

THE EFFECTS OF DELAYED EXTINCTION, DISCRETE REINFORCERS,
AND REINFORCEMENT SCHEDULES ON THE PARTIAL
REINFORCEMENT EXTINCTION EFFECT

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Using an operant paradigm, Johnson, Harrell, and Pachman (1979) demonstrated attenuation of the partial reinforcement extinction effect (PREE) by extending the time delay between acquisition and extinction. They hypothesized that the PREE may prove to be a transient phenomenon. After training on a standard lever-press task, the authors applied an extinction procedure at delays of 1-day, 7-days, and 31-days, to four groups of rats trained under continuous (CRF) and three fixed-ratio (FR 4, FR 8, FR 12) schedules. The dependent measure was total number of responses to an extinction criterion of 5 minutes of no responding. Each extinction session was 30 minutes in length.

Johnson et al. (1979) interpreted the results as supporting a decrement in resistance to extinction for all partial groups at a 31-day delay. The mean number of responses to extinction for all 31-day delay groups were: CRF - 54.84, FR 4 - 296.83, FR 8 - 232.83, and FR 12 - 316.30. Although the CRF group remained significantly

different from the partial groups, the differences among the partial groups were no longer significantly different, when the 31-day delay groups were compared to the 1-day and 7-day delay groups. Basing their prediction on the decrease in number of responses to extinction at different time delays, and loss of significant differences among the partial groups over time, the authors concluded that "extremely long delays may result in elimination of the PREE, even after intermittent schedules with relatively infrequent reinforcements" (p. 115).

Since the late 1930s intermittent reinforcement schedules have been reported in experimental literature, with voluminous research and extensive support given to the PREE. Demonstration of the PREE is documented in journals of psychology, education, medicine, and counseling (Amsel, 1962; Borsen, 1961; Jenkins & Stanley, 1950; Kelleher & Gollub, 1962; Lewis, 1960; Robbins, 1971), and reported in psychology and learning texts (Catania, 1979; Ferster & Skinner, 1957; Hilgard & Bower, 1975; Hintzman, 1978; Holland & Skinner, 1961; Hulse, Deese, & Egeth, 1967; Keller & Schoenfeld, 1950; Mower, 1960; Rachlin, 1976; Restle, 1975; Reynolds, 1975; Swartz, 1978).

Respondent Paradigms and the Partial Reinforcement

Extinction Effect

Even respondent paradigms report investigations of intermittent pairings of the unconditioned stimulus (US) with the conditioned stimulus (CS) during conditioning, and the effects of such procedures on immediate and delayed extinction trials (Brogden, 1939, 1940; Cole, 1939; Grant & Schipper, 1952; Humphreys, 1939a, 1939b, 1940; Longnecker, Krauskopf, & Bitterman, 1952; Pavlov, 1927; Peterson, 1960; Razran, 1934, 1939; Rescorla, 1967). However, the respondent and operant procedures involve two distinct processes, each with different critical parameters. Inclusion and comparison of the two in the present study would obscure rather than clarify the specific operant - PREE relationship under question. "Respondent conditioning is an instance of stimulus control applied to stimulus-presentation operations rather than to the contingencies in consequential operations" (Catania, 1979, p. 199), as it is in operant conditioning. Most of the "available data suggest that the effectiveness of a CS diminishes rapidly with increases in the intermittency of its pairing with a US" (Reynolds, 1975, p. 112).

The Partial Reinforcement Extinction Effect in Discrete Trial and Free Operant Paradigms

Alternatively, most available data suggest quite an opposite trend in discrete trial and free operant paradigms, where increases in intermittent schedules demonstrate the PREE in most cases. A survey of this area of partial reinforcement literature reveals some characteristics in common.

One pertinent factor is the delay between training and extinction. The traditional delay has ranged from no delay to 24 hours, occasionally 48 hours. Delays beyond 48 hours occur very infrequently in the literature.

A second factor is those critical variables manipulated in studies which fail to demonstrate the partial reinforcement acquisition effect (PRAE), and/or the PREE. Three manipulated factors related to failure of PRAE are reported by Jenkins and Stanley (1950) in a review article. They are massed or spaced intertrial intervals (ITIs), sequence of continuous or partial schedules presented, and minimized secondary reinforcers. In discrete trial studies, manipulation of any or all of these three variables has led to differential results in PRAE and PREE investigations.

