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The Effect of Number of Reinforcements and Post-Extinction Interval on Spontaneous Recovery¹

EARL D. SCOTT AND DAVID L. KNUTSON

Abstract. Thirty hooded rats were trained in a Skinner box to press a bar to obtain a food reinforcement. Half of the subjects received 30 reinforced trials in training and half received 60 reinforcements. The response was extinguished to a criterion of 10 minutes without the occurrence of a response. Subjects from each of the reinforcement groups were equally divided and assigned to the three post-extinction test groups. One group was tested for spontaneous recovery 24 hours after extinction, the second was tested 48 hours after extinction, and the third group 72 hours following extinction. The only variable found to be significantly related to spontaneous recovery was number of reinforced responses in training, with greater number of reinforcements resulting in increased spontaneous recovery.

Numerous authors have commented on the dearth of experimental work related to spontaneous recovery (Underwood, 1953; Hartman and Grant 1960; Murphy et al., 1956). Most textbooks still refer to Pavlov when discussing the phenomenon, therefore, a series of parametric studies were planned, the first of which is here reported.

Pavlov (1927) believed that responses would spontaneously recover 100% of their strength if sufficient time lapsed between extinction and the test for spontaneous recovery. Murphy, Miller, and Finocchio (1956) found some monkey subjects showed recovery, in some cases over 100%, 200 days after extinction; other monkeys displayed no recovery of response strength after this period. Similarly, Lewis (1956) and Howat and Grant (1958) found greater spontaneous recovery the longer the interval between extinction and test for recovery.

The evidence concerning the effect of number of reinforcements during training is contradictory. Williams (1938) reported more spontaneous recovery with greater number of training trials; however, Prokasy (1958) found increased resistance to extinction but diminished spontaneous recovery with greater numbers of training trials.

The present experiment was designed to evaluate the effect of two main variables on spontaneous recovery: (1) the number of reinforced responses, 30 vs. 60; (2) the length of post-extinction

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delay, 24, 48. and 72 hours; and (3) incidentally, the relationship of number of extinction responses to spontaneous recovery.

The experiment originally was that of a 2 x 3 factorial design, but as pointed out below, a parametric analysis of variance was not carried out.

METHOD

Apparatus: A Skinner box, a Lehigh Valley Test Chamber, model No. 1316, was used with the appropriate operant conditioning control panel for the continuous schedule and time intervals as described below. Depression of the response bar resulted in the automatic delivery of a 45 mg. Noyes pellet.

In the test chamber a house light was always on, and approximately one inch above the response bar a stimulus light was on when a bar depression would result in reinforcement. When the bar was pressed the light went out and stayed out for 5 seconds during which time additional bar presses would not result in the delivery of additional food pellets, thus preventing S from making a number of rapid presses and piling up numerous food pellets.

Subjects: The Ss were 30 hooded rats, 19 males and 11 females, varying in age from 90 to 150 days.

Procedure: Subjects were randomly assigned to one of the six experimental conditions, five Ss to each experimental condition. The experimental groups thus formed were given a two-number designation, e.g., Group 30-24 made 30 reinforced responses in training and were tested 24 hours after reaching the extinction criterion, for spontaneous recovery. The assignment of subjects to experimental conditions is indicated in Table 1. The subjects were put on a 24 hour feeding schedule, being fed for

Table 1. The Experimental sub-groups and the number of subjects assigned to each

		Post-extinction Delay (Hours)		
		24	48	72
Number of	30	5	5	5
Reinforced Responses	60	5	5	5

one hour at the same time each day in a special feeding cage. On the fifth day of the schedule at the time feeding usually started, the training of the bar pressing response was initiated. When training was begun, 10 reinforcements were given by the experimenter by manually activating the reinforcement mechanism, shaping the bar pressing behavior so far as possible with 10 reinforcements. Subjects were then left in the apparatus until 30 reinforced responses had been made. Groups receiving only 30 reinforcements went immediately into extinction training

upon making the 30 reinforced responses. Groups receiving 60 reinforcements were removed from the apparatus, placed in the feeding cage and fed for one hour on their first day of training; on the second day of training, they again remained in the test chamber until an additional 30 reinforcements had been obtained, then were immediately subjected to extinction. During extinction the stimulus light immediately over the bar was off for all subjects. When the extinction criterion of 10 minutes with no response was met by an S, it was fed for one hour in the feeding cage, then returned to the living cage.

For Groups 30-24 and 60-24 the test for spontaneous recovery began 24 hours from the time the extinction criterion was met. All other groups were put on a 24 hour feeding schedule, the exact time of feeding being determined by the time they had completed extinction, until the appropriate time for their spontaneous recovery test period.

