

EXTINCTION-INDUCED RESURGENCE:  
PRELIMINARY INVESTIGATIONS AND POSSIBLE APPLICATIONS

ROBERT EPSTEIN

*Northeastern University*

and

*Cambridge Center for Behavioral Studies*

When recently reinforced behavior is no longer effective, previously reinforced behavior often recurs. Though the phenomenon has been described from time to time in both the experimental and clinical literatures, it has never been stringently investigated. Its robustness is suggested, however, by both formal and informal observations of humans and other animals. Applications in both theoretical and practical domains are suggested, among them problem solving, schedules of reinforcement, foraging theory, and psychotherapy.

In a passage on extinction in an influential paper on superstition, Staddon and Simmelhag (1971) write:

one effect of a relaxation of [reinforcement] is a more or less transient increase in the relative influence of the distant past at the expense of the immediate past. In behavioral extinction, this should involve the reappearance of old (in the sense of previously extinguished) behavior patterns. (p. 25)

They cite no references in the text but add a footnote:

Other than clinical accounts of regression, we have been able to find only one published report of this effect—in an account describing shaping porpoises to show novel behaviors (Pryor, Haag, & O'Reilly, 1969). However, we have frequently observed it while shaping pigeons. . . . [The] increase in variability during extinction of the most recently reinforced response generally includes the reappearance of earlier responses. (p. 25)

Notterman (1970, p. 93) describes a similar phenomenon as one of four major extinction effects; no supporting data are cited. Yates (1970, p. 28) emphasizes the importance of such a process in therapy; again, no references. Recent statements of such a principle seem to be the exception; many current texts that discuss extinction phenomena at length mention no such principle at all (e.g., Bower & Hilgard, 1981; Catania, 1979; Donahoe & Wessells, 1980;

Preparation of the paper was supported in part by NIH Grant MH32628 to the Foundation for Research on the Nervous System and by a Sigma Xi Grant-in-Aid of Research. I thank J. Cerella for support and suggestions, and J. Cautela, F. S. Keller, I. Iversen, and H. Wichman for stimulating discussion. Address correspondence to Robert Epstein at the Cambridge Center for Behavioral Studies, 11 Ware Street, Cambridge, MA 02138.

Fantino & Logan, 1979; Ferster, Culbertson, & Boren, 1975; Hintzman, 1978; Karen, 1974; O'Leary & Wilson, 1975; Rachlin, 1976; Reynolds, 1975).

A defensible—though, at this point, somewhat imprecise—principle of extinction-induced resurgence 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. In spite of a recent lack of interest, variations on this principle have had a long and distinguished history in psychology.<sup>1</sup> Furthermore, data are available which support it, and, just as significantly, there appear to be no disconfirming data.

#### Brief History

A special case of resurgence would seem to be Freud's (1920) concept of regression, though the concepts differ in several respects. Regression refers to a psychodynamic mechanism that is supposed to underlie changes in behavior. The principle of resurgence, in contrast, is purely descriptive; no mechanism is implied. Regression is said to proceed to points of fixation which are established during childhood; hence, emerging behaviors are said to be infantile and primitive. The principle of resurgence makes no such restriction. Finally, regression is usually understood to be a response to punishment—to "powerful external obstacles"—rather than simply to nonreinforcement (though Freud himself seems not to have made the distinction). Consequently, most laboratory studies of regression used punishment rather than extinction to induce earlier forms (Everall, 1935; Hamilton & Krechevsky, 1933; Martin, 1940; Mowrer, 1940