SPONTANEOUS RECOVERY FOLLOWING ELIMINATION OF THE REST PERIOD

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Abstract

Previous studies have demonstrated that stimuli associated with the onset of acquisition training sessions result in greater response strength following extinction than do other stimuli presented more frequently during training. The present study investigated the suggestion that the normal operation for spontaneous recovery, i.e. a rest period between the extinction and test phases, may be only one of an almost infinite set of operations which will lead to the apparent increase in response strength associated with spontaneous recovery. Pigeons (48 in 4 groups of 12 S's) were given 5 daily acquisition sessions of 20 trials each. On day 6, all birds were extinguished to the dominant stimulus. The 4 groups received: 1) training and test with the dominant stimulus, 30 minute rest (standard SR group); 2) training with the dominant stimulus and test with the distinctive stimulus, no rest (disinhibition group); 3) training with a first trial distinctive stimulus and test with that distinctive stimulus, 30 minute rest; and 4) training with a first trial distinctive stimulus and test with that distinctive stimulus, no rest. Response frequency during the test phase was greatest for groups 3 and 4, while responding was almost completely absent for

group 2, the "disinhibition" group. The results are seen as supporting the view that the phenomenon of spontaneous recovery is not dependent upon a rest period, but rather on any cue of first trial distinctiveness.

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Figure 1. Response frequency during the SR test trial as a function of testing with either the "dominant" or the "distinctive" CS. (from Burstein & Moeser, 1971.)

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Introduction

Spontaneous Recovery Following Elimination of the Rest Period

The phenomenon of spontaneous recovery has typically been defined as "the return in strength of a conditional response, whether partial or complete, brought about by [a] lapse of time following its diminution by extinction" [italics added] (Kimble, 1961). Such definitions emphasize the often dramatic differences in response strength obtained between two consecutive trials during an extinction series if a rest period is inserted at the end of an extinction phase; i.e. between the last extinction trial and the first spontaneous recovery test trial. The rest period has come to be used as a test for the differences in residual effects produced by variations in the extinction procedure (e.g. massed vs distributed extinction, "below zero" extinction), while the phenomenon of SR itself has been used to test for the "effect of time" on extinction and thus to obtain insight into the nature of extinction. Typical explanations of "the effect of time" are that a fatigue-like state which has built up during extinction dissipates with time (e.g. Hull's I_R) or that the activity interpolated between the last extinction trial and the test of retention interferes

with the retention of the extinctive tendency (e.g. Liberman's retroactive inhibition (forgetting) of experimental extinction). Thus the assumption that the rest period is essential has resulted in SR being seen as a useful testing technique and as an awkward experimental fact to be explained away rather than as a phenomenon to be investigated in its own right.

Despite this tendency, there have been efforts to determine with some precision the stimulus conditions which control, or at least affect, the phenomenon of spontaneous recovery. In general, these efforts have emphasized the similarity between the SR test trial and the start of acquisition sessions. Thus Skinner (1950) suggested that "the stimulation coincident with the beginning of an experiment must be extensive and unlike anything occuring in the later part of the experimental period... When the organism is again placed in the experimental situation, the stimulation is restored;" (p.55). While Skinner seemed to emphasize events external to the actual conditioning procedure which are reintroduced in testing for SR (e.g. handling the S, placing S in the experimental situation, etc.), Burstein (1967) attempted to point out that along with these "external" cues, there are cues inherent in the conditioning procedure itself which could result in the reinstatement of response strength associated with SR. Burstein noted that what is

generally referred to as "the CS" might better be viewed as a series of different CS's since each member of a CS series is presented at a different point in time and bears a different temporal relationship to the total pattern of CS presentations. Burstein suggested that the first CS in a series (CS_1) is quite dissimilar from the other CS's within an acquisition-extinction procedure in that it is the only CS not preceded by other CS's. Because of the intrinsic distinctiveness of a "first" CS, the tendency not to respond generated by extinction procedures generalizes less to it than to other CS's. Since the operations for producing spontaneous recovery involve, "by definition", a fairly lengthy rest period prior to the test of SR, Burstein contended that the CS presented on a test of SR is much more similar to CS_1 than to the CS's presented during the extinction trials. "For this reason, response strength is much greater to this test stimulus than it was to the previous CS presentation, i.e., to the CS on the last extinction trial." (p.390).