Critical factors in discrete trial studies. MacIntosh (1970) found that a long delay between trials (spaced trials) reduced resistance to extinction in partially reinforced (PR) rats and increased resistance to extinction in consistently reinforced rats. Sheffield (1949) had previously found in a rat study, that longer ITIs caused reduction in the PREE, and that it disappeared at longer intervals. In a second study, MacIntosh (1970) found that massed trials increased resistance to extinction for PR rats, and decreased resistance to extinction for CRF groups. Gonzalez and Bitterman (1969) found a significant PREE in spaced trials (at least 1 hour apart), only if a large reward was used. The conclusion of these discrete trial studies is that long ITIs reduce the magnitude of the PREE, in that they increase resistance to extinction for CRF training, but decrease resistance to extinction following PR training. MacIntosh (1970) stated that the "condition least favorable to a PRE would be spaced acquisition training followed by massed extinction" (p. 346).

Critical factors in operant paradigms. By comparison, the critical variables in a free operant paradigm are not identical to those in the discrete trial situation. One variable emphasized in operant designs is how to determine when the response is fully established (Branch, 1977;

Youtz, 1938). Sidman (1960) developed a steady state methodology, and emphasized detailed guidelines for the analysis of behavior in transition. The processes of acquisition and extinction are examples of behavior in transition. Such transient states are vulnerable to loss of stimulus control. Only when the transient state achieves a steady state criterion and maintains such a criterion for a period of time can learning or extinction processes be complete.

Just as massed or spaced ITIs may effect retention of the PREE, so may the sequence of continuous or partial schedules presented in training. In an operant experiment with rats, Keller (1940) investigated sequence of continuous and periodic operations, and resistance to extinction. After a short period of lever-press conditioning, subjects were divided into two groups. One group was further conditioned under an extended continuous sequence followed by an extended periodic sequence. With the second group, schedule sequences were reversed. During the first 5 minutes of extinction, the group with a continuous sequence just prior to extinction showed significantly greater resistance to extinction. After 175 minutes of extinction, neither group showed significant differences in resistance to extinction. Keller concluded that sequence of operations

may introduce a constant error if the extinction period is truncated.

The third critical factor reported by Jenkins and Stanley (1950) that can affect PRAE or PREE results, is minimized secondary reinforcers. Investigations of this factor is found in operant literature. Dutch (1974) compared FR and CRF schedules in an operant design with rats, using water as a reinforcer. The particular variable of interest was a magazine click during extinction procedures. Extinction began on the day following completion of acquisition. "The click was a weak but effective incentive for CRF subjects and a strong incentive for FR subjects. With extended training the click also became an informative stimulus for FR 10 subjects in that it reduced resistance to extinction" (p. 445).

Delay of Extinction in Operant Paradigms

The previous variables which affect PRAE or PREE results interact with the transient processes of acquisition and extinction. The critical variable in the present study occurs between these two transient phenomena; that is the delay between acquisition and extinction procedures. Some of the first operant studies incorporating a delayed extinction procedure within their designs occurred in the late 1930s.

In 1938a, Youtz investigated a 15-day delay of extinction. Rats were divided into two groups, each group receiving a different number of reinforcers. CRF schedules were used with all animals. Youtz was concerned with this question: Did an operant response show an increase in strength over time as did a conditioned reflex? Both operant and respondent responses were concerned only with continuous reinforcement procedures. During the extinction procedure, all rats at the 15-day delay showed a greater number of responses (lever presses) than did the comparable 1-day delay groups. Youtz hypothesized loss of habituation to the total experimental situation over time, which showed a functional similarity between an operant response and a conditioned reflex response.

In another experiment using the same basic design, Youtz (1938b) employed three time delays, immediate, 24 hours, and 55 days. One additional variable entering into this study is spontaneous recovery, since Youtz applied the extinction procedure to all groups at each time delay. The 24-hour extinction curve showed the typical characteristics of spontaneous recovery as recorded in the literature (Hulse, Deese, & Egeth, 1967). However, the 55-day extinction curve showed effects of spontaneous recovery, and an additional factor. There was greater recovery than

predicted at the 55-day delay. Although Youtz did not specifically identify the additional factor, his hypothesis from the earlier study, loss of habituation to the total experimental situation over time, was his general conclusion.

