxed state. Following S's response, S remained for 100 sec. in the non-shock compartment. S was then returned to the home cage for 24 hours. This procedure made the 20-trial group and the time-out groups comparable with respect to the time when the twentieth trial or the single additional trial occurred. Deviations from the general time-out procedure, for specific time-out conditions, described that condition and differentiated it from all others. The three time-out groups are described below.

Time-out-in-home-cage group.--After reaching criterion and remaining for 100 sec. in the non-shock compartment, S was returned to its home cage for 36 min. Then S was returned to the non-shock box for 100 sec. and received one sampling trial under the new internal stimulus conditions. Extinction began after a delay of 24 hours.

Time-out-in-non-shock-compartment group.--After reaching criterion, _S_ received 19 simulated trials (38 min.). In each simulated trial _S_ spent 100 sec. in the non-shock compartment and 20 sec. in a neutral cage (an individual cage distinct from the social home cages) before being again placed in the non-shock compartment. This group differed from the time-out-in-home-cage group in terms of the place where the change in internal state occurred. Again, one sampling trial was given under the new internal stimulus conditions. Extinction began after a delay of 24 hours.

Time-out-five-sampling-trials group.--After reaching criterion, _S_ was returned to its home cage for 32 min. The _S_ was then returned to the non-shock compartment for 100 sec. and received five successive sampling trials with the shock stimulator disconnected under the new internal stimulus conditions. Extinction began after a delay of 24 hours. This group was included as a special control for the potency of a single sampling trial during the relaxed state.

Two _Ss_ in the 20-trial group reached the extinction criterion during the 20 sampling trials. When this occurred training was discontinued. But, after a delay of 24 hours, these _Ss_ were given further extinction trials and were included in the analysis. In the time-out groups, two _Ss_ failed to respond during the sampling trial. When this occurred _S_ was extinguished after a delay of 24 hours and was also included in the analysis.

The inclusion of these Ss was necessary since excluding them introduces an element of selectivity not present in other groups.

24-hour-retention group.--After reaching criterion, S was immediately given one sampling trial and was returned to its home cage. Extinction began after a delay of 24 hours.

40-minute-retention group.--After reaching criterion, S was returned to its home cage for 36 min. as in the time-out groups, prior to being placed in the non-shock compartment for 100 sec. Extinction began 40 min. after reaching criterion.

0-minute-retention group.--After S reached criterion, extinction began immediately.

For all Ss that received delay periods prior to extinction, S spent the entire time in its home cage. Extinction was considered to be complete when S failed to respond to the CS for a 60 sec. period on two successive trials. When S did not respond to the CS, S remained in the shock compartment for 120 sec. until the next trial was administered.

Results

All Ss were considered to have received one or more sampling trials after the acquisition criterion was reached and before extinction was begun. In analyzing resistance to extinction, both the acquisition criterion trials and the sampling trials were excluded. Only extinction trials following the appropriate delay periods were considered in the analysis of results. For example, the 20 additional avoidance trials in the 20-trial group were not included in the analysis. To maximize comparability between groups, the first trial after criterion in the 0-minute and 40-minute retention groups was arbitrarily considered to be a sampling trial and was excluded from the analysis.

The results are analyzed exclusively in terms of mean number of trials to extinction. The mean number and standard deviations for all groups are presented in Table II. Statistical comparisons of import are summarized in Table III and the raw data for all groups are presented in Table VIII and Table IX (Appendix). Throughout, all statistical tests are two-tailed.

A single classification analysis of variance (Table X in Appendix) was performed on the number of trials necessary to reach the learning criterion for all eleven groups in the four experiments. The overall test was not significant ($F = .665$) indicating that differences in learning could not reasonably account for the obtained effects during extinction.

The 20-trial group took significantly more trials to extinguish than the 24-hour-retention group ($t = 2.83$, $df = 9$,[2] $p < .02$). Without this finding the remainder of the study would have little meaning.

The time-out-in-home-cage group and time-out-in-non-shock-compartment group were treated essentially the same in terms of

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[2] Where F-tests indicated heterogeneity of variance, Welch's formula (Winer, 1962) was used to obtain the appropriate degrees of freedom.

