The Journal of Abnormal and Social Psychology
Vol. 48, No. 2, 1953

TRAUMATIC AVOIDANCE LEARNING: THE OUTCOMES OF SEVERAL EXTINCTION PROCEDURES WITH DOGS

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The persistence of behavior with no obvious reinforcement poses special problems for theories of learning. But numerous experimental studies confirm the clinical observation that traumatically acquired habits maintain a marked resistance to extinction despite the lack of renewed primary reinforcement (3, 4, 6, 8). The generality of the problem has been indicated by Mowrer (9), who formulates as the central problem of neurosis the paradoxical perpetuation of non-adaptive behavior.

The present research deals with the extinction of a habit acquired under the conditions of traumatic avoidance learning. The habit proved to be markedly resistant to the ordinary extinction procedure. However, extinction could be brought about through the use of special techniques. The obtained data suggested theoretical explanations of high resistance to extinction as well as explanations of the relative efficacy of the special techniques. We presume that the findings have a wide generality for theories of therapy and the nature of psychological trauma.

The findings to be reported in this paper were obtained under the following conditions. Using a modification of the Mowrer-Miller shuttlebox, learned avoidance responses were established in normal mongrel dogs. Under the impetus of very intense (just subtetanizing) electric shock, the dogs were trained to jump over a barrier from one compartment to the other in order to avoid the shock. The details of the training procedure are given in another paper (13). Ten trials comprised each day's session. After the animals had met an acquisition criterion of 10 successive responses on a given day, different dogs were subjected to different types of extinction procedures. It is the results of a series of such extinction experiments which will be the subject of this paper.

Experiment 1. Pilot Experiment

Two dogs were trained with a CS-US interval of 10 seconds, with a three-minute intertrial interval. The CS consisted of two segments: a buzzer sounded for one second, together with the raising of the gate which separated the two compartments of the shuttlebox. After these animals had met the criterion of acquisition, they were not shocked regardless of how long they remained in a given compartment without jumping.[2]

We had expected these dogs to extinguish spontaneously since the barrier was set at the height of the back of the animal, thus making the jumping response quite effortful. Instead, the experimenters found themselves running the animals day after day with no signs of extinction. Indeed, the latencies of response to the CS gradually *decreased* and the behavior of the animals became more and more stereotyped. One of the animals was continued for 190 extinction trials and the other for 490 trials. The dog which continued for 490 extinction trials had received only 11 shocks during the acquisition phase. The experimenters felt that this ordinary extinction procedure was *not efficient* in removing the jumping response. While the dogs *might* have extinguished spontaneously after several hundred, or even several thousand, trials more, the behavior and latencies of the animals gave no suggestion of this conceivable eventuality.

An attempt was then made to discourage the 490-trial dog from jumping by electrifying the opposite compartment on each trial, so that the dog jumped *into* shock. The gate was immediately lowered after each jump to prevent retracing, and the shock, at just subtetanizing level, was continued for three seconds and then terminated. The dog became more upset, and at subsequent presentations of the CS jumped more vigorously. His latencies were maintained at their already extremely fast level of 1.0–1.2 seconds. After 100 additional trials under this shock-extinction procedure, the dog was still jumping regularly into shock and gave no signs of extinguishing. As he jumped on each trial, he gave a sharp anticipatory yip which turned into a yelp when he landed on the electrified grid in the

[1] This research was supported by grants from the Medical Sciences Division of the Rockefeller Foundation. It was facilitated by the Laboratory of Social Relations, Harvard University. Dr. Wynne was a U.S. Public Health Service Postdoctoral Research Fellow in Mental Health when this work was initiated. The authors wish to thank E. S. Brush, F. R. Brush, N. Kogan, B. N. Cohn, and E. Smulekoff for research assistance and many useful suggestions.

[2] The reader is referred to another paper of this series (13) for precise details of the training procedure and the consequent behavior of the dogs during the *acquisition phase* of avoidance learning.

opposite compartment of the shuttlebox. We then increased the duration of the shock to 10 seconds and ran the dog for 50 more trials. Latencies and behavior did not change. Evidently punishment for jumping was ineffective in extinguishing the jumping response.

We tried a third extinction procedure with the same dog, one designed to prevent the dog from jumping in the presence of the CS. We placed a plate of glass in the opposite compartment, flush against the barrier and gate so that it blocked the passage between the two compartments. The plate of glass could not be seen by the dog until the gate was raised and the buzzer was sounded. The glass barrier was inserted on trials 4–7 of each extinction day. On the other six trials, the dog was shocked for jumping as before. This procedure was intended to have a "reality-testing" function for the dog. Ostensibly, the procedure let the dog "know" that the presence of the CS no longer signified shock. On the first glass-barrier trial, he jumped forward immediately at the CS and smashed his head against the glass. He drew back and was fairly quiet, and the gate was lowered after two minutes. On the subsequent trials, on which he did not strike the glass, he barked furiously, panted very rapidly, quivered, and drooled while the CS was present, but quieted down after the gate was lowered, and remained quiet during the minute before the next trial was started. On the 8th–10th trials, when the glass barrier was no longer present, he did not attempt to jump, and the gate was lowered after two minutes. This two-minute period constituted the arbitrary criterion for no response. At long last, after 647 extinction trials, the dog failed to jump in the presence of the CS alone. On the following day, the dog jumped into shock with short latencies on the first three trials, thus showing complete spontaneous recovery. He did not jump on trials 8–10. On five subsequent days, during which the glass barrier was never present, he jumped only on the second trial of the third day with a latency of 1.3 seconds. With this dog there was no gradual lengthening of latencies, but, rather, extinction was an all-or-none affair.