Also in 1938, Skinner employed a 45-day delay between conditioning and extinction of an operant response while investigating memory in rats. The basic design was conditioning a CRF lever-press response, with no extinction procedures until 45 days after acquisition. The resulting extinction curves at 45 days were about the same as those with no time delay before extinction procedures. He concluded that no forgetting occurred during the time delay. One relevant factor Skinner considered in the study was that "aging was a problem if the period of retention was much longer than 45 days" (p. 92). Amsel and Chen (1976) also considered varying age a relevant factor in predicting immediate and long-term persistence in rats.

In the Youtz and Skinner experiments, delayed extinction procedures failed to show decrements in responding for rats on CRF schedules. Youtz even found increases in response strength after time delays.

In other studies investigating retention, Skinner (1960, 1979) overcame the aging factor of rats by using

pigeons, which live for decades. Extinction delays of 6 months, 1 year, 2 years, 4 years, and 6 years were used.

He used

birds with a long history of a . . . subtle visual discrimination on a variable-ratio schedule of reinforcement. At six months the birds responded accurately to the visual discrimination and showed a large extinction curve that demonstrated the original behavior to be essentially intact. [At 1 year, 2 years, 4 years, and 6 years,] all [birds] struck the target accurately although the extinction curves were smaller. [Skinner] published one curve showing retention of the target behavior after 4 years. It contained 700 responses, which [he] estimated, . . . as from one-half to one-quarter of the responses that would have been emitted 4 years earlier. [Skinner] ran remaining pigeons after 6 years and got small extinction curves even then. (Skinner, 1979, p. 368)

In the retention experiment by Skinner, delayed extinction procedures failed to show decrements in responding at 6 months using pigeons on VR schedules. At 2, 4, and 6 years increasing decrements in total number of responses

became evident. The visual discrimination showed no decrement at the 6-month, 1-, 2-, 4- or 6 year extinction delays.

Youtz (1938a, 1938b) hypothesized loss of habituation to the total experimental situation over time, to explain increases in response strength after long extinction delays. A similar hypothesis could be applied to the resulting VR rate decrements over time found by Skinner, if loss of habituation means loss of stimulus control, or a reconditioning process rather than a forgetting process. Then both the rats' decrement and no decrement in accuracy of the visual discrimination, which occur simultaneously, are explained. Evidently, extended delays interact differentially with CRF and PR schedules, and affect different dependent measures differentially.

A relevant study by Aiken and Gibson (1965) employed a 21-day extinction delay. Rats on CRF and FR 5 schedules lever-pressed for food pellets. After acquisition, the rats were divided into four groups. One CRF group and FR group underwent extinction procedures at a 1-day delay, and the remaining CRF and FR groups at a 21-day delay. The "extinction measures were rate of responding in the first 35 minutes of extinction and the total number of responses to a criterion of 10 minutes without responding"

(p. 528). Analysis concentrated on the rates of responding for the first 35 minutes rather than on the total number of responses because there was great variability in the times to extinction. The FR 5 groups had an average rate of about 7.0 at the 1-day delay, and 6.2 at the 21-day delay. The CRF groups had an average rate of about 4.0 at the 1-day delay, and 5.0 at the 21-day delay. Observing the CRF increase and FR decrease in response rates after extended extinction delays, the authors interpreted the results in "terms of changes over time in the stimulus generalization gradients of the stimuli controlling the behavior chains associated with the two reinforcement schedules" (p. 527). Once again, an extended extinction delay has interacted differentially with continuous and intermittent schedules. The great variability in the dependent measure, number of responses to extinction, possibly reveals an imprecise extinction criterion definition. The second dependent measure, number of lever-presses for the first 35 minutes of extinction (a rate measure), is a behavior in transition. Analyzing a behavior in transition before the process may be complete, may not accurately represent final results.

Complications also arise in attempting interpretation of other discrete trial and operant studies containing

delayed extinction procedures. The delays are often incidental other variables in complex designs.