TABLE II

MEAN TRIALS TO EXTINCTION AND STANDARD DEVIATIONS FOR ALL GROUPS

Group	Mean	S.D.
Experiment I		
20-trials	24.7	23.3
Time-out-in-home-cage	20.7	29.409
Time-out-in-non-shock-compartment	25.6	29.239
Combined-time-out	23.15	28.652
Time-out-five-sampling-trials	9.1	7.219
24-hour-retention	3.7	2.495
40-minute-retention	17.7	15.319
0-minute-retention	36.1	32.518
Experiment II		
Shock-cue-immediate-extinction	39.1	14.043
Shock-cue-delayed-extinction	31.7	23.238
Experiment III		
Immediate-shock-cue	11.2	13.782
Experiment IV		
Shock-cue-20 sec. ITI	18.5	17.619

TABLE III

SUMMARY OF STATISTICAL COMPARISONS FOR TRIALS TO EXTINCTION IN EXPERIMENT I

Comparisons	Mean	t	df	P
20-trials group with 24-hour-retention group	24.7 / 3.7	2.83	9*	< .02
Time-out-in-home-cage group with Time-out-in-non-shock-compartment group	20.7 / 25.6	.748	18	N.S.
Combined-time-out group with 24-hour-retention group	23.15 / 3.7	3.02	19*	< .01
Combined-time-out group with Time-out-five-sampling-trials group	23.15 / 9.1	2.07	23*	< .05
20-trials group with Combined-time-out group	24.7 / 23.15	.313	28	N.S.
20-trials group with Time-out-five-sampling-trials group	24.7 / 9.1	2.02	11*	< .10
Time-out-five-sampling-trials group with 24-hour-retention group	9.1 / 3.7	2.24	11*	< .05

* Welch's formula was used to obtain the appropriate degrees of freedom.

the locus of the sampling trial and since they did not differ significantly (t = .748) they were combined for further analyses. This combined-time-out group also took significantly longer to extinguish than the 24-hour-retention group (t = 3.02, df = 19, $p < .01$) but did not differ from the 20-trial group (t = .313). Thus the non-incremental position is supported. The combined-time-out group extinguished significantly slower than the time-out-five-sampling-trials group (t = 2.07, df = 23, $p < .05$), indirectly adding further support to the non-incremental position.

The trend becomes somewhat obscured, however, as borderline significance was obtained when the 20-trial group and five-sampling-trials group were compared. That the 20-trials group extinquished more slowly than the five-sampling-trials group (t = 2.02, df = 11, $p < .10$) appears to support an incremental position. But, the time-out-five-sampling-trials group took significantly longer to extinguish than the 24-hour-retention group (t = 2.24, df = 11, $p < .05$) indicating that the effects of sampling are still present.

TABLE IV

SUMMARY OF ANALYSIS OF VARIANCE FOR NUMBER OF TRIALS TO EXTINCTION FOR THE RETENTION GROUPS

Source of variation	d.f.	Mean Square	F
Between groups	2	2640.533	6.101*
Within groups	27	432.781	
Total	29		

* $p < .01$

The results for the 0-minute, 40-minute, and 24-hour-retention groups are presented in Fig. 1. A single classification analysis of variance (Table IV) was significant ($F = 6.101$, $df = 2/27$, $p < .01$). Further comparisons indicated that the 0-minute-retention group took longer to extinguish than the 40-minute-retention group ($p < .01$) and the 40-minute-retention group took longer to extinguish than the 24-hour-retention group ($p < .05$). The obtained relationship appeared to be log linear.

Discussion

Pilot work previously indicated that a series of successful avoidance trials after criterion increased resistance to extinction 24 hours later as compared with a procedure where there were no further trials after criterion. That the 20-trial group was significantly more resistant to extinction than the 24-hour-retention group confirms this finding. The implication of this effect from an incremental learning position is that the additional trials strengthened the habit. The implication from a non-incremental position is that the relaxation-associated stimuli that were sampled during the 20 additional trials (early extinction) became associated with the avoidance response and that one sampling trial, appropriately placed, should be as good as 20 trials.