Two more animals were run with the same training procedures as with the first two, except that 20 trials a day, instead of 10, were carried out. The ordinary extinction procedure was used. One animal was discontinued after 310 extinction trials and the other after 280 extinction trials. During these trials, neither animal showed any signs of spontaneous extinction.

Some of the questions posed by the results of this pilot study suggested the succeeding experiments: (*a*) Did the shock-extinction procedure (punishment) fail because the animal had so much practice in jumping before the procedure was instituted? That is, *does the ordinary extinction procedure decrease the likelihood of effectiveness of the special procedures?* (*b*) Would the "reality-testing," glass-barrier procedure have been effective if it had been used directly after ordinary extinction? (*c*) Would the combined glass-barrier and shock-extinction procedure have been as effective if it had been preceded by the glass-barrier procedure rather than by shock extinction?

Experiment 2. The Effects of Ordinary Extinction Procedure

This experiment was designed to test the efficacy of the ordinary extinction procedure. The simplest hypothesis might claim that the removal of all primary reinforcement (shock) should lead to either the gradual or sudden extinction of the jumping response.

Thirteen dogs were given avoidance training in the shuttlebox situation, using the following procedures. The CS consisted of turning off a light over the compartment in which the dog happened to be and raising the gate. The light stayed off and the gate stayed up until the dog jumped into the lighted compartment, after which the gate was lowered. The light-out signal was a modification of the procedure used in the pilot experiment, and it replaced the buzzer. As in the pilot experiment, an intense shock was used. The CS-US interval was 10 seconds, and the barrier set for each dog was at the height of his back. The intertrial interval was three minutes, and 10 trials were given each day. The criterion for acquisition of the jumping response was 10 avoidances in 10 trials. A complete description of the training procedures is given in another paper (13).

After the criterion of learning was reached, no shock was administered in the presence of the CS, no matter how long a dog might delay in jumping. Such a procedure, where the shock reinforcement is no longer administered, we shall call *ordinary extinction*. Ordinary extinction was carried on for 20 days after each dog met the learning criterion. Thus each dog received 200 trials following the criterion trials, or at least 210 trials since the last shock had been received during the acquisition phase.

During the ordinary extinction procedure, not a single animal delayed jumping long enough to meet the (arbitrary) criterion of no-response, or infinite latency, which was set at *two minutes without jumping in the presence of the CS.* In other words, no extinction was obtained. In fact, there were only 11 responses with a latency greater than 10 seconds during the 2582 extinction responses.[8] Rather than showing any signs of

[8] One dog missed 10 trials because of an oversight, one dog missed eight trials because of a sore foot; this accounts for the fact that the total number of responses was less than 2600 (20 days × 10 trials × 13 animals).

extinction, there was a general tendency for the latencies to shorten. Figure 1 presents a graph of the mean reciprocal of response latency as a function of days after meeting the criterion of learning. Each point represents the mean for the 13 dogs for 10 trials for a given day of extinction. The arrow at the origin of the abscissa designates the mean for all dogs for the 10 criterion trials. It can be seen that the dogs were jumping with a mean latency of approximately 2.7 seconds during the criterion trials. The mean latencies gradually decreased, and after 200 ordinary extinction trials, the dogs were jumping with a mean latency of approximately 1.6 seconds.

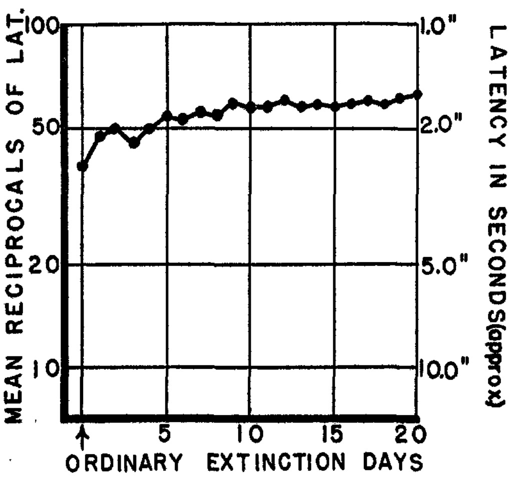

FIG. 1. MEAN RECIPROCALS OF LATENCY AS A FUNCTION OF NUMBER OF ORDINARY EXTINCTION DAYS

Each point is the mean reciprocal of response latency for thirteen dogs for the ten trials of a given day. Note that the ordinate for mean latency in seconds is approximate because the antireciprocal of the mean reciprocal of latency is not necessarily the same as the mean latency in seconds.

An inspection of the curve suggests that the latency asymptote had not yet been reached after 200 trials. This is not surprising, since it will be remembered that one of the dogs in the pilot experiment was jumping regularly at 1.0–1.2 seconds at the end of 490 extinction trials.

During the extinction trials, and accompanying the decrease in latency of the jumping response, the experimenters were impressed with certain behavioral changes. First, the behavior of the dogs, both in style of jumping and in intertrial behavior, became stereotyped. Each dog appeared to have developed his own particular "ritual." Such rituals involved actual response patterns as well as orientation in the apparatus. For example, a protocol description of one dog's behavior reads as follows: "At CS responded immediately and made clean jump with no pause. Then sat immobile in rear-door corner, with his back six inches from the rear, along wall opposite door, facing barrier gate, but nose pressed against wall. No panting or other reactions." For the next trial, the behavior was precisely the same, with the position again along the left side of the compartment with reference to the barrier, nose pressed against the wall.