Gleitman and Bernheim (1963), and Gleitman, Steinman, and Bernheim (1965) investigated 24- and 25-day extinction delays in two operant studies employing fixed-interval (FI) schedules with rats. Since the general characteristics of FI schedules are lower response rate in acquisition and maintenance, with smooth extinction curves, attenuation of FI schedules would be reflected in higher response rates in initial stages of extinction, and rough wavy extinction curves. The results of both studies reflected such, showing

an increase in response strength if what was learned originally involved the suppression of a response. [A] longer retention interval led to a rise in the first-half ratios [of ITIs] when compared to either control groups. (1965, p. 462)

Sidman (1956) addressed a similar question in an operant paradigm while investigating variable-interval (VI) schedules with rats. He concluded that a rise in ITI first-half ratios were due to establishment of time discrimination, and that a forgetting hypothesis was inadequate in explaining the results.

Generalization Gradients, Delayed Testing, and Learning Curves

Another area of research involving complex discrimination variables is studies concerned with generalization gradients and delayed testing. Thomas and Lopez (1962) investigated the effects of delayed testing on generalization slopes with pigeons using a compound FR-VI schedule in an operant design. Successive extinction procedures were applied at delays of 1 minute, 24 hours, and 1 week. There were no significant differences between the 24-hour and 1-week generalization slopes, while small but significant differences from the two occurred in the 1-minute slope. Although the extinction delays were applied to all groups, the fact that the 24-hour and 1-week slopes remained relatively identical supports a long term retention prediction for complex visual discriminations. Skinner's (1960, 1979) pigeon experiments in retention agree with Thomas and Lopez's (1962) results, that long-term retention of complex visual discriminations remains intact.

Investigating generalization gradients in a runway experiment with rats, Perkins and Weyant (1958) delayed testing for one group at 60 seconds and for another at 1 week. They found greater speeds for delayed test groups than for comparable 60-second groups. Interpretation of

their results is complicated by the addition of an altered stimulus condition in testing.

The generalization studies point to possibly two different processes, short-term retention and long-term retention. A complex visual discrimination in pigeons might retain its accuracy over a long time period, while the response rate of that discrimination diminishes over time.

Learning curves are another source of retention over time. Ebbinghaus' classical forgetting curve shows great persistency of long-term memory at 31 days, if the short-term memory losses are overlooked (Catania, 1979, p. 321).

Reinforcers as Crucial Factors

Other variables of possibly crucial importance in assessing the PREE and delayed extinction procedures, are types of reinforcers and their manipulation. MacDonald and Toledo (1974) compared food and water reinforcers in two experiments assessing PREE in rats.

In both experiments, there was greater persistence of behavior which had been reinforced with food than with water. In [Experiment] 2, the [PREE] was observed with food reward, but not with water. (p. 288)

A free operant design was used in Experiment 1, and a discrete trial design in the second. CRF and VI 60-second schedules were used, with 12 daily extinction trials beginning 1 day after training. No overall correlation was evident in either experiment between acquisition rate and extinction rate.

In 1968, Ison and Rosen used sucrose in a straight runway acquisition design. CRF and PR schedules, percent of sucrose solutions, and number of training trials were varied. After acquisition was complete, 40 extinction trials followed, and then 16 reacquisition trials.

Both acquisition and extinction performances were increased by larger values of the acquisition variables. Reacquisition performance was positively related to reacquisition magnitude. (p. 375)

Such results are not in complete agreement with studies that manipulate magnitudes of food reinforcers. The authors stated that critical variables vary so much among relevant experiments that "it is impossible to isolate the particular constellation of values which may consistently produce interacting functions" (p. 378), without much further and more exhaustive research.

Young, Favret, and Keyes (1975) also used sucrose as a reinforcer when investigating the PREE. In a mixed design, rats ran down a runway on a PR schedule and pressed a lever in the goal box on a PR or CRF schedule. The extinction procedure was applied to half the subjects in the runway, and half on the lever.

Results show that for subjects extinguished on the lever the PRE was a function only of the lever reinforcement schedule and was independent of the runway schedule. However for subjects extinguished in the runway, PR runway-trained subjects receiving CRF leverpress training were more resistant to extinction than were PR runway-trained subjects receiving PR leverpress training. [Results indicated] that there is no transfer of the PRE from one response to another even in the same general experimental situation. (pp. 181-182)

Using basically the same design as above, Young, Favret, and Blakney (1976) extinguished rats immediately and successively for 3 days, and equated reinforcement for CRF and PR groups.