The Ss in the combined-time-out group received one sampling trial after 40 min. Presumably a large portion of the internal stimuli associated with shock have dissipated by this time and have been replaced by relaxation-associated stimuli. On the other hand,

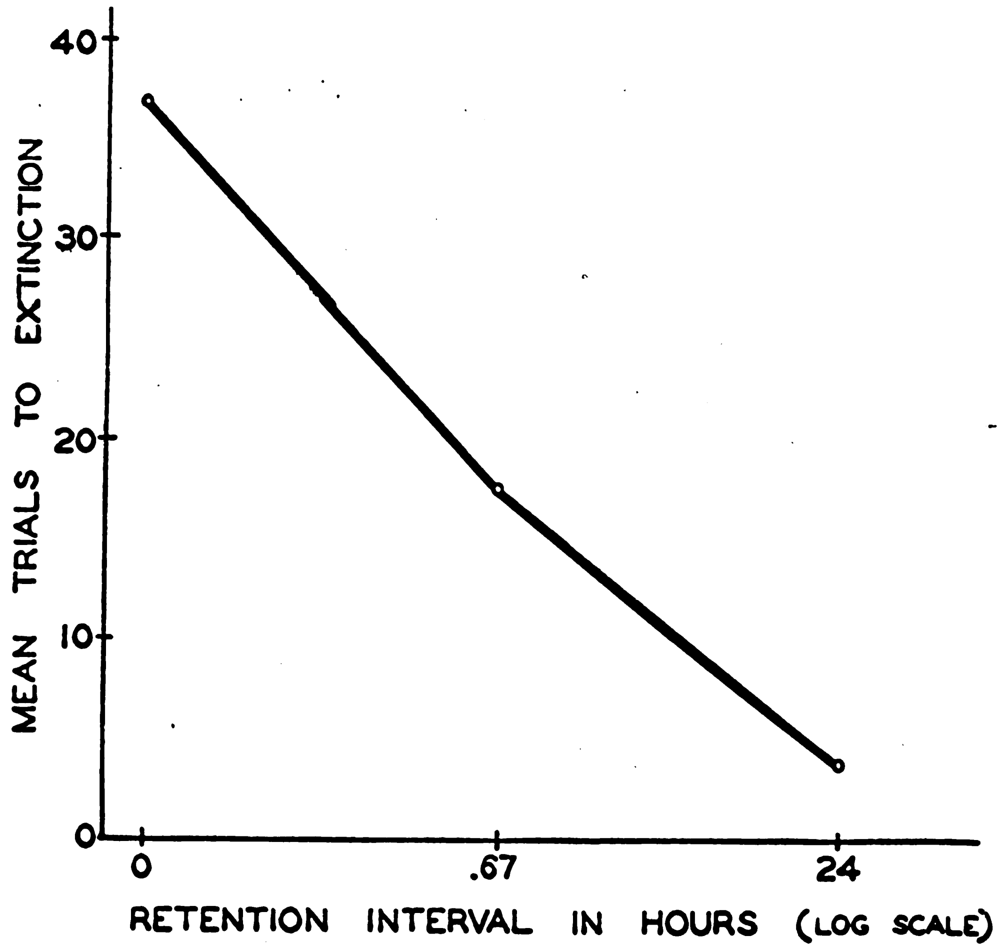

Figure 1. Retention of an avoidance response after 0 min., 40 min. and 24 hours.

Ss in the 24-hour-retention group received one sampling trial immediately after reaching criterion when the shock-associated stimuli still prevailed. In the 24-hour-retention group the relaxation-associated stimuli could not be sampled and could not be associated with the response. That the combined-time-out group took significantly longer to extinguish than the 24-hour-retention group clearly supports a non-incremental stimulus sampling position. That is, the opportunity to sample relaxation-associated stimuli in the avoidance situation emerges as a critical variable for continued avoidance responding after 24 hours. Furthermore, since the 20-trial group and the combined-time-out group do not differ significantly in resistance to extinction, the effect appears to be independent of total avoidance trials.