In a recent study, Burstein & Moeser (1971) investigated this hypothesis that the apparent increase in response strength associated with spontaneous recovery can best be explained in terms of the similarity between the stimulus on an SR test trial and the CS_1. Three groups of pigeons were given five daily key peck acquisition sessions

of 30 trials each. "Group 1" was presented with a distinctive stimulus (a red CS) on the first trial of each daily acquisition session. On all remaining acquisition trials, the CS was green. Similarly, "Group 20" was presented with the distinctive CS on the twentieth trial of each acquisition session, and with the green CS on all remaining trials. "Group C", the control group, received the green CS on all acquisition trials. On day six, all S's were extinguished to the dominant (green) CS, and were returned to their "home cages" for twenty minutes. Following this rest period, each of these groups was divided into two subgroups, one being tested for spontaneous recovery to the dominant CS, and the other to the distinctive CS. As shown in Fig. 1, response frequency on the SR test trial was greatest in that group which was presented with the same distinctive stimulus on both the first acquisition trial and the test trial (Group 1-dist.). Responding was almost completely inhibited in the group which was presented with a distinctive stimulus solely on the test trial (Group C-dist.). Performance for the group presented with the distinctive CS on the twentieth acquisition trial and tested with the distinctive CS (Group 20-dist.) was intermediate and did not differ from that of the three groups tested with the dominant stimulus.

These results offer strong support for the position

taken by Burstein. The greatest reinstatement in response strength was obtained when the SR test stimulus was the most similar to the "CS_1" (red stimulus) and at the same time most easily distinguishable from the dominant stimulus (green CS) presented on the other acquisition and extinction trials. While a "stimulus trace" position might be invoked to explain the greater response to the distinctive (and non-extinguished) CS, the test performance for the group presented with the same distinctive CS on the twentieth acquisition trial and the SR test trial would seem to make this explanation untenable. The authors concluded that "the rest period currently viewed as essential for generating the phenomenon of SR may merely be one of an almost infinite number of operations which will generate the apparent increase in response strength associated with SR" (p. 233) in that the rest period serves to create a distinctive stimulus associated with the onset of acquisition trials which are reinforced.

A second study (Burstein & Mackenzie, in press) was designed to test whether or not "identical elements" or "stimulus traces" are essential to replicating the reinstatement of response strength displayed in the previous study. It was, at the same time, designed to test whether or not an abstraction or concept such as novelty could reinstate response strength if it were associated with

the onset of acquisition training sessions. The concept of "novelty" involved training all S's with a different distinctive stimulus on the first trial of each of five daily acquisition sessions. Following extinction to the dominant stimulus on day six, S's were broken down into seven groups which were tested for residual response strength to each day's distinctive stimulus, the dominant CS, or a novel CS never before presented. It was found that response strength to each day's distinctive CS was greater than to the dominant CS, thus supporting the findings of the previous study despite the fact that the test stimulus had been presented to each S only once prior to the test trial. Contrary to the previous study in which a completely novel CS inhibited SR trial responding, the group tested with a new novel CS exhibited the highest response strength in this study. The authors stated that "it seems in principle unlikely that any position involving a stimulus trace or the reintroduction of previously presented stimulation would be tenable in explaining these results, since the test stimulus was never presented before". The contradictory results obtained in these two studies for groups tested with a completely new CS was taken as strong evidence that the concept of novelty can in fact be used to generate the apparent increment in response strength associated with "SR", provided that the concept had previously been

associated with the onset of reinforced acquisition trials.

The "informational value" interpretation of spontaneous recovery advanced by the authors suggested to them that the "rest period" currently viewed as essential for generating the phenomenon of SR may be essential only to the extent that a period devoid of CS presentations is necessary to create a distinctive "first" stimulus. As the Burstein & Mackenzie study demonstrated that there are many operations which may be used to associate a distinctive stimulus with the onset of acquisition sessions, the authors suggested that the rest period could possibly be eliminated and the phenomenon of SR maintained if such a distinctive stimulus, previously associated with the onset of reinforced acquisition trials, were used on the test trial.