Second, the frequency and intensity of overt emotional reactions, both to the CS and in the intertrial interval, decreased markedly. The types of emotional signs which usually disappeared during the course of ordinary extinction were defecation, urination, yelping and shrieking, trembling, attacking the apparatus, scrambling, jumping on the walls of the apparatus, and pupillary dilation. Whining, barking, and drooling tended to decrease in magnitude but often persisted throughout the 200 trials. Panting tended to persist relatively undiminished if it occurred during the early trials. Some dogs showed no overt emotional signs during the latter part of ordinary extinction. All dogs, early in the extinction procedure, showed some resistance—often very strenuous—to being placed into the apparatus. But most dogs, after 10 or 12 days of extinction, no longer resisted being placed into the apparatus. Many voluntarily hopped inside, displaying no visible emotional response.

Not only were there no signs of extinction in our dogs from day to day, but there was very little change in mean latency from trial to trial within experimental days. In Figure 2 are plotted the mean latencies for all dogs as a function of trials-within-days. On the first trial of each day, the mean reciprocal of latency for the 20 days was 56.1, while the mean reciprocal for the tenth trial was 55.1. This change is insignificant, representing but a small fraction of a second. There appears to be a slight warm-up effect on the first three trials, but this trend is also insignificant. Spontaneous recovery from the last trial of one day to the first trial of the next is minute, if present at all; it is indicated by the dotted line. The slight downward trend of the reciprocals between the third and tenth trials might indicate that longer experimental sessions would be more conducive to producing longer latencies, but this is doubtful.

The results of this experiment indicate that the ordinary extinction procedure is quite ineffective for eliminating the jumping response. If anything, it seems only to strengthen it. It can of course be argued that

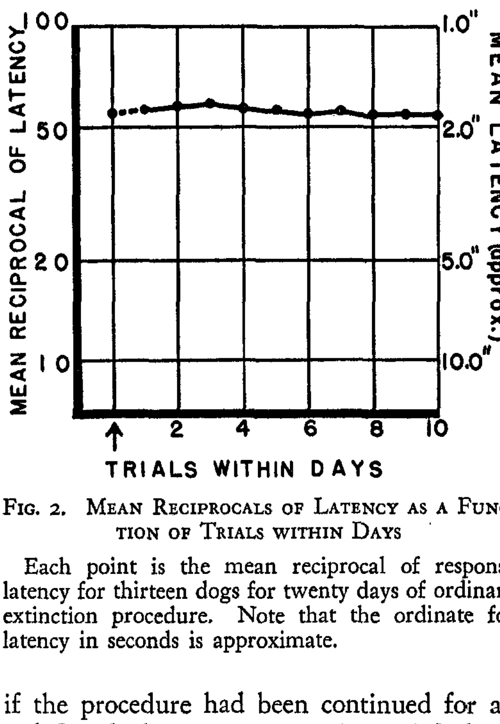

FIG. 2. MEAN RECIPROCALS OF LATENCY AS A FUNCTION OF TRIALS WITHIN DAYS

Each point is the mean reciprocal of response latency for thirteen dogs for twenty days of ordinary extinction procedure. Note that the ordinate for latency in seconds is approximate.

if the procedure had been continued for an indefinitely long time extinction *might* have occurred. But we must stress that within the time spans covered by this and the pilot experiment there were *no* signs of extinction of jumping.

EXPERIMENT 3. THE EFFECTS OF THE GLASS-BARRIER, REALITY-TESTING PROCEDURE

This experiment was designed to test the efficacy of an extinction procedure which physically prevented the animal from jumping in the presence of the CS. From one point of view, this technique corresponds to "reality testing." The animal was forcibly exposed to a sequence of events in which the CS, followed by *not*-jumping, is *no longer* followed by shock. Will the dog, as a result of this new "knowledge," stop jumping?

Nine dogs were trained in the same manner as those of Experiment 2, with the exception that four had learned with a CS-US interval of 20 seconds instead of 10 seconds. Some of these dogs had been used in Experiment 2. Five of the dogs were carried through the 200 trials of ordinary extinction, just as in Experiment 2, while the other four were given only 10 ordinary extinction trials beyond the 10 criterion trials. Thus, we had a group of animals which had jumped approximately 10 times as often as the other group. Then the glass-barrier procedure was introduced as follows: On trials 4–7 of a given day, a plate of glass was placed flush against the barrier and gate on the side opposite the compartment containing the dog. The glass had three narrow vertical strips of adhesive tape placed upon it. After presentation of the usual CS, these adhesive strips enabled the dog to discriminate visually the presence or absence of the glass-barrier. On trials 1–3, and 8–10, the dog was free to jump as in ordinary extinction. If the dog failed to jump in two minutes, the CS was removed, and the latency was defined as infinite or "no-response." Of the nine dogs, seven failed to extinguish in 10 days of the glass-barrier procedure. One dog stopped jumping during the fourth day, and was run the next day again with no responses occurring. Another dog stopped jumping on the fifth day, and was run for 10 trials on the following day, giving no responses to the CS. One of the dogs which extinguished had previously been run for 200 ordinary extinction trials, while the other dog which extinguished had been run for only 20 trials of ordinary extinction. (Both of these dogs had been trained with a CS-US interval of 10 seconds.) Of the seven dogs which *did not* extinguish, four had no occurrences of an infinite latency (two minutes without jumping). Only on trials 8–10 were there any infinite latencies for the other three animals. In most cases where infinite latencies, or very long ones, occurred on the eighth trial, the animals behaved in very much the same way as they did when the glass barrier was present. The animals looked as though they "thought" the glass barrier was still there. In two instances where trial 10 produced an infinite latency, on the following day the first trial latencies were 1.3 seconds and 1.5 seconds, respectively. These were dramatic cases of spontaneous recovery. Of the seven animals which did not extinguish, only two had any latencies over 5 seconds on trials 1–3. Of the nine animals in the experiment, eight showed an all-or-none pattern whenever the latencies changed. That is, the animals either jumped quickly (from 1 to 4 seconds) at the presentation of the CS, or they did not jump for long time periods, in some cases not at all. Such long latencies were then typically followed by very short ones on the next trial. Such all-or-none changes were also noted in our study of the characteristics of acquisition (13). There was no gradual lengthening of latencies during the 10 glass-barrier days. Even the two dogs which extinguished showed a sudden transition from short latencies to infinite ones during the course of their extinction. Our protocols indicated that most dogs, when first confronted with the glass barrier, exhibited a wide variety of intense emotional responses. These usually disappeared after several repetitions of the glass-barrier procedure.