Results showed that subjects that received CRF on the lever were significantly more resistant to extinction than were subjects that received PR

on the lever. . . . [They hypothesized] that a nonreinforced runway run produces a greater frustrative reaction when lever reinforcement is under conditions of CRF. (p. 314)

After surveying the water and sucrose studies, the effects of liquid reinforcers upon the PREE remain uncertain. No apparent studies have combined PREE, delayed extinction, and saccharin reinforcers in an operant paradigm with rats. General information on saccharin solutions in rat studies is found in articles by Beebe-Center and Waddell (1948), Sheffield and Roby (1950), and Foster (1968). Beebe-Center and Waddell stated that the "saccharin solution most preferred by rats was 1.3 g/liter" (p. 517). Foster supported earlier findings by Sheffield and Roby that "saccharin preference does not extinguish in the absence of the 'primary reinforcer'" (p. 82). Saccharin solutions might prove to be viable reinforcers in investigating the parameters in question.

Purpose of the Study

The purpose of this study was to identify conditions under which delayed extinction will and will not produce attenuation of the PREE. Within an operant paradigm, a PREE was expected in delayed extinction with saccharin water reinforcer used with rats. And within the same

experiment, under similar conditions, attenuation of the PREE was expected with plain water used as a reinforcer.

Possible Hypotheses and Theoretical Explanations

After considering particular design parameters and viable reinforcers used in investigating PREE and delayed extinction, several distinctions were made before forming hypotheses to explain the expected results of this study. One such distinction was the difference between forgetting and extinction, which the extended time delays incorporated in the design.

[T]hree processes which assure . . . that behavior will be dropped—either temporarily or permanently—from the response repertoire of an organism are: (1) forgetting, (2) punishment and the application of aversive stimulation, and (3) extinction. . . . Extinction can be operationally defined as the removal of reinforcement following the occurrence of some response that has been reinforced in the past. . . . Spontaneous recovery appears when time is allowed to elapse . . . between successive sessions or periods of extinction. . . . [T]he amount of recovery depends upon the duration of the time

interval: the longer the time interval, the greater the recovery. (Hulse, Deese, & Egeth, 1975, pp. 106, 113).

It was hypothesized that if the extinction process was consistently repeated, the response or spontaneous recovery of the response, would eventually stop occurring.

[T]he "extinction procedure" consists of allowing the response to occur without reinforcement after it has been conditioned. If the extinction procedure eliminates a response, then extinction behavior has occurred.

Forgetting is supposed to be a decrease in the likelihood that a response will occur as a result of that response's not having been made for a longer period of time. . . . [T]he forgetting procedure consists of preventing a response from occurring for a period of time [by removal of a conditioned stimulus] after it has been conditioned. . . . When this forgetting procedure eliminates a response, forgetting has occurred (Whaley & Malott, 1971, p. 49).

Forgetting is a process that involves "operations common to all memory systems, . . . encoding, storage, and retrieval. . . . [F]orgetting may be due to a failure of

any of the three operations of a memory system" (Hulse, Deese, & Egeth, 1975, pp. 335-336). Presence of the conditioned stimulus is assumed.

Forgetting and extinction behavior are similar in that they both consist of a decrement in the rate of the response. They are different in that forgetting is due to lack of opportunity to respond and extinction is due to responding without reinforcement. (Whaley & Malott, 1971, p. 49)

It was hypothesized in this study that the two processes of forgetting and extinction would not confound the results because each group would be under essentially similar conditions except for the manipulated dependent variables which were not related to proactive or retroactive interference phenomena. Whether the forgetting procedure involves a passive decay process or an active interference from environmental and behavioral variables is still debatable in experimental literature.

In clarifying the expected results of this study, many existing theories and hypotheses could explain possible attenuation of the PREE after delayed extinction procedures. That differential forgetting occurred across groups addresses attenuation of the PREE and extended extinction

delays; not whether forgetting occurred or not. Since little or no attenuation of the PREE did occur in some groups, two general theoretical approaches in experimental literature might account for the forgetting aspect of the phenomenon. Trace theories assume a passive decay process and have implicit neurological bases. Disuse and perseveration-consolidation theories are of this nature. Neo-Hullian theories would generally be trace theories. Interference theories in explanation, more often rely upon competition among different responses by environmental and behavioral variables and procedurally do not rely on memorial explanations. Guthrie's theory of forgetting is an interference theory.