The present study was designed to assess the accuracy of this suggestion. It was felt that any "spontaneous recovery" displayed following the elimination of the rest period would be difficult to explain in terms of the traditional inhibition and interference models of SR.

Method

Subjects: The S's were 48 White King pigeons, male and female, maintained at 80% ad libitum weight, randomly divided into 4 groups of 12.

Apparatus: A Grason-Stadler operant-conditioning station (E1100PE) was used. White noise was piped into the operant chamber from a Grason-Stadler noise generator (E829E) to eliminate the effects of transient noises. A Grason-Stadler Multiple Stimulus Projector (E4580) was modified to present the necessary stimuli. Two CS's were used, red (Wratten Filter No. 25) and green (Wratten Filter No. 61).

Procedure: S's were magazine and key-peck trained to a white key light. The "house" light was removed and each S was given 5 days of acquisition training consisting of 20 trials of 15 seconds each during which the CS light was on and all responses were reinforced by 3 seconds access to food (standard Purina Pigeon Pellets). CS trials were separated by 15 second "blackout" periods during which the operant chamber was completely dark and no reinforcement was available. On day 6, all S's underwent extinction until they reached a criterion of 5 consecutive trials without a response. The SR test phase consisted of a second extinction series to the same criterion.

Design: The 48 S's were divided into 4 groups on the basis

of 1) whether or not a distinctive first trial CS was used in the acquisition sessions, and 2) whether or not a rest period separated the SR test trials from the extinction phase. The operations defining each of the 4 groups are as follows:

Control-30; all acquisition, extinction, and test trials with the same (green) CS; 30 minute rest period in the home cage between the extinction and test phases. This is the "standard spontaneous recovery group" representing a typical procedure used to generate the phenomenon.

D-30; the distinctive (red) CS used on the first trial of each acquisition session, the dominant (green) CS on trials 2-20 of each acquisition session and on all extinction trials; 30 minute rest period; SR test with the distinctive CS. This group replicates the group from the Burstein & Moeser (1971) study which was presented with the same distinctive CS on both the first acquisition trials and the test trial.

D-0; the same procedure was used as in the previous group with the exception that the rest period was eliminated.

Control-0; the dominant (green) CS used on all acquisition and extinction trials; no rest period; test with the distinctive (red) CS. To be strictly analogous to the D-0 group, this group should have been tested with the dominant CS. It should be noted, however, that such

a procedure would merely result in the continuation of extinction past the criterion. By switching to the distinctive (for this group, novel) CS, this group becomes a "disinhibition control group", allowing a test of the hypothesis that any increase in response strength shown on the test trials by the D-O group is due to the disinhibiting influence of the change in CS colour, rather than to the effects of "first trial distinctiveness".

Results

An analysis of variance showed that there were no significant differences between groups, $F(3/44) < 1$, in response frequency over the last five trials in the acquisition series. There were also no significant differences during extinction in response frequency on the first extinction trial, $F(3/44) < 1$, in total response frequency during extinction, $F(3/44) = 1.34$, or in number of trials to the criterion of five successive trials without a response, $F(3/44) < 1$.

Three measures of spontaneous recovery were obtained: 1) the response frequency on the first test trial (as reported by Burstein & Moeser, 1971, and Burstein & Mackenzie, in press); 2) the total response frequency during the test phase; and 3) the number of test trials to the criterion of five successive trials without a response (see Table 1).