The results of this experiment indicate that the glass-barrier procedure *does* produce extinction in *some* dogs. However, *within the ten-day span covered by the experiment,* the procedure failed to extinguish the jumping response in most of the dogs. It is to be noted that there was no difference between dogs trained for 10 and for 200 ordinary extinction trials, one of each group extinguishing.

EXPERIMENT 4. THE EFFECTS OF THE SHOCK-EXTINCTION, PUNISHMENT PROCEDURE

This experiment was designed to test the efficacy of an extinction procedure which punished (with shock) the performance of the jumping response. The simplest expectation might be that shock-punishment would "stamp out" the jumping response.

Thirteen dogs were trained in the same manner as those in Experiment 2. Some of them had participated in Experiment 2. Seven were trained with a 10-second CS-US interval and six were trained with a 20-second CS-US interval. Seven were given 200 trials of ordinary extinction, just as in Experiment 2, while the other six dogs were given only 10 ordinary extinction trials after meeting the learning criterion. Then the shock-extinction procedure was introduced for all dogs. This was carried out as follows: The dog was shocked for three seconds in the compartment *into which* he jumped. No shock was administered if the animal did not jump in the presence of the CS. The immediacy of the shock-for-jumping was guaranteed by having the grid onto which the animal jumped electrified before the presentation of the CS. The shock level was the same as that used in training. The gate was immediately lowered after a jump in order to prevent retracing. A two-minute latency was again arbitrarily defined as infinite, or "no-response," and the CS was removed at the end of this two-minute period.

Of the 13 dogs in this experiment, 10 failed to extinguish in 100 shock-extinction trials. Three dogs extinguished; one of these animals had received 200 trials of ordinary extinction and two had received 10 trials of ordinary extinction prior to the introduction of the shock extinction procedure. All these three gave infinite latencies in the first 11 trials of punishment for jumping. They all met a criterion of no responses in 10 trials at the end of the second day of shock extinction. There was *no spontaneous recovery* once an infinite latency had occurred: if one of these three animals failed to jump he did not jump again. The transition from jumping to not-jumping was abrupt in two of the three animals. There was a considerable lengthening of latencies on the trials which preceded the onset of infinite latencies for one of these dogs.

The ten animals which did *not* extinguish showed an *entirely different course of behavior*. Nine of the 10 exhibited *no* infinite latencies. In fact, there was a tendency for the latencies to shorten on the first shock-extinction trials. These dogs jumped *faster* and *more vigorously* into the shock than they had jumped previously under the ordinary extinction procedure. (See Table 1 for a description and analysis of these data.) They often slammed into the far end of the compartment into which they were jumping. In addition, they all developed anticipatory reactions prior to jumping, which indicated that they "knew" they were to be shocked. The most common reaction was to yelp at the CS, jump vigorously, and then yelp at the shock, barking rapidly when the shock was terminated. This behavior continued for 100 trials of the shock-extinction procedure. Some long latencies did occur, but they were scattered and were usually followed by short latencies. However, one dog had six infinite latencies on the second day of shock extinction. Yet this dog failed to extinguish, and his latencies on the tenth day were short!

Several types of trend were evident in the latencies of the 10 dogs which did *not* extinguish. It is impossible, therefore, to generalize for all animals. Some dogs showed progressively shortening latencies, and some showed a slight and gradual lengthening of latencies. None showed radically lengthened latencies. One dog showed lengthening latencies for the first three days of shock extinction and thereafter showed gradually shortening latencies. Despite these different trends, trial-to-trial and day-to-day variability in latencies was very small during the 100 trials of shock extinction *for those animals which did not extinguish*. All animals were extremely upset by the procedure, exhibiting symptoms of terror.

The results of this experiment indicate that the shock-extinction procedure *does* produce abrupt extinction in *some* dogs. However, within the ten-day span covered by the experiment, the procedure failed to extinguish the jumping response in most of the dogs. Punishment seemed to *increase* the strength of the jumping response in most dogs, as indicated by shorter latency and greater vigor of response. Again, there is no significant difference between animals trained for 10 and for 200 ordinary extinction trials.

if the dog jumped in the presence of the CS he jumped into shock. The shock was on for three seconds. The gate was lowered to prevent retracing. (If the dog did not jump in two minutes, the CS was withdrawn and the trial was scored as infinite in latency, or "no-response.") Then, on trials 4 through 7, the glass barrier was present, just as in Experiment 3. The CS was removed after two minutes' exposure to the glass barrier. Of course, the animal could not jump to the opposite compartment during trials 4–7. Then, on trials 8–10 the same procedure used on trials 1–3 was introduced again, and the animals were shocked if they

