

RESURGENCE OF PREVIOUSLY REINFORCED BEHAVIOR DURING EXTINCTION

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ABSTRACT

Pigeon's pecks on one of two keys were reinforced with food and then extinguished over one or more sessions. In a test session, an alternative response was reinforced 20 times and then all reinforcement was withheld. After delays ranging from 21 to 195 sec, during which the frequency of the alternative response could be observed to decrease, pecking reappeared at relatively high rates on the key correlated with a history of reinforcement. The data provide support for a widely applicable principle: When recently reinforced behavior is no longer effective, previously reinforced behavior recurs.

Key words: extinction; pigeon; regression; reinstatement; resurgence.

A simple principle of potentially wide application may be stated as follows: When, in a given situation, recently reinforced behavior is no longer reinforced, behaviors that were previously reinforced under similar circumstances tend to recur. The principle has been stated in various ways for more than fifty years (Barker, Dembo and Lewin, 1941; Estes, 1955; Freud, 1920; Hull, 1952; Maltzman, 1955; Masserman, 1943; Mowrer, 1940; Notterman, 1970; Sears, 1943; Yates, 1970), though no systematic investigations have been made. Recent statements of the principle often cite no references (e.g., Notterman, 1970; Yates, 1970; cf. Staddon and Simmelhag, 1971).

Previous studies, inspired by Freudian theory, typically used punishment rather than extinction to induce earlier forms (Everall, 1935; Hamilton and Krechevsky, 1933; O'Kelley, 1940a, 1940b; Martin, 1940; Mowrer, 1940; Sanders, 1937). Reports of extinction-induced resurgence have been incidental to other observations and concerns (consider Barker et al., 1941; Leitenberg, Rawson and Bath, 1970; Miller

and Miles, 1936; Pryor, Haag and O'Reilly, 1969); consequently, critical controls have not been conducted. Previous observations (e.g., Barker et al., 1941; Leitenberg et al., 1970) have not distinguished the resurgence effect from frustration effects (Amsel, 1958) or the variability in behavior which is typically induced in extinction (Antonitis, 1951). Previously reinforced behavior may have recurred in some studies because reinforcement of an alternative behavior had prevented the extinction of the previously reinforced behavior (Leitenberg et al., 1970; Rawson, Leitenberg, Mulick and Lefebvre, 1977). Resurgence has not been demonstrated when the previously reinforced response has itself been extinguished. In spite of occasional restatements in the modern psychological literature, the principle is not generally invoked, even when it would be useful in interpreting effects that otherwise appear anomalous (e.g., Enkema, Slavin, Spaeth and Neuringer, 1972; Epstein and Skinner, 1980; Lindblom and Jenkins, 1981).

The following experiment provides support for a general principle of resurgence as stated above.

METHOD

Six male, adult Racing Homer pigeons served as subjects. None had served in laboratory experiments prior to this one. Each was maintained at approximately 80% of its free-feeding weight. A standard Skinner box was employed, on one wall of which were two standard keys, 12 cm apart, and a feeder recess where grain could be presented. Three-second presentations of food served as reinforcers. A peck on either key produced a brief high-pitched tone as feedback. The chamber was illuminated by an overhead white light. Extraneous sounds were masked by a ventilation fan and white noise. A video camera with a wide-angle lens was mounted to a side wall of the chamber and afforded a clear view of the bird and front panel. A TRS-80 microcomputer scheduled reinforcers during the first phase of the experiment and recorded the number of pecks during all phases. Pecking was also recorded continuously on two cumulative recorders during all phases. One-hour sessions were conducted daily. All test sessions were videotaped.

The experiment had three phases. In the first, pecking either the left key (subjects 26Y, 28Y and 38Y) or the right key (subjects 17Y, 21Y and 39Y) was reinforced intermittently with food. Pecking was reinforced on a variable-interval 1-min schedule until a moderate, steady rate of responding was established. Then reinforcement was withheld for one or more sessions (Table 1); the number of sessions was determined by random number (the upper limit was set at 15). All sessions were 1 hr in length. Finally, a test session was conducted as follows: Reinforcement was withheld for at least 30 min and until no peck had occurred for at least 10 min (in most cases, more than 20 min). Then some alternative response, incompatible with key pecking, was reinforced 20 times (Table 1). The bird was observed on a video monitor and the feeder was operated with a hand switch. After 20 reinforcements of the alternative response, all reinforcement was subsequently withheld.