Almost all experimental studies from which such forgetting theories derive support, concern short-term memory, whereas delayed extinction procedures clearly concern a long-term process. Whether short-term and long-term memory are two different processes or extremes on a continuum still remains debatable. Forgetting may be an imprecise label for the processes in question.

Proactive and retroactive interference are certainly active processes which contribute to the forgetting phenomenon. Proactive interference was investigated by Underwood (1957), and Underwood and Postman (1960). Their studies

showed a

substantial amount of forgetting could be attributed to proactive interference from related material learned earlier. . . . Perhaps there would be little forgetting or no forgetting at all if it was not for proactive interference [and] retroactive effects. (Catania, 1979, p. 323)

Although human subjects and verbal material were used in the Underwood studies, an extended application of their hypothesis to rats in a lever-pressing procedure could be made. What related experiences does the rat have prior to, during, and after experimental procedures? Or, what response topographies, response classes, and reinforcer histories already exist? What happens to a conditioned operant response during the time of delayed extinction? Is the response prevented from occurring in the absence of discriminative stimuli (a forgetting procedure), or does it occur in some form (an extinction or learning procedure)? Consider the rat's movements during an extended delay of extinction. The topography of the lever press response is not occurring, but the consumatory response still occurs. The animal orients to the food, grasps it, and consumes it—and reinforcement is continuous. During an extended delay of extinction, the end chain of

the conditioned response may interfere with the particular experimental schedules, and intermittent schedules may lose intermittent characteristics.

In this study, a reinforcer was used during conditioning that the subject had no contact with prior to and during the extinction delay; thus the retroactive and proactive interference effects attributable to reinforcer history were minimized. By using a saccharin reinforcer this study expected substantial retention of the PREE after delayed extinction.

Method

Subjects

Subjects were 56 male Long-Evans rats, weighing approximately 250-300 g when deprivation began. Throughout the experiment all animals had free access to food pellets in their individual cages. Seven days prior to training all rats were handled daily for 1 minute, weighed, and watered for 15 minutes.

Apparatus

Two operant conditioning chambers, each with a water dipper and a retractable lever, were individually housed in sound attenuating enclosures. Electromechanical modules programmed schedules and recorded the number of reinforcements and responses per animal. Cumulative recorders also recorded individual rates.

Procedure

The study was run in three replications. No reinforcement contrast was involved. Within a single replication, one-half of all subjects received plain water, and the remaining one-half received saccharin water at a 1.3 g/liter solution. Each of these two groups were further subdivided into two groups, one run on a CRF schedule, the other on an FR schedule. By the end of acquisition training, four distinct groups had been formed: CRF-water, CRF-saccharin water, FR 20-water, FR 20-saccharin water.

The beginning and ending of a session were defined as presentation and retraction of the lever. One reinforcement equaled .01 ml. Training consisted of one daily session, with the number of lever presses balanced (200 per session), and a 23-hour water deprivation balanced across groups. After each session, and a 10-minute delay, each animal received water ad lib for 10 minutes.

Habituation, dipper and magazine training began after seven water deprivation days. For 5 days each rat was placed in the chamber. The session began with the lever extending and an immediate VI 30-second schedule commencing. After approximately 25 reinforcement opportunities the session ended. On the sixth day each subject was placed in the chamber. Fifty of 56 subjects began spontaneous

lever pressing within a 10-minute period. The remaining six rats received manual shaping sessions until the lever-press response was occurring spontaneously approximately five sessions later. An attempt to balance the total number of reinforcers received by each animal was made. When all animals were responding, CRF acquisition schedules began. All animals were run for 15 days on CRF schedules.

On the 16th day one-half of both reinforcer groups (water and saccharin) were shifted to FR schedules. The remaining animals continued on CRF schedules through acquisition, receiving 200 reinforcers per daily session. The FR schedule was 4, 5, 7, 8, 9, 10, 11, 13, 14, 15, 17, 18, and 20. When FR 20 was reached, all FR subjects were run 5 days on the FR 20 schedule to establish a stable rate approximating the stable rate present in the CRF groups. CRF and FR groups were balanced by number of responses made per session rather than number of reinforcers.