TABLE 1

MEAN RECIPROCALS OF RESPONSE LATENCY FOR THE FIVE TRIALS PRECEDING AND FOLLOWING THE ONSET OF THE SHOCK-EXTINCTION PROCEDURE

	Shock Extinction Follows 200 Ordinary Extinction Trials	Shock Extinction Follows Only 20 Ordinary Extinction Trials
Before shock extinction	50.7	50.5
After onset of shock extinction	72.9	63.1

ANALYSIS OF VARIANCE

Source	F	p
A. Trials before and after onset of shock extinction	15.02	$>.01$
B. Number of trials preceding onset of shock-extinction procedure	1.21	—
A×B Interaction	2.50	—

EXPERIMENT 5. THE EFFECTS OF A COMBINATION OF THE GLASS-BARRIER PROCEDURE AND THE SHOCK EXTINCTION PROCEDURE

This experiment was designed to test the efficacy of a procedure which combined in close juxtaposition the two special extinction techniques tested in the preceding experiments. Here punishment and reality-testing both occurred within the same day's experimental session.

Sixteen dogs were trained in the acquisition of avoidance in the same manner as those in Experiment 2. Of these, seven were trained with a 10-second CS-US interval and nine were trained with a 20-second CS-US interval. Ten had 200 trials of ordinary extinction, just as in Experiment 2, while the other six dogs were given only 10 trials of ordinary extinction after meeting the learning criterion. All of the dogs in this experiment had failed to extinguish in 100 trials of *either* the glass-barrier procedure *or* the shock-extinction procedure. Ten of the dogs had been subjected to the shock-extinction procedure and six had experienced the glass-barrier procedure. Then the combination of glass-barrier and shock-extinction procedure was introduced in the following manner: On the first three trials, the glass barrier was not present, but jumped to the CS. Thus the shock-extinction procedure was used on the first and last three trials of each day, and the glass-barrier procedure was used on the middle four trials. It was decided arbitrarily to terminate this experiment at the end of 10 days if no extinction occurred.

Fourteen out of 16 dogs extinguished before 7 days of the combined procedure. The extinction criterion, as in previous experiments, was 10 infinite latencies on a given day. When a dog failed to respond on the first three trials of a day, the glass barrier was not used, and 10 trials were given in order to test for the occurrence of extinction. The remaining two animals failed to extinguish in 10 days, or 100 trials. One of them had had 200 ordinary extinction trials, and one had had only 10 ordinary extinction trials. Both had had 100 shock extinction trials prior to the combined procedures. One of the two dogs which did not extinguish in 10 days of the combined procedure showed no signs of extinction after 10 days. The other dog showed lengthening latencies and one infinite latency on the last day of the combined procedure. *All* of the six dogs which had had 10 days of *glass-barrier trials prior to the combined procedure* met the extinction criterion in 30 trials or less, with a mean of 25.0 trials to meet the criterion of extinction. The eight dogs which had had *shock extinction,* and which *did* extinguish in the combined procedure, met the criterion for extinction in less than 70 trials of the combined procedure, with a mean of 43.8 trials.

The mean number of shocks required for extinction in the *combined* procedure was 8.2 shocks for the six dogs which had had the glass-barrier procedure and 14.3 shocks for the eight dogs which had had the shock-extinction procedure. This difference (14.3–8.2) is statistically significant ($p = .01$).

The results of this experiment indicate that the combined glass-barrier and shock-extinction procedure is highly effective in producing extinction of the jumping response. Again there is no difference between dogs trained for 10 and for 200 ordinary extinction trials. There are, however, several indications that this technique is more effective when preceded by the glass-barrier rather than by the shock-extinction technique. We have no data on how effective the present combined procedure would have been if introduced immediately after the ordinary extinction procedure, without the intervention of a special technique.

Summary of Results

A summary of the findings of Experiments 2, 3, 4, and 5 is given in Table 2. From this table, several generalizations are possible: (*a*) The ordinary extinction procedure is ineffective. (*b*) Either the glass-barrier procedure or the shock-extinction procedure *can* produce extinction of jumping, but the proportions of animals extinguishing are small. There is little to choose between the two procedures. (*c*) The combined procedure is the most effective. It makes little difference whether it is preceded by 200 or by 10 ordinary extinction trials. There are, however, some indications that the combined procedure is more effective following the glass-barrier procedure than following the shock procedure. Not only is this trend detectable in the proportions of animals extinguishing with each sequence, but also the trend is clearly present in the data on (*a*) number of trials required to achieve the extinction criterion, and (*b*) number of shocks in the combined procedure required to produce extinction.

TABLE 2

Proportions of Animals Extinguishing with the Various Extinction Procedures

Experiment	Special Procedure Used	After 200 Trials Ordinary Extinction Procedure	After 10 Trials Ordinary Extinction Procedure	Total
2	None	0/13	0/10	0/23
3	Glass-barrier procedure only	1/5	1/4	2/9
4	Shock procedure only	1/7	2/6	3/13
5	Combined procedure, glass-barrier procedure first	4/4	2/2	6/6
5	Combined procedure, shock procedure first	5/6	3/4	8/10

Theory

We had, in planning the extinction experiments, definite expectations about the relative effectiveness of the various extinction procedures. For the most part, these expectations were derived from the two-process theory outlined in another paper on the acquisition of traumatic avoidance learning (13).