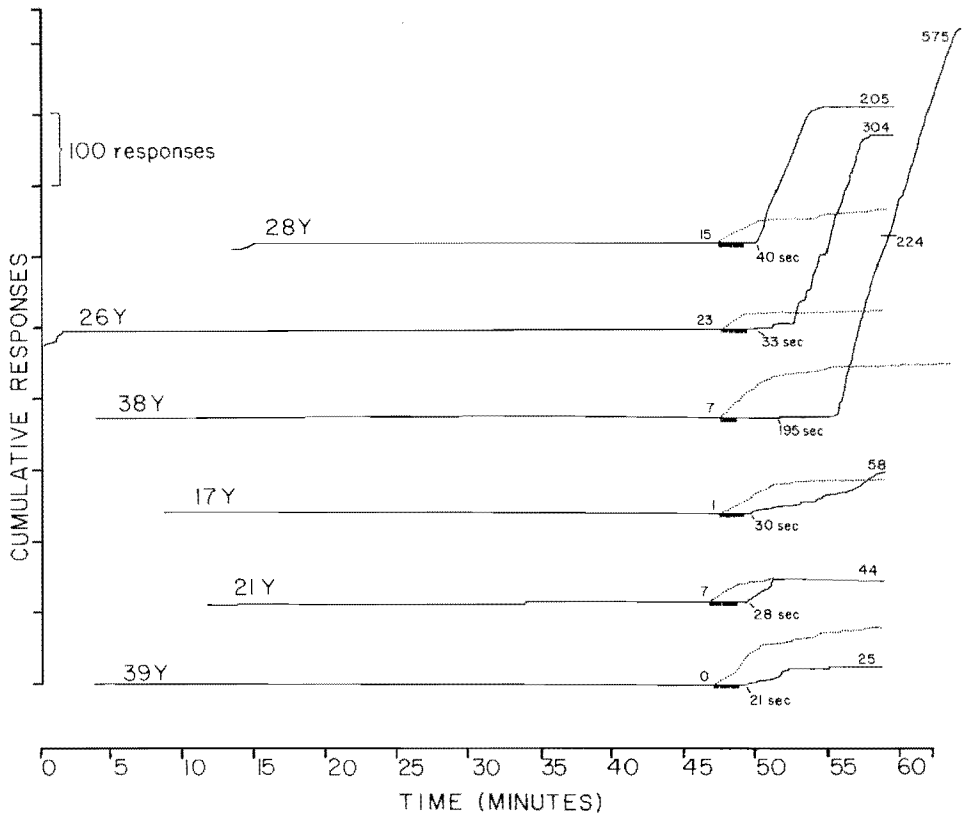


Figure 1. Cumulative records of responding on the key correlated with a history of reinforcement, shown for the entire test session of each of the six subjects. The left-hand portions of each curve show few or no responses. The dark areas below the curves at right mark the period during which some alternative response (Table 1) was reinforced 20 times. Following the termination of the last reinforcer, pecking resumed after a delay, the duration of which is marked below each record. Sessions were terminated 10 min after the termination of the last reinforcer, except for bird 38Y. The small numbers above each curve indicate the total number of responses at that point in the session; thus, bird 28Y pecked 15 times during the first few minutes of the session and an additional 190 times during the 10 min following the last reinforcer. The dotted lines show occurrences of the alternative response (see first footnote on p. 394).