According to the incremental position, five sampling trials should result in greater resistance to extinction than a single sampling trial. This was not the case; thus, the incremental position was not supported. The problem with the time-out-five-sampling-trials group is that they did so poorly, extinguishing faster than the groups that received a single sampling trial. At least part of this discrepancy can be explained by assuming that these five sampling trials were highly effective extinction trials occurring when S was in a relaxed state. According to elicitation theory relaxation is the competing response that is responsible for extinction in avoidance learning. Thus, the gradual development of relaxation, as response, constitutes the competing responses that are responsible for eventual extinction in all groups. Considerable relaxation, chained in over trials, could have been present in the time-out-five-sampling-trials group causing them to extinguish rapidly after 24 hours.[3]

An apparent inconsistency is present since strengthening is posited for the single sampling-trial groups. In the elicitation framework, however, relaxation mediates both acquisition of avoidance responses and the acquisition of competing responses during extinction. Presumably one sampling trial would not permit sufficient relaxation for extinction effects. It must be admitted, however, that the results from the time-out-five-sampling-trials group are rather puzzling and requires further research.

In this connection, the 20 additional avoidance trials in the 20-trial group could be called extinction trials. But, it is preferable to conceive of most of them at least as sampling trials. If they were extinction trials the 20-trial group should extinguish faster than groups that did not receive such trials. This is clearly not the case as the 20-trial group was more resistant to extinction than the 24-hour-retention group. Indeed, what may be operationally considered to be an extinction trial may deviate considerably from "the process of extinction". What we typically call extinction probably contains both stimulus sampling and extinction functions.

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[3] Pilot work supports this contention since <u>S</u>s that received 3-5 widely spaced sampling trials (10 min. intervals) were as resistant to extinction as <u>S</u>s which received only one sampling trial after the time-out period.

The results for the retention of an avoidance response are also consistent with the present analysis of stimulus sampling effects. Retention is best immediately after S reaches criterion, that is, when S successively samples small changes in its internal state. With a brief delay between criterion and extinction, retention is intermediate. With a delay of 24 hours, retention is poorest. Although the relationship appears to be log linear, it is premature to assume log linearity since only three points are represented on the curve.

CHAPTER III

EXPERIMENT II

Experiment II was designed to investigate the effects of sampling for internal stimuli when the shock cues are reinstated immediately following a time-out period.

Method

<u>Subjects</u>.--The <u>S</u>s were 20 male albino rats, 90 to 110 days old and assigned at random to two groups of 10 <u>S</u>s each.

<u>Procedure</u>.--The apparatus and general procedure were the same as in Experiment I. After reaching criterion, <u>S</u>s were returned to their home cage for 36 min. as in the time-out conditions in Experiment I. <u>S</u> then spent 100 sec. in the non-shock compartment prior to being placed in the shock compartment for 20 sec. With the termination of this 20 sec. period, <u>S</u> received a shock (unpaired with the CS) until <u>S</u> escaped shock (shock-cue). After remaining in the non-shock compartment for 100 sec., <u>S</u> was again placed in the shock compartment before receiving a sampling trial with the CS alone. Half of the <u>S</u>s were extinguished immediately and half after a 24 hour delay.

Results

The mean trials to extinction and standard deviations are presented in Table II. Statistical comparisons involving groups in both Experiments I and II are summarized in Table V. The shock-cue-immediate-extinction group did not differ significantly from the 0-minute-retention group (t = .267) indicating that the effect of the additional shock trial was negligible.

The shock-cue-delayed-extinction group did not differ from the shock-cue-immediate-extinction group (t = 1.72). Also, the shock-cue-delayed-extinction group was significantly more resistant to extinction than the 24-hour retention group (t = 3.79, df = 9, $p < .01$) but did not differ significantly from the combined-time-out group (t = 1.73, df = 28, $p < .10$). The convincing resistance to extinction in the shock-cue-delayed-extinction group was not predicted and requires further analysis.