We assumed that, in the course of acquisition, conditioned emotional reactions would be established through the process of classical conditioning, of CS-US contiguity in time. Further, we assumed that these emotional reactions would give rise to stimuli having drive properties. When an animal in our experiment was regularly avoiding the shock, he was in reality escaping from the CS, and each jump was, therefore, followed by a reduction in the intensity of the emotional response elicited by the CS. Thus, not only was the jumping response reinforced by shock termination during the escape phase of acquisition, but also by anxiety reduction during the early avoidance trials. Theoretically, we would expect that the jumping response would be reinforced on each occasion that the CS aroused anxiety and the jumping response terminated or reduced the anxiety. However, once the animal is regularly avoiding the shock, the CS is no longer followed by the US, and the temporal contiguity necessary to reinforce the conditioned emotional responses is no longer present. This dissociation of the CS and US should, according to classical conditioning principles, lead to extinction of the emotional responses in the presence of the CS. If this should occur, there should then be no basis for the reinforcement of the instrumental jumping responses; there would be no anxiety to be reduced. The instrumental response should then gradually extinguish. These formulations would predict a long course of extinction for avoidance responses because the conditioned emotional reactions would have to be extinguished before the extinction of the instrumental response would start to occur. However, extinction of the instrumental response should occur.

With such a theory in mind, we expected that the learned jumping response would continue to decrease in latency several trials after the last shock had been received. As long as the conditioned emotional response had not been extinguished, each jump in the presence of the CS would be followed immediately by anxiety reduction. According to the law of effect, the bond between the CS and the jumping response should be consistently strengthened, with a correlated progressive shortening of response latency. This, in fact, did occur. In Experiment 2, the latencies shortened over a period of about 100 trials following the trial on which the last shock was received. *But it is at this point that a real weakness in our interpretation appears.*

In a paper on the acquisition of traumatic avoidance responses we argued that the latency of the *conditioned emotional reaction* should be of the order of magnitude 1.5–2.5 seconds (13). But, after approximately 100 trials of ordinary extinction, the latency of the entire *jumping* response had in fact decreased to a mean value of about 1.7 seconds, and at the end of 200 trials of ordinary extinction the mean latency was about 1.6 seconds.

The instrumental jumping response *itself* usually has a latency of from 1.0 to 1.5 seconds at its asymptote. (Some individual animals produced latencies as short as 0.9 seconds, though very rarely.) Thus, if the animals' jumps were responses to their own emotional reactions, or if they were responding to drive arousal, the asymptote for the latency of the jumping response in the presence of the CS should have been approximately 2.4 to 3.4 seconds, i.e., the sum of the latencies for drive arousal and for jumping. But the animals were jumping faster than this within 10 to 20 trials after meeting the acquisition criterion (see Fig. 1). Obviously, the animals at this point *could not* have been responding to their own emotional reactions. The assumption that autonomic arousal serves as the stimulus for the jumping response is contradicted by the facts. The latency data indicate that, at this point, the jumping response has an extremely high habit strength and is activated by minimal drive. In any event, it cannot be argued that the jumping is energized by a *full-blown anxiety reaction to the CS.*

It is clear that either something was fundamentally wrong with our interpretation of acquisition (13), or that additional principles have been overlooked. For, once the animals are jumping in a period of time shorter than that required for the emotional reaction to take place in the presence of the CS, we can no longer argue that jumping continues to be reinforced by anxiety reduction. Then, since no further reinforcement occurs, the jumping response ought gradually to extinguish.

The data described in Experiment 2 indicate that the animals *did* become less and less emotional during the ordinary extinction trials. However, there is substantial evidence to indicate that the conditioned emotional responses which were established early in training had not, in reality, been *extinguished* at the end of 200 trials of ordinary extinction procedure. It will be remembered that most of the dogs in Experiment 3 were profoundly upset when introduction of the glass barrier first restrained them in the presence of the CS. Though, during ordinary extinction, with very short latencies of the instrumental act we see no emotional reactions, when the animals are later held in the presence of the CS by the glass barrier they demonstrate that the CS has *maintained its capacity to elicit anxiety*.

But if the emotional response has not been extinguished, what has happened to it? The effect of early reinforcements has shortened the latency of jumping to the point where, since the dog's jump removes the CS so quickly, the conditioned emotional reaction may not be elicited at all! This would save the emotional reaction from extinction, since it is no longer exercised. But, if the emotional reaction is not elicited, we are now confronted with the picture of a dog continuing to jump without further reinforcement!

The law of effect would account for the persistence of a *certain number* of jumping responses after the last reinforcement. The exact number would be a function of the amount of reinforcement received. The law of effect would then predict a lengthening of latency, leading toward extinction of the jumping response. But, *what will happen if the latency of jumping increases?* If, as we have hypothesized, the conditioned emotional reaction has not yet been extinguished, a longer latency will leave the dog in the presence of the CS for a time interval long enough for the emotional reaction to be elicited. (The glass-barrier procedure did, in fact, accomplish this.) The elicitation of the emotional response when a long latency occurs ought to lead to a jump which will in turn be followed immediately by anxiety reduction. This further reinforcement would again strengthen the bond between the CS and jumping. A cyclical mechanism of this sort, with the emotional reaction being elicited only rarely, but, when elicited, giving renewed strength to the CS-jumping bond, would account for the high resistance of the jumping response to the ordinary extinction procedure. The final extinction of jumping could begin only when the emotional reaction had been elicited often enough to be itself extinguished, or at a low strength.

We feel that the order of events which we have described is general to *all* learned avoidance responses. The picture is surprisingly akin to the clinical picture in compulsive neurosis. It contains the possibility of the organism "frightening itself" by remaining in the presence of the CS long enough for the CS to be effective, while no emotionality will be elicited with *short* latencies for *instrumental* acts. We feel that this interpretation can help us to circumvent the "dilemma of fear as a motivating force," which Eglash (1) feels is a stumbling block for anxiety-reduction theories.