RESULTS AND DISCUSSION

Results from the test session are shown in Figure 1. Relatively few key pecks occurred before reinforcement. The responses of subjects 17Y, 26Y and 28Y were concentrated in the first few minutes of the session, a phenomenon called 'spontaneous recovery' (subject 17Y pecked only once). After reinforcement of the alternative behavior ceased, pecking resumed on the key correlated with a history of reinforcement. Few pecks occurred on the control key either before or after the alternative behavior was reinforced (Table 1), which indicates that the resumption of pecking

TABLE 1

Bird	No. of sessions, VI reinforcement	No. of extinction sessions	Alternative response	Control key pecks	
				Before reinforcement	After reinforcement
17Y	31	11	head back	0	0
21Y	36	5	quarter turn right	0	0
26Y	49	2	wing raise	1	0
28Y	42	1	head down	0	0
38Y	11	6	head down	0	1
39Y	15	12	head turn right	0	0

on the other key was not simply a frustration effect (Amsel, 1958) or a result of the increase in variability in behavior which is often observed during extinction (Antonitis, 1951).

A consistent feature of all of the cumulative records is the interval of time which occurs between the last reinforcer and the first key peck. The dotted traces show clearly that the interval was produced by repeated occurrences of the alternative response*^{***}. In general, the higher the rate of the alternative response, the longer the interval (compare, for example, the records for birds 38Y and 17Y). Moreover, the resumption of key pecking was generally correlated with a decrement in the rate of the alternative response.

The current study includes three features which were lacking in previous work: First, a second key was included so that the resurgence effect could be distinguished from other extinction effects. Second, key pecking was extinguished for between 1 and 12 sessions before an alternative response was reinforced (Table 1); thus, the possibility was minimized that the previously reinforced behavior recurred simply because reinforcement of an alternative behavior had prevented its extinction. Third, large effects were shown for individual organisms in a single session (cf. Hull, 1934).

Free reinforcers during extinction are known to have discriminative properties

* The dotted traces in Figure 1 were produced by an independent observer who viewed a videotape of each test session from the point at which reinforcement began and tapped a key when she saw what was, in her judgment, the response that was reinforced. The key taps generated a cumulative record of the alternative responses.

** The cumulative record for bird 26Y would appear to indicate a sudden cessation of the alternative response (wing raising) immediately after the last reinforcer. The tape shows, however, that the bird's wings were raised high for 37 sec following the reinforcer. The wings fluttered slightly and the bird circled the chamber during most of this period. The observer (see previous footnote) scored this episode as a single response.

and may reinstate responding (Hollis, 1968; Reid, 1958; Spradlin, Girardeau and Hom, 1966)*. Reinforcement of the alternative response in the present experiment may have reinstated key pecking because, in the past, the operation of the feeder was the occasion upon which subsequent key pecks had been reinforced. Thus the reinforcers may have had two opposing effects. First, as discriminative stimuli, they may have reinstated a tendency to peck the key, and second, as reinforcers, they may have strengthened incompatible behavior that prevented key pecking. When reinforcement ceased, the onset of key pecking may have been prevented until the incompatible behavior was sufficiently weak (cf. Staddon, 1977).

Although this explanation cannot be ruled out in the present instance, resurgence has appeared in procedures which do seem to rule out the discriminative role of the reinforcer. When the alternative response is reinforced intermittently and for a long period of time, thousands of responses may appear before the rate declines in extinction, and it may be hours before previously reinforced behavior appears (Epstein, 1983; cf. Leitenberg et al., 1970). It is also possible that the reinstatement of responding which is produced by a free reinforcer may in part be extinction-induced: The reinforcer may strengthen an alternative response, which is then quickly extinguished (cf. Henton and Iversen, 1978; Skinner, 1938).

Resurgence is undoubtedly affected by many variables – the schedules according to which both the old and new behaviors are reinforced, the type and magnitude of the reinforcers (will the old response resurge if the old and new responses are established with different reinforcers?), the period of time over which the responses are reinforced, the time that elapses after the old response is last reinforced, the overlap in the stimulus conditions under which the responses are reinforced, and so on. Matters are complicated when many responses are available to resurge, as is probably the rule in the natural environment: What variables determine the order of resurgence and the distribution of responses? The degree of extinction of the previously reinforced response is undoubtedly an important factor. It is likely that the more complete the extinction, the less the resurgence (Rawson et al., 1977). The data for birds 17Y and 39Y show, however, that resurgence can occur even when extinction has been extensive and is virtually complete.