An analysis of variance based upon the response frequency during the first test trial was significant, $F(3/44) = 10.11$, $p < .001$. Separate t-tests were performed in an attempt to identify the sources of the overall significance. The comparison between groups D-0 and D-30 (which differed only in that the former group received no rest period) was not significant, $t(22df) = 0.579$, thus indicating that the elimination of the rest period had no significant effect. The groups which received a first trial distinctive CS

during acquisition (D-0 and D-30) responded significantly more often than did the standard spontaneous recovery group (Control-30), $t(34df) = 3.01$, $p < .0025$ for the one-tailed hypothesis being tested, confirming the results of the previous studies. Response frequency for the Control-30 group was significantly greater than for the "disinhibition" group (Control-0), $t(22df) = 2.08$, $p < .025$ for the one-tailed hypothesis being tested. This confirms the results of the Burstein & Moeser study in which responding was almost totally inhibited to a completely novel stimulus presented on the test trial, following a rest period.

A second analysis of variance was performed for the total response frequency during the test phase, and was found to be significant, $F(3/44) = 4.99$, $p < .01$. Individual t-tests reveal that the sources of significance are substantially the same as for response frequency on the first test trial. The comparison between groups D-0 and D-30 was not significant, $t(22df) = 0.29$, further indicating that the elimination of the rest period had no significant effect on response strength if the test CS had previously been associated with the onset of reinforced acquisition trials. Total response frequency during the test phase for the distinctive first trial CS groups (D-0 and D-30) was significantly greater than for the standard SR group (Control-30), $t(34df) = 2.136$, $p < .025$ for the one-tailed

hypothesis being tested, and greater for the Control-30 group than for the "disinhibition" group (Control-0), $t(22df) = 4.47$, $p < .001$.

Finally, an analysis of variance, performed on the number of test trials to criterion, was significant, $F(3/44) = 4.29$, $p < .01$. Separate t-tests reveal that the overall significance can be attributed to the almost total lack of responding by the Control-0 group. All comparisons not involving the "disinhibition" group resulted in t-values of less than 1, while the comparison of groups D-0, D-30, and Control-30 to Control-0 was significant, $t(46df) = 3.22$, $p < .001$.

Discussion

The results of this study provide strong support for the hypothesis that a "rest period" is not essential for generating the apparent increase in response strength associated with spontaneous recovery, and when taken in conjunction with the previous studies, offer further support for an informational value interpretation of SR.

The two groups which received a distinctive stimulus associated with the onset of acquisition training responded significantly more than did the standard SR control group, both in terms of the first test trial and in terms of total test performance. This confirms the findings of the two previous studies. No significant difference, however, was found between the two distinctive first trial stimulus groups (D-0 and D-30) on either response measure, indicating that for these groups, the rest period was a negligible factor in determining test performance. These findings are in accord with the informational value interpretation advanced by Burstein. It was suggested that "the high response frequency obtained...in groups which received matched distinctive stimuli on the first acquisition trial and on the test trial would be relatively unaffected if the rest period were abolished, since removal of the rest period would eliminate firstness as a distinctive cue, but would not eliminate colour as an effective

cue." (Burstein & Moeser, 1971, pp.333-334). It would appear that in the present study the informational value provided by the distinctive CS colour reached an asymptotic level, that is, any information which may have been provided by the rest period, in terms of firstness, became redundant and thus did not contribute to the further recovery of response strength.

The test performance of the Control-0 group is also seen as supporting this interpretation. As in the group reported by Burstein & Moeser which was presented with a distinctive stimulus solely on the test trial following a rest period, test trial responding was virtually eliminated in the Control-0 group. This lack of response strength is seen as a result of the absence of cues associated with the onset of reinforced acquisition trials. In the case of Control-0, the elimination of the rest period removed firstness as a possible distinctive cue, while the lack of prior exposure to the distinctive (red) CS eliminated association with acquisition onset as a possible source of information. Thus the low response strength displayed by the Control-0 group can be explained in terms of the absence of those cues which normally make the SR test stimulus more similar to those associated with the onset of reinforced acquisition sessions than to those in the extinction phase. The results of the analogous group

reported by Burstein & Moeser can be explained in similar terms. While the rest period used with this group may have provided a cue of firstness, the test CS was easily distinguishable from the stimuli presented on all previous trials, including the "CS_1's". It is suggested that the dissimilarity of the test stimulus and the "CS_1" generated by the difference in colour is greater than the similarity resulting from "firstness". The "net" information available to the S thus stresses dissimilarity from the stimulus associated with the onset of acquisition training, resulting in the continuation of the non-response tendency developed during extinction.