Those animals assigned to 1-day extinction procedures underwent extinction 24 hours after the last acquisition day. The number of lever presses during the extinction session was recorded every 15 minutes for the total of a 90-minute extinction session. The 45-day extinction groups underwent similar extinction procedures, 45 days

after the last acquisition day. The delayed extinction animals were maintained in their individual living cages on ad lib food and water, until the water deprivation schedule began on Day 38. The same general water deprivation procedures were followed as were earlier in the study.

Results

The dependent measure assessing resistance to extinction was the total number of lever presses during a 90-minute extinction session.

The results revealed slight increases in the total number of responses for FR saccharin and CRF saccharin groups after a 45-day extinction delay, when compared to similar groups at 1-day extinction delays. All water groups at the 45-day extinction delay showed slight attenuation in total number of responses when compared with 1-day extinction groups. Although such results were hypothesized, the three-way interaction did not reach a level of significance. The great variability, evident in the group means and standard deviations in Table 1, can possibly account for this.

The data were analyzed using a three-way analysis of variance (ANOVA) (see Table 2). Significant main effects were found for Schedule ($F = 62.81$, $df = 1/48$, $p < .0009$)

Table 1
Means and Standard Deviations for Total Number
of Extinction Response for All Groups

Group	<u>M</u>	<u>SD</u>	<u>N</u>
For Entire Population	343	226	(56)
Time Delay (1-day)	326	200	(28)
and Reinforcer (water)	287	164	(14)
and Schedule (CRF)	173	39	(7)
and Schedule (FR)	401	162	(7)
and Reinforcer (saccharin water)	365	231	(14)
and Schedule (CRF)	171	58	(7)
and Schedule (FR)	559	156	(7)
Time Delay (45-day)	360	251	(28)
and Reinforcer (water)	258	169	(14)
and Schedule (CRF)	155	77	(7)
and Schedule (FR)	362	177	(7)
and Reinforcer (saccharin water)	461	284	(14)
and Schedule (CRF)	257	162	(7)
and Schedule (FR)	666	224	(7)

Table 2

Three-Way Analysis of Variance:

Total Number of Extinction Responses

Source	<u>df</u>	<u>MS</u>	<u>F</u>	<u>p</u>
Time Delay (A)	1	16,082	0.76	.388
Reinforcer (B)	1	275,380	13.02**	.001**
Schedule (C)	1	1,328,404	62.81***	.000***
A X B	1	55,125	2.61	.113
A X C	1	0	0.00	.999
B X C	1	114,573	5.42*	.023*
A X B X C	1	1,554	0.07	.788
Error	48	21,149		
Total	55			

* $p < .05$.

** $p < .01$.

*** $p < .001$.

and Reinforcer ($F = 13.02$, $df = 1/48$, $p < .001$). The main effect of Time Delay was not significant ($F = .76$, $df = 1/48$, ns). The main effect of Time Delay revealed no significant differences between the 1-day and 45-day extinction groups, due to the combined interactions of reinforcers. The two-way interaction produced one significant interaction. Schedule X Reinforcer ($F = 5.42$, $df = 1.48$, $p < .02$). The Reinforcer X Time Delay interaction ($F = 2.61$, $df = 1/48$, $p < .11$), the Schedule X Time Delay interaction ($F = 0.00$, $df = 1/48$, $p < .99$), and the three-way interaction ($F = 0.07$, $df = 2/48$, $p < .79$) were not significant.

Discussion

The differential effects of unique reinforcers and reinforcer history were evident, but they did not have the hypothesized effects upon the PREE. Saccharin water did prove to be a viable reinforcer while investigating the parameters in question, although the results did not reach significance in relation to the PREE. The PREE did not attenuate for the saccharin animals. In fact, this dependent measure showed a slight increase. Thus the PREE may not be a transient phenomenon under these experimental parameters. Slight attenuation of the PREE did occur with the plain water groups.