TABLE V

SUMMARY OF STATISTICAL COMPARISONS FOR TRIALS TO EXTINCTION IN EXPERIMENT II

Comparisons	Mean	t	d.f.	p
Shock-cue-immediate-extinction group	39.1			
with		.267	18	N.S.
0-minute-retention-group	36.1			
Shock-cue-immediate-extinction group	39.1			
with		1.72	18	N.S.
Shock-cue-delayed-extinction group	31.7			
Shock-cue-delayed-extinction group	31.7			
with		3.79	9	$< .01$
24-hour-retention group	3.7			
Shock-cue-delayed-extinction group	31.7			
with		1.73	28	$< .10$
Combined-time-out group	23.15			

Discussion

Following a time-out period and a shock trial, it is apparent that the Ss are very resistant to extinction, independent of the delay between the shock and the beginning of extinction. But, it is unlikely that the shock per se contributed to this resistance to extinction since the additional shock yielded only slight and non-significant superiority over groups that did not receive an additional shock after reaching criterion. These results compare well with the finding that additional errors (shock) after the initial success (avoidance) do not strengthen the avoidance habit (Theios, 1963).

The resistance to extinction in the shock-cue-immediate-extinction group is of the same order as the resistance to extinction in the 0-minute-retention group. In both groups, extinction is occurring under stimulus conditions that are quite similar to those that prevail during acquisition. Any differences between acquisition and extinction accrue gradually, and generalization decrement is kept at a minimum.

The high degree of resistance to extinction in the shock-cue-delayed-extinction group was not predicted but this finding is not necessarily contradictory to a stimulus sampling hypothesis. There are several possible explanations. One explanation is that the additional shock itself may strengthen the habit although the unlikelihood of this contingency has already been discussed.

Another explanation is based on the notion that relaxation presumably occurs faster and faster with successive opportunities to relax. Furthermore, a single shock following a long period of relaxation should result in a faster onset of relaxation, than for a series of repeated shock trials. After a 40 min. period, a single intertrial interval of 120 sec. after shock may result in enough relaxation so that S can sample relaxation-associated stimuli on the subsequent avoidance trial. Experiments III and IV were designed to investigate these alternatives.

CHAPTER IV

EXPERIMENT III

Experiment III was designed to investigate the effects of a shock-cue when it was not preceded by a time-out period. In other words, does an additional shock *per se* significantly increase resistance to extinction.

Method

Subjects.--The *S*s were 10 male albino rats, 90 to 110 days old.

Procedure.--The apparatus and general procedure were the same as in Experiment I. After reaching criterion, *S* remained in the non-shock compartment for 100 sec. prior to being placed in the shock compartment for 20 sec. Then *S* immediately received a shock-cue (as in Experiment II) and a sampling trial after 120 sec. Extinction began after a delay of 24 hours.

Results

The mean trials to extinction and the standard deviation for the immediate-shock-cue group are presented in Table II. Statistical comparisons involving groups from Experiments I, II, and III are summarized in Table VI. The immediate-shock-cue group extinguished significantly faster than the shock-cue-delayed-extinction group ($t = 4.80$, $df = 18$, $p < .001$) but did not differ significantly from the 24-hour-retention group ($t = 1.69$) indicating that the additional shock had negligible effects.

TABLE VI

SUMMARY OF STATISTICAL COMPARISONS FOR TRIALS TO EXTINCTION IN EXPERIMENT III

Comparisons	Mean	t	d.f.	p
Shock-cue-delayed-extinction group	31.7			
with		4.80	18	$< .001$
Immediate-shock-cue group	11.2			
Immediate-shock-cue group	11.2			
with		1.69	18	N.S.
24-hour-retention group	3.7			

Discussion

It is clear that the time-out condition and not shock *per se* is critical for the high level of resistance to extinction after 24 hours. Again, the effect of the additional shock yields slight and non-significant superiority over comparable groups.