While these results tend to support the informational value hypothesis, there seems to be no obvious way to explain them in terms of the more traditional models of spontaneous recovery. The inhibition model of SR (e.g. Hull, 1952) is dependent upon a rest period in that there must be time for the I_R, built up during extinction, to dissipate. It is difficult to see how the high response frequency displayed by the D-0 group could be explained by this model, since no rest period was provided to allow the dissipation of I_R. Likewise, the interference hypothesis proposed by Liberman (1944; 1948) seems inapproapriate in that it is dependent upon a rest period to provide the opportunity for activities which interfere with the retention

of extinction. While a "stimulus trace" or "identical elements" position could be invoked to deal with the performance of the D-0 group, the results of the Burstein & Mackenzie study suggest that such constructs are not required to explain the present findings. Finally, the test performance of the Control-0 group, which differed from D-0 only in that the distinctive CS was not presented during acquisition training, would seem to eliminate a disinhibition hypothesis from serious consideration.

These results, therefore, offer further support for the suggestion of Burstein & Mackenzie that the rest period is only one of many possible operations which will lead to the apparent increase in response strength associated with the phenomenon of spontaneous recovery. In general, it is felt that <u>any</u> operation which stresses the similarity between the SR test trial and the onset of acquisition series while, at the same time, maintaining a degree of dissimilarity between the SR test stimulus and the stimuli presented during other extinction trials, will result in such a characteristic recovery of response strength. Thus, Liberman (1944) found that the interpolation of an eyeblink conditioning procedure during the period between the extinction and test of recovery of a conditioned GSR increased the amount of spontaneous recovery of the GSR. He also found that if the stimuli used for the original and the

interpolated conditioning were similar (1000 cps tone and 60-cycle buzz), there were greater effects upon spontaneous recovery than if the stimuli were dissimilar (1000 cps tone and light). Similarly, Reid (1958) noted that "The reinforcing event is present as a stimulus in the situation in which a response is acquired and is absent from the extinction situation. When extinction conditions are made more similar to those of acquisition by introducing a reinforcer unrelated to behaviour ('free' reinforcement), the extinguished response is restored". (p. 202) Further research into the precise stimulus conditions which control the phenomenon of SR will determine the fruitfulness of this informational value interpretation.

References

Burstein, K. R. Spontaneous recovery: A (Hullian) non-inhibition interpretation. Psychonomic Science, 1967, 11, 389-390.

Burstein, K. R. & Mackenzie, L. Response strength to a completely novel stimulus as a function of previous training: An example of concept formation in the pigeon. Journal of Comparative and Physiological Psychology, in press.

Burstein, K. R. & Moeser, S. The informational value of a distinctive stimulus associated with the initiation of acquisition trials. Learning and Motivation, 1971, 2, 228-234.

Hull, C. L. A Behavior System. New Haven: Yale University Press, 1952.

Kimble, G. A. Hilgard and Marquis' Conditioning and Learning. New York: Appleton-Century-Crofts, 1961.

Liberman, A. M. The effect of interpolated activity on spontaneous recovery from experimental extinction. Journal of Experimental Psychology, 1944, 34, 282-301.

Liberman, A. M. The effect of differential extinction on spontaneous recovery. Journal of Experimental Psychology, 1948, 38, 722-733.

Reid, R. L. The role of the reinforcer as a stimulus. British Journal of Psychology, 1958, 49, 202-209.

Skinner, B. F. Are theories of learning necessary? Psychological Review, 1950, 57, 193-216. In B. F. Skinner, Cumulative Record. New York: Appleton-Century-Crofts, 1961.

Table 1. Mean results by group for three measures of Spontaneous Recovery.