In a previous study, Johnson, Harrell, and Pachman (1979) hypothesized that the PREE was a transient phenomenon, and their results supported their hypothesis. After a 31-day delay, animals trained under partial schedules showed PREE attenuation. Only in part did this study support Johnson et al. (1979), and that support came from the plain water groups. Johnson et al. (1979) used food pellets as reinforcers. Perhaps the types and magnitude of the reinforcers are critical factors as the Ison and Rosen (1968) and MacDonald and Toledo (1974) studies suggested. Gonzalez and Bitterman (1969) only found significant PREE when using large reward. The saccharin water groups of this study may have been receiving supranormal reinforcer.

Most literature surveys documenting discrete trial and free operant paradigms do support the PREE. One variable often emphasized in free operant designs is how to determine when the response is fully established (Branch, 1977; Sidman, 1960; Youtz, 1938). This present study revealed great variability in individual subject and group rates. Determining a stable rate definition for both CRF and FR groups was tenuous.

Another factor contributing to the results of this study was the duration of the extinction session at 90

minutes. Since every subject, with the exception of two, was still responding after the 90-minute duration, the conclusions reached by Keller (1940) may still be relevant. Keller extended extinction sessions to 175 minutes, and concluded that sequence of operations may introduce a constant error if the extinction period is truncated. Perhaps the 90-minute extinction session was not of sufficient duration. Aiken and Gibson (1965) also reported great variability in time to extinction, which further enhances the possible relevance of this factor.

Few studies documented in the literature have extended the time delay between training and extinction beyond 24 or 48 hours. In 1938a, Youtz investigated a 15-day delay of extinction posing the question: Did an operant response show an increase in strength over time? All rats at a 15-day delay showed a greater number of responses when compared to 1-day delay groups (all groups were on CRF schedules). This study, which extends the time delays to 45 days, partially supports the Youtz (1938a, 1938b) studies, since all saccharin water animals at a 45-day delay showed a greater number of responses when compared to 1-day saccharin groups. However, all plain water groups showed the opposite trend. Youtz used

food pellets as reinforcers. Water may be a weak reinforcer without the additional saccharin enhancement.

In another operant study which extended the time delay between conditioning and extinction to 45 days, Skinner (1938) investigated memory in rats and concluded that there was no forgetting. The resulting extinction curves at 1-day and 45-day delays were about the same. In the Youtz (1938a, 1938b) and Skinner (1938) experiments, delayed extinction procedures failed to show decrements in responding for rats on CRF schedules. While the reinforcer used in their studies was a solid rat chow, and the reinforcers in the present study were plain water and saccharin water, this study does partially agree with their results. Some of the same uncontrolled factors relevant to internal validity were posed in the Skinner (1938) and Youtz (1938a, 1938b) studies as were evident in the present study: history, maturation, instrumentation, etc. Even in other similar retention experiments, Skinner (1979) found the same differential results.

One explanatory hypothesis which did emerge from Skinner's (1938, 1979) experiments in extinction delays might also be relevant to this present study. If loss of habituation means loss of stimulus control, rather than a forgetting process, then both the small rate decrement in

this study's plain water animals and the small increase in the saccharin groups can be so interpreted.

This study was concerned with long-term memory, which remains an area little investigated and documented in the literature. Catania (1979), Underwood (1957), and Underwood and Postman (1960) have explored long-term memory with human subjects. This study attempted to extend some of their hypotheses to rats in a lever-pressing procedure. Since little or no attenuation of the PREE occurred, perhaps this study did substantially eliminate proactive interference and retroactive effects that contribute to the phenomenon of forgetting.

The purpose of this study was to identify conditions under which delayed extinction will and will not produce attenuation in the PREE. Since the results demonstrated trends in the expected directions which were not statistically significant, the contribution to and expansion of knowledge in this area remains limited. However, this study is one of the first that combines water and saccharin water reinforcers, PREE, and delayed extinction in an operant paradigm with rats. In any future research using similar variables and design, those uncontrolled factors relevant to internal validity, even external validity, are not to be underestimated. Possible factors

contributing to the great variability in this study were: uncontrolled humidity and temperature, multiple replications, equipment malfunction, and variability in individual subject operant rates.

The possible hypotheses and theoretical explanations offered to interpret the expected results of this study are still valid. The distinction made between forgetting and extinction dealt with operational definitions and may be a matter of semantics. Within an experimental realm, the procedures do differ. Whether the processes differ remains a moot question: Is it a passive decay process (time dependent), or active interference from environmental and behavioral variables (cue dependent)?

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