CHAPTER V

EXPERIMENT IV

Experiment IV was designed to examine the effect of an additional shock following a time-out period under conditions in which a short time period intervened between the shock-cue and the subsequent sampling trial. This is a test of the hypothesis that relaxation can take place within 120 sec. when this interval is preceded by a long time-out period.

Method

Subjects.--the *S*s were 10 male albino rats, 90 to 110 days old.

Procedure.--The apparatus and general procedure were the same as in Experiment I. After reaching criterion, *S* was returned to its home cage for 36 min. The *S* was then placed in the non-shock compartment for 100 sec. prior to being placed in the shock compartment for 20 sec. The *S* then received an additional shock trial as in Experiment II. After 20 sec. (10 sec. in the non-shock compartment and 10 sec. in the shock compartment) *S* received a sampling trial. Extinction began after a delay of 24 hours.

Results

The mean trials to extinction and the standard deviation for the shock-cue-20 sec. ITI group are presented in Table II. Statistical comparisons involving groups from Experiments I, II, III, and IV are summarized in Table VII. The shock-cue-20 sec. ITI group extinguished significantly faster than the shock-cue-delayed-extinction group ($t = 2.86$, $df = 18$, $p < .02$) and significantly slower than the 24-hour-retention group ($t = 2.63$, $df = 9$, $p < .05$) providing sufficient support for the hypothesis that relaxation can take place within 120 sec. when this interval is preceded by a prior time-out period. The shock-cue-20 sec. ITI group and the immediate-shock-cue group did not differ significantly ($t = 2.07$, $df = 18$, $p < .10$).

TABLE VII

SUMMARY OF STATISTICAL COMPARISONS FOR TRIALS TO EXTINCTION IN EXPERIMENT IV

Comparisons	Mean	t	d.f.	p
Shock-cue-delayed-extinction group	31.7			
with		2.86	18	$< .02$
Shock-cue-20-sec. ITI group	18.5			
Shock-cue-20-sec. ITI group	18.5			
with		2.63	9	$< .05$
24-hour-retention group	3.7			
Shock-cue-20-sec. ITI group	18.5			
with		2.07	18	$< .10$
Immediate-shock-cue group	11.2			

Discussion

The finding that the shock-cue-20 sec. ITI group extinguished significantly faster than the shock-cue-delayed-extinction group is consistent with the hypothesis that *S* relaxes within a 120 sec. interval when the additional shock is preceded by a long time-out period. This in turn means that the avoidance response on the sampling trial was associated with relaxational stimuli. With the 20 sec. ITI this was not the case, and *S* extinguished faster than when the intertrial interval was 120 sec.

The fact that relaxation may occur during a 120 sec. intertrial interval cannot account for all of the superiority of the shock-cue-delayed-extinction group. This is evident since the shock-cue-20 sec. ITI group represents an intermediate condition that is significantly more resistant to extinction than the 24-hour-retention group. It is still possible that the shock itself is critical, and this is partially supported by the non-significant differences between the shock-cue-20 sec. ITI group and the immediate-shock-cue group. But, the majority of evidence indicates that the effects of the shock *per se* are negligible. Some additional factor then must account for the fact that resistance to extinction in the shock-cue-20 sec. ITI group is significantly greater than that present in the 24-hour-retention group.

An obvious interpretation, from the data and from the observed behavior of *S*s, is that a single shock did not reinstate the emotional responses that were associated with shock and which were present during acquisition. Such an interpretation is reasonable since 75% of the *S*s given an additional shock only received a brief shock (one sec. or less). In other words, the majority of *S*s received a sampling trial while they were partially relaxed and this presumably increased resistance to extinction 24 hours later.

CHAPTER VI

GENERAL DISCUSSION

Avoidance learning research has previously yielded results that can be interpreted as support for a non-incremental learning position. Madsen and McGaugh (1961) used a passive avoidance situation and Maatsch (1959) used an active avoidance situation. They demonstrated one-trial learning under optimal acquisition conditions. Theios (1963) has mathematically described an avoidance task with mathematical models which assume all-or-none properties. The present study represents an approach which emphasizes the post-acquisition conditions under which relaxational stimuli are sampled and associated with the avoidance response.