	Resp. Freq. on first Test Trial	Total Resp. Freq. during Test Phase	No. of Test Trials to Criterion
Control-0	1.00	2.33	6.00
Control-30	3.42	14.75	12.25
D-0	11.33	42.17	15.00
D-30	13.42	37.33	12.08

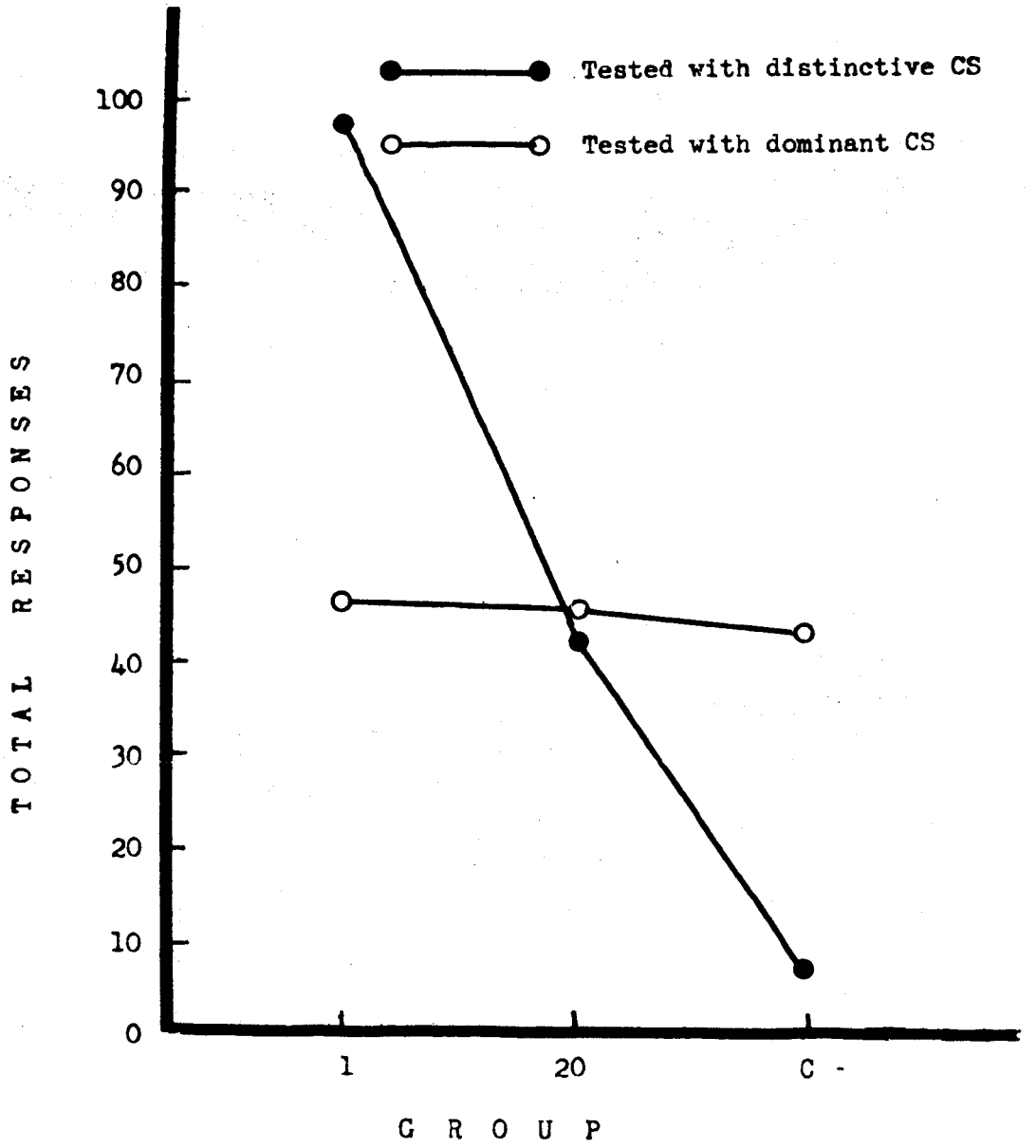

Fig. 1. Response frequency during the SR test trial as a function of testing with either the "dominant" or the "distinctive" CS. (from Burstein & Moeser, 1971.)