This formulation suggests an interesting experiment. If the animal's jump can be delayed until *after* an emotional reaction has been elicited by the CS, and then the animal is allowed to jump, two opposing processes should go on. The habit strength of the jumping response should be augmented; but the elicitation of the emotional reaction without the presentation of the US (shock) should weaken the strength of the conditioned emotional response (anxiety). Of course, the best way to produce extinction of the emotional response would be to arrange the situation in such a way that an extremely intense emotional reaction takes place in the presence of the CS. This would be tantamount to a reinstatement of the original acquisition situation, and since the US is not presented a big decremental effect should occur. One of the main problems in extinguishing avoidance conditioning is, thus, keeping the animal in the presence of highly disturbing danger signals which are no longer followed by noxious stimulation. Usually, well-learned instrumental responses *prevent this from happening* and slow up the course of extinction. (It seems to us that the "reality-testing" procedures in psychotherapy are *partly* designed to face this problem.)

But there is a second principle, possibly just as important as the first. Extinction should be much easier to obtain if, in conjunction with the reality-testing procedure, the animal is not allowed to perform the instrumental avoidance response. Our glass-barrier procedure approximated this, since the CS was removed at the end of two minutes, and any anxiety reduction that took place was preceded in time by *responses other than jumping*. Thus, while only two out of nine of our animals extinguished in 10 days of the glass-barrier procedure, on the basis of our argument we would be forced to predict that this procedure would, in relatively few additional trials, have led to extinction for all animals. There is some reason to believe that the reality-testing procedure must approximate the acquisition situation more closely than we were able to approximate it, in order for this prediction to materialize. The behavior of the dogs was at first puzzling. It will be remembered that they were initially upset by the glass-barrier procedure, but they quickly quieted down with successive trials, and later most dogs remained in a relatively relaxed state when the glass barrier was encountered. It was surprising to see the dogs jump quickly on trials on which the glass barrier was not present when they seemed to have "learned to relax" in the presence of the CS plus the glass barrier. We feel that they learned to discriminate the two conditions, with and without glass barrier, and that each condition controlled its own response. This raises an interesting problem: after traumatic avoidance learning has taken place, how do we fashion reality-testing procedures that are indiscriminally different from the acquisition situation, so that the instrumental act can be removed? (Presumably the psychotherapist, when forcing reality testing on a patient, has learned some way of doing this, or else the patient would relapse completely on leaving the therapist's office.) We are forced to predict that the glass-barrier procedure would be far more efficient than the ordinary procedure. Furthermore, an additional experiment, in which the animal is forced to delay jumping long enough to elicit the emotional response, but is then allowed to jump, should definitely be *less* efficient than the glass-barrier procedure we have already used.

While a two-process theory forces us into fairly definite predictions about the glass-barrier, reality-testing procedure, its application to the shock-extinction procedure is by no means clear-cut. A simple Thorndikian interpretation of the shock-extinction procedure might maintain that punishment of the jumping response ought to stamp it out. The data do not support such an interpretation. (Neither do the data presented by Gwinn (2), on the use of punishment in the extinction of a running response in rats.) Only 3 of 13 dogs met the extinction criterion during 10 days of the shock-extinction procedure. The other 10 persisted in jumping, and on the average their latencies shortened. Gwinn has reported that his rats, when shocked for running, at first increased their running speed, but with additional shock trials some of them gradually extinguished, and the others were discontinued without reaching an extinction criterion.

From our point of view, the failure of the shock procedure to bring about extinction in 10 of our animals might be explained with the help of an additional assumption. In the shock-extinction procedure, we would clearly expect a few jumps on the basis of previous reinforcement of jumping. However, during the initial jumps into shock, the CS is once again followed by the US, though it is true that the jumping response intervenes between the two events. We assume that the renewed pairing of CS and US, by contiguity principles, drastically strengthens the fear reaction to the CS. At the same time, the habit strength of the jumping response should be weakened through Thorndikian action of punishment. We would then have to claim that the increase in drive more than counterbalances the decrease in the habit strength of jumping. We observed that emotionality between trials increased greatly during shock-extinction trials. The raised anxiety level probably affects the "operant level" for jumping in a shuttlebox situation. This phenomenon might overlap with the fear reaction specifically aroused by presentation of the CS.

This is clearly a dialectical argument in its present form, capable of accounting for *any* observable results! But it would not be difficult to test the formulation. Any technique which first reduces the strength of the anxiety reaction ought to increase the efficacy of the shock-extinction procedure. This follows, since the hypothetical events crucial for extinction are the lowering of drive and the lowering of habit strength. If, at the beginning of the shock-extinction procedure, drive (anxiety) is low, then the Thorndikian action of punishment can presumably take place *before* the new series of shocks can build up the intensity of anxiety in the presence of the

CS. We can then predict that if the use of punishment, increasing the anxiety level, *follows* a reality-testing procedure that is continued until the conditioned emotional reaction has diminished, it will be much more effective than if the punishment procedure *precedes* reality-testing. If, however, because of previous procedures the anxiety level elicited by the CS is fairly high at the beginning of the shock-extinction procedure, the new shock series will drive the anxiety level to a point where the decremental, Thorndikian effects of punishment cannot be observed. Thus, we can predict that *if extinction does take place with shock-extinction procedure, it must do so within very few trials, or else be extremely difficult to obtain.*

Our data are not in disagreement with these predictions. Of 10 animals who received the shock-extinction treatment before the combined treatment, two failed to extinguish during the combined procedure. Of six animals who received the glass-barrier procedure before the combined procedure, all extinguished during the combined procedure. In addition, the animals in the latter group required fewer trials of the combined procedure, as well as fewer shocks, to meet the extinction criterion. Using the shock procedure alone, those three animals which did extinguish did so in less than a dozen trials, while those who did not extinguish were jumping with short latencies after 100 trials. A more crucial experiment would have employed the shock and glass-barrier procedure in sequence, counterbalancing for order of presentation, without introducing the combined procedure. Then the sequence of glass barrier followed by shock should lead to rapid extinction.