The time when S is permitted to sample relaxational stimuli is critical. This is evident as Ss extinguish rapidly after 24 hours if previously they did not receive a sampling trial while in a relaxed condition. It is true that the first extinction trial coming 24 hours later, permits S to sample relaxational stimuli in the avoidance situation. But, by this time, generalization decrement is maximal, and the avoidance response is so weak, for example, that half the Ss in this group never even responded prior to reaching the extinction criterion (see Table IX in Appendix).

Thus there is a limited time period during which the effect can occur. The limiting conditions depend upon two related stimulus-change gradients. Soon after the last shock is received, S begins to relax. Progressively, over time, relaxation-associated stimuli begin to accumulate. The gradual accumulation of these relaxational stimuli represents one changing stimulus gradient. Paralleling this dimension is another gradient related to shock-associated stimuli. Soon after the last shock is received, shock-associated stimuli begin to dissipate. In other words, as S relaxes, relaxational stimuli replace shock-associated stimuli. The gradually changing stimulus conditions represent gradually increasing generalization decrement since intially only the shock-associated stimuli were conditioned to the avoidance response.

At some point in time, the gradient for shock-associated stimuli and the gradient for relaxation-associated stimuli must intersect. Where this point is located is undoubtedly a function of individual differences in Ss' capacity to relax as well as other psychological variables which affect the rate at which relaxational stimuli replace shock-associated stimuli. These individual differences may well account for some of the variance that was found. The point at which S samples the relaxational stimuli in the avoidance situation will determine the effectiveness of that sampling trial. If the sampling trial occurs where the gradients intersect, then its effectiveness is maximized. If it occurs before the gradients intersect, that is, when the shock-associated stimuli have dissipated somewhat but still predominate, then the greater portion of stimuli sampled will be shock-associated stimuli. After 24 hours when relaxation-associated stimuli prevail there will be considerable generalization decrement. Extinction will be fairly rapid since more shock-associated stimuli than relaxation-associated stimuli have been conditioned to the avoidance response. On the other hand, if the sampling trial occurs after the gradients intersect, then the sampling trial can also be ineffective. This is the case when the generalization decrement between acquisition and the sampling trial is considerable. With relaxation-associated stimuli predominating there may be insufficient shock-associated stimuli to mediate an initial avoidance response; and therefore, the relaxational stimuli cannot be conditioned to avoidance.

Kamin, Brimer, and Black (1963) have shown that there is a lack of parallelism between fear and instrumental avoidance learning. Their study revealed that fear cannot maintain an avoidance response and that some other factor must be responsible for maintained avoidance responding. In this connection, the present study shows that relaxational stimuli, when sampled and associated with the avoidance response, can elicit and maintain avoidance responding.

CHAPTER VII

SUMMARY

In the present series of experiments, rats were trained to avoid shock in a one-way shuttlebox to a criterion of two successive avoidances. Subsequent to the acquisition criterion, Ss received either 1, 5, or 20 additional avoidance trials (called sampling trials). In Experiment I, Ss were given sampling trials following an appropriate time-out period. The Ss that received a sampling trial immediately after reaching criterion extinguished rapidly 24 hours later, that is, when the internal stimuli were associated with a relaxed state rather than an emotional state. The other Ss (time-delay groups) received sampling trials approximately 40 min. after reaching criterion when the shock-associated stimuli had dissipated and when the relaxation-associated stimuli that would prevail 24 hours later could be sampled. In contrast to Ss that received the sampling trial when the shock-associated stimuli prevailed, these time-delay Ss were highly resistant to extinction. Furthermore, a single sampling of relaxation-associated stimuli was as effective as 20 sampling trials given over the same time period. This was interpreted as support for a non-incremental learning position.

The retention of an avoidance response was simultaneously investigated for three delay intervals (0 min., 40 min., and 24

hours). A typical retention curve was obtained which was approximately log linear.