When primitive behaviors resurge, some speak of 'regression'. Resurging behaviors need not be primitive, however (Masserman, 1943). The principle of resurgence seems useful in interpreting moment-to-moment changes in behavior in any domain in which behavior is sometimes ineffective, such as problem solving (Epstein and Medalie, 1983; Epstein, in press-a; Maltzman, 1955; Hull, 1952), foraging, or responding on intermittent and concurrent schedules of reinforcement.

* Novel stimuli can also reinstate responding under certain conditions, but negative results seem to be the rule in operant conditioning procedures. Consider Boakes (1973), Boakes and Halliday (1975), Skinner (1936).

The principle implies that behavior that has been extinguished is not necessarily 'forgotten', which is to say that it can recur under appropriate circumstances (cf. Epstein and Skinner, 1980). Moreover, resurgence is one of several phenomena that make multiple repertoires available, and hence it may lead to the spontaneous interconnection of repertoires, an important source of novel behavior (Chance, 1960; Epstein, in press-b; Epstein and Skinner, 1981; Maltzman, 1955).

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REFERENCES

- Amsel, A. The role of frustrative nonreward in noncontinuous reward situations. *Psychological Bulletin*, 1958, 55, 102-119.
- Antonitis, J.J. Response variability in the white rat during conditioning, extinction, and reconditioning. *Journal of Experimental Psychology*, 1951, 42, 273-281.
- Barker, R.G., Dembo, T. and Lewin, K. *Studies in Topological and Vector Psychology. No. 2. Experiments on Regression and Frustration*. Iowa City: Iowa University, 1941.
- Boakes, R.A. Response decrements produced by extinction and by response-independent reinforcement. *Journal of the Experimental Analysis of Behavior*, 1973, 19, 293-302.
- Boakes, R.A. and Halliday, M.S. Disinhibition and spontaneous recovery of response decrements produced by free reinforcement in rats. *Journal of Comparative and Physiological Psychology*, 1975, 88, 436-446.
- Chance, M.R.A. Kohler's chimpanzees - How did they perform? *Man*, 1960, 60, 130-135.
- Enkema, S., Slavin, R., Spaeth, C. and Neuringer, A. Extinction in the presence of free food. *Psychonomic Science*, 1972, 26, 267-269.
- Epstein, R. An experimental analysis of 'cognition'. Paper presented at the 63rd annual meeting of the Western Psychological Association, San Francisco, April 1983.
- Epstein, R. Simulation research in the analysis of behavior. In A. Poling, R.W. Fuqua and R. Ulrich (Eds.), *Control of Human Behavior, Vol. 4*. Glenview, Ill.: Scott, Foresman, in press-a.
- Epstein, R. Bringing cognition and creativity into the behavioral laboratory. In T.J. Knapp and L. Robertson (Eds.), *Contemporary Views of Cognition*. Hillsdale, N.J.: Erlbaum, in press-b.
- Epstein, R. and Medalie, S.D. The spontaneous use of a tool by a pigeon. *Behaviour Analysis Letters*, 1983, 3, 241-247.
- Epstein, R. and Skinner, B.F. Resurgence of responding after the cessation of response-independence reinforcement. *Proceedings of the National Academy of Sciences, U.S.A.*, 1980, 77, 6251-6253.
- Epstein, R. and Skinner, B.F. The spontaneous use of memoranda by pigeons. *Behaviour Analysis Letters*, 1981, 1, 241-246.
- Estes, W.K. Statistical theory of spontaneous recovery and regression. *Psychological Review*, 1955, 62, 145-154.
- Everall, E.E. Perseveration in the rat. *Journal of Comparative Psychology*, 1935, 19, 343-369.
- Freud, S. *A general introduction to psychoanalysis*. New York: Boni and Liveright, 1920.
- Hamilton, J.A. and Krechevsky, I. Studies in the effect of shock upon behavior plasticity in the rat. *Journal of Comparative Psychology*, 1933, 16, 237-253.