Our interpretation of the shock-extinction procedure might be further sustained by an experiment in which the punishing shock is of low intensity. Here, the increment to conditioned anxiety might be less than the decrement to habit strength. Extinction might then take place quickly if the low-punishment procedure were preceded by the glass-barrier procedure.

The results of Experiment 5, on the combined extinction procedure, are not at odds with our theoretical discussion. This procedure, as we would expect, was more effective when it was preceded by glass-barrier treatment than when preceded by the punishment procedure. The combined procedure was effective in 14 out of 16 cases. Its effectiveness probably derives from the fact that the reality-testing procedure tends to reduce the strength of conditioned emotional reactions. This reduction offsets the increase of anxiety produced by the punishment shocks, at a time when the habit strength of jumping is being decreased through punishment. The result is extinction of jumping.

While the data of our five extinction experiments are fairly well fitted by our theoretical formulation, we are left with many points of difficulty, as well as some circular reasoning. Despite such shortcomings, the fact that the argument suggests new, independent lines of attack on the problem of extinction of traumatic avoidance learning is encouraging.

On most points, our interpretation of traumatic avoidance learning is in essential agreement with both Miller (5, 6) and Mowrer (7, 8). We agree with them that the development of the acquired anxiety drive is essential to the establishment of avoidance conditioning. We differ with Mowrer in including skeletal responses among those emotional reactions which are susceptible to classical conditioning. We differ with Miller because we feel that a one-process, S-R reinforcement theory is inadequate. We do not believe that anxiety is reinforced through the law of effect, but rather through principles of stimulus contiguity. In this respect, we tend to be more sympathetic with the views of Schlosberg (10) and of Skinner (11, 12).

In carrying out our analysis of the rather minute details of behavior of dogs in a traumatic avoidance learning situation, we were faced with several inadequacies in current theory. Our own theoretical formulations have been, for the most part, improvised to account for our own findings. They and those of Miller, Mowrer, and Schlosberg are not mutually exclusive. At present, all of the theoretical alternatives supplement each other and help to order the data on avoidance conditioning.

SUMMARY

We have described a series of five experiments in which several different procedures

were used to bring about the extinction of traumatically induced avoidance responses in dogs. These were the main findings:

1. With an ordinary extinction procedure, cessation of responding was extremely difficult to obtain.

2. A glass-barrier, reality-testing procedure was moderately effective. In this procedure the animal was detained in the presence of the danger signal without being shocked and the instrumental avoidance response was not allowed to occur.

3. A shock-extinction or punishment procedure was approximately as effective as the glass-barrier procedure. In this procedure the animal was punished for making the instrumental response.

4. A combination of the reality-testing and punishment-for-responding procedures was very effective in producing extinction. This combination procedure was more effective when preceded by reality testing than it was when preceded by the punishment technique.

These findings were interpreted from the point of view of a modified two-process learning theory similar to Mowrer's (8).

REFERENCES

1. EGLASH, A. The dilemma of fear as a motivating force. *Psychol. Rev.*, 1952, **59**, 376–379.
2. GWINN, G. T. The effects of punishment on acts motivated by fear. *J. exp. Psychol.*, 1949, **39**, 260–269.
3. MAIER, N. R. F., & KLEE, J. B. Studies of abnormal behavior in the rat. XII. The pattern of punishment and its relation to abnormal fixations. *J. exp. Psychol.*, 1943, **32**, 377–398.
4. MAIER, N. R. F. Studies of abnormal behavior in the rat. XVII. Guidance versus trial and error in the alternation of habits and fixations. *J. Psychol.*, 1945, **19**, 133–163.
5. MILLER, N. E. Studies of fear as an acquirable drive: I. Fear as motivation and fear-reduction as reinforcement in the learning of new responses. *J. exp. Psychol.*, 1948, **38**, 89–101.
6. MILLER, N. E. Learnable drives and rewards. In S. S. Stevens (Ed.), *Handbook of experimental psychology*. New York: Wiley, 1951.
7. MOWRER, O. H. Anxiety-reduction and learning. *J. exp. Psychol.*, 1940, **27**, 497–516.
8. MOWRER, O. H. On the dual nature of learning—A reinterpretation of "conditioning" and "problem solving." *Harv. educ. Rev.*, 1947, Spring, 102–148.
9. MOWRER, O. H. Learning theory and the neurotic paradox. *Amer. J. Orthopsychiat.*, 1948, **18**, 571–609.
10. SCHLOSBERG, H. The relationship between success and the laws of conditioning. *Psychol. Rev.*, 1937, **44**, 379–394.
11. SKINNER, B. F. Two types of conditioned reflex and a pseudo-type. *J. gen. Psychol.*, 1935, **12**, 66–77.
12. SKINNER, B. F. *The behavior of organisms.* New York: Appleton-Century-Crofts, 1938.
13. SOLOMON, R. L., & WYNNE, L. C. Traumatic avoidance learning: acquisition in normal dogs. *Psychol. Monogr.*, 1953, **67**, No. 4 (Whole No. 354).

Received November 21, 1952. Prior publication.