The testing situation for spontaneous recovery was exactly the same as that for extinction, i.e, stimulus light was off and there was no reinforcement. The criterion for extinction was also used during the test for spontaneous recovery. The extent of spontaneous recovery was determined by the number of responses made until 10 consecutive minutes had passed with no response being made.

RESULTS AND DISCUSSION

Due to the small number of subjects in each sub-group and the nature of the dependent variable measure, number of bar presses, it was decided to use nonparametric techniques for the analysis of the data in order to avoid making the required assumptions for the usual analysis of variance. The Kruskal-Wallis (H) Test (Seigal, 1956) was used to determine the effect of the main variables on spontaneous recovery.

For the post-extinction intervals of 24, 48, and 72 hours respectively, the average number of responses given in spontaneous recovery was 132.5, 181.5 and 151. The Kruskal-Wallis Test revealed that the differences between these groups were not significant, ($H = 2.29$; $p = .50$).

For the two reinforcement groups, 30 and 60 reinforcements, the mean number of responses in spontaneous recovery was 143 and 322 respectively. The Kruskal-Wallis Test was performed, and the difference between these groups was very significant, ($H = 68.37$; $p < .001$). Thus, the amount of training significantly affects spontaneous recovery, but the interval between extinction and test for spontaneous recovery does not.

Concerning extinction data, it was found that the 60 reinforcement group gave significantly more responses in extinction than did the 30 reinforcement group, ($H = 15.897$; $p < .001$). This finding added to the fact that the 60 reinforcement group also gave more responses in spontaneous recovery, suggests a positive relationship between number of extinction responses and number of spontaneous recovery responses, therefore, an overall Spearman rank correlation was computed. A rho of .80 was obtained which was significant at less than the 1% level of confidence. A rank correlation coefficient was then computed for each of the reinforcement groups separately. For the 30 reinforcement group rho was $-.29$, and for the 60 reinforcement group rho was $.18$, neither of which was significant. It was concluded that the overall correlation of $.80$ was due to the greater number of responses, in extinction and spontaneous recovery, made by the 60 reinforcement group, and not to any general relationship between number of extinction responses and spontaneous recovery responses.

The results of this experiment do not substantiate the findings of Ellson (1938), Lewis (1956), or Howat and Grant (1958), that there is an increase in amount of spontaneous recovery with increased intervals between extinction and the test for spontaneous recovery. Two differences in experimental procedure may, with further investigation, account for this divergent result: (1) While Ellson used a bar pressing response in his experiment, Lewis employed a runway and Howat and Grant conditioned the eye lid response. Spontaneous recovery may occur differently with different response measures. (2) The different post-extinction intervals used by Howat and Grant, and by Ellson were measured in minutes. Lewis used two intervals 20 minutes and 24 hours. Further research may show that greater amounts of spontaneous recovery are obtained with increased post-extinction intervals only when all intervals used are relatively brief.

In opposition to the results reported by Prokasy (1958), but in agreement with Williams (1938), it was found that greater numbers of reinforced responses produced significantly greater amounts of spontaneous recovery. Prokasy also reported a significant negative relationship between number of extinction responses and spontaneous recovery responses. As with most other variables related to spontaneous recovery the resolution of these conflicting reports awaits the collection of additional data, since available information is so meager.

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Bar Press Behavior Reinforced by Pup Retrieval¹

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Abstract. A method was developed to test the reinforcing effects of pup retrieval on the behavior of lactating female rats. A modified bar press chamber was employed. One section of the chamber served as the nest area for the mother and young. The female was taught to bar press in order to be admitted to a retrieving area containing a pup which the female could retrieve and return to the nest. The results indicated that high and sustained rates of bar pressing could be obtained using pup retrieval as the reinforcing event. The data obtained using this method were discussed in relation to bar press conditioning employing conventional reinforcers.

Part of the maternal behavior pattern in the rat consists of retrieving pups that are found outside the nest. Some combination of stimuli which the pup presents is sufficient to evoke this response, which consists of the female leaving the nest, approaching the pup, grasping it with the teeth behind the head, and depositing it back in the nest area. The retrieving response persists in most lactating females up until about the time the pup's eyes are opened. At this developmental stage, the pups are capable of considerable locomotion and the female typically ceases any vigorous retrieving activity.

The retrieving response, as well as other aspects of the maternal pattern, has been of continuing interest to students of animal behavior, who have investigated many of the variables which control or influence it. In the present work, a technique was devised for studying the reinforcing properties which an opportunity to retrieve the young may provide.

The first attempt was to bring the retrieving response under the control of a light. This was done by pairing light onset with the opportunity for pup retrieval. The time between light onset

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