- Henton, W.W. and Iversen, I.H. *Classical Conditioning and Operant Conditioning: A Response Pattern Analysis*. New York: Springer-Verlag, 1978.
- Hollis, J.H. Chlorpromazine: Direct measurement of a differential behavioral effect. *Science*, 1968, 159, 1487-1489.
- Hull, C.L. The rat's speed-of-locomotion gradient in the approach to food. *Journal of Comparative Psychology*, 1934, 17, 393-422.
- Hull, C.L. *A Behavior System*. New York: John Wiley, 1952.
- Leitenberg, H., Rawson, R.A. and Bath, K. Reinforcement of competing behavior during extinction. *Science*, 1970, 169, 301-303.
- Lindblom, L.L. and Jenkins, H.M. Responses eliminated by noncontingent or negatively contingent reinforcement recover in extinction. *Journal of Experimental Psychology: Animal Behavior Processes*, 1981, 7, 175-190.
- Maltzman, I. Thinking: From a behavioristic point of view. *Psychological Review*, 1955, 62, 275-286.
- Martin, R.F. 'Native' traits and regression in rats. *Journal of Comparative Psychology*, 1940, 30, 1-16.
- Masserman, J.H. *Behavior and Neurosis*. Chicago: University of Chicago Press, 1943.
- Miller, N.E. and Miles, W.R. Alcohol and removal of reward: An analytical study of rodent maze behavior. *Journal of Comparative Psychology*, 1936, 21, 179-204.
- Mowrer, O.H. An experimental analogue of 'regression' with incidental observations on 'reaction-formation'. *Journal of Abnormal and Social Psychology*, 1940, 35, 56-87.
- O'Kelley, L.I. An experimental study of regression. I. Behavioral characteristics of the regressive response. *Journal of Comparative Psychology*, 1940, 30, 41-53.
- O'Kelley, L.I. An experimental study of regression. II. Some motivational determinants of regression and perseveration. *Journal of Comparative Psychology*, 1940, 30, 55-95.
- Notterman, M. *Behavior: A Systematic Approach*. New York: Random House, 1970.
- Pryor, K.W., Haag, R. and O'Reilly, J. The creative porpoise: Training for novel behavior. *Journal of the Experimental Analysis of Behavior*, 1969, 12, 653-661.
- Rawson, R.A., Leitenberg, H., Mulick, J.A. and Lefebvre, M.F. Recovery of extinction responding in rats following discontinuation of reinforcement of alternative behavior: A test of two explanations. *Animal Learning and Behavior*, 1977, 5, 415-420.
- Reid, R.L. The role of the reinforcer as a stimulus. *British Journal of Psychology*, 1958, 49, 202-209.
- Sanders, M.J. An experimental demonstration of regression in the rat. *Journal of Experimental Psychology*, 1937, 21, 493-510.
- Sears, R.R. *Survey of Objective Studies of Psychoanalytic Concepts*. New York: Social Science Research Council, 1943.
- Skinner, B.F. A failure to obtain 'disinhibition'. *Journal of General Psychology*, 1936, 14, 127-135.
- Skinner, B.F. *The Behavior of Organisms*. New York: Appleton-Century-Crofts, 1938.
- Spradlin, J.E., Girardeau, F.L. and Hom, G.L. Stimulus properties of reinforcement during extinction of a free operant response. *Journal of Experimental Child Psychology*, 1966, 4, 369-380.
- Staddon, J.E.R. Schedule-induced behavior. In W.K. Honig and J.E.R. Staddon (Eds.), *Handbook of Operant Behavior*. Englewood Cliffs, N.J.: Prentice-Hall, 1977.
- Staddon, J.E.R. and Simmelhag, V.L. The 'superstition' experiment: A reexamination of its implications for the principles of adaptive behavior. *Psychological Review*, 1971, 78, 3-43.
- Yates, A.J. *Behavior Therapy*. New York: John Wiley, 1970.

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