In Experiment II, shock-associated stimuli were reinstated after the time-out period by giving S an additional shock in the shock compartment. These Ss were highly resistant to extinction after a delay of 24 hours even though the sampling trial followed the shock within 120 sec. Experiments III and IV were designed to clarify this finding. Experiment III demonstrated that the effect required the presence of a time-out period and not the additional shock per se. Experiment IV was consistent with the hypothesis that S may relax within 120 sec. when the additional shock is preceded by a long time-out period. Thus the results of Experiment II were interpreted by positing that the avoidance response on the sampling trial was actually associated with relaxational stimuli and could thus maintain an avoidance response 24 hours later. The data from Experiments III and IV were most readily interpreted as indicating that a single shock was insufficient to reinstate fully the emotional stimuli of original learning.

In general, the results supported a non-incremental learning position and emphasized the importance of stimulus sampling in avoidance learning.

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APPENDICES

TABLE VIII

THE NUMBER OF TRIALS TO THE ACQUISITION CRITERION FOR ALL SS FOR ALL GROUPS (THE TWO CRITERION RESPONSES ARE INCLUDED)

Group	Subjects 1	2	3	4	5	6	7	8	9	10	Mean
					Experiment I						
20-trials	6	4	4	4	7	6	11	7	5	5	5.9
Time-out-in-home-cage	6	5	6	7	3	5	5	5	4	5	5.1
Time-out-in-non-shock-compartment	4	5	6	10	8	5	4	3	9	10	6.4
Time-out-five-sampling-trials	6	7	4	5	4	4	9	9	3	7	5.8
24-hour-retention	4	8	8	5	6	6	4	3	6	7	5.7
40-minute-retention	3	9	3	5	4	12	6	7	8	5	6.2
0-minute-retention	8	9	6	10	8	5	6	4	5	5	6.6
					Experiment II						
Shock-cue-immediate-extinction	12	9	5	8	5	5	5	5	5	7	6.6
Shock-cue-delayed-extinction	10	6	8	6	3	4	6	6	6	5	6.0
					Experiment III						
Immediate-shock-cue	6	8	7	5	5	3	4	6	4	7	5.5
					Experiment IV						
Shock-cue-20 sec. ITI	6	5	6	6	4	4	3	8	5	4	5.1

TABLE IX

THE NUMBER OF TRIALS TO THE EXTINCTION CRITERION FOR ALL SS FOR ALL GROUPS (THE TWO EXTINCTION CRITERION RESPONSES ARE INCLUDED BUT THE SAMPLING TRIAL IS NOT)

Group	Subjects 1	2	3	4	5	6	7	8	9	10	Mean
				Experiment I							
20-trials	9	54	32	15	2*	2*	37	15	71	10	24.7
Time-out-in-home-cage	27	15	3	99	2*	3*	5	27	23	3	20.7
Time-out-in-non-shock compartment	14	7	2	39	49	3	88	2	48	4	25.6
Time-out-five-sampling-trials	23	15	17	2	8	3	11	6	4	2	9.1
24-hour-retention	2	2	3	9	2	2	7	5	2	3	3.7
40-minute-retention	9	44	2	2	17	15	16	29	3	40	17.7
0-minute-retention	29	119	24	12	62	13	30	20	35	17	36.1
				Experiment II							
Shock-cue-immediate-extinction	56	20	44	21	27	38	29	54	48	54	39.1
Shock-cue-delayed-extinction	16	5	7	54	59	58	17	61	22	18	31.7
				Experiment III							
Immediate-shock-cue	42	2	2	24	4	3	2	7	23	3	11.2
				Experiment IV							
Shock-cue-20 sec. ITI	44	2	3	7	2	22	12	34	11	48	18.5

* Ss that either extinguished during the 20 additional trials (20-trial group) or failed to respond on the sampling trial (time-out-in-home-cage group).

TABLE X

SUMMARY OF ANALYSIS OF VARIANCE FOR NUMBER OF TRIALS TO ACQUISITION CRITERION FOR ALL GROUPS

Source of Variation	d.f.	Mean Square	F
Between groups	10	2.82	.665
Within groups	99	4.24	
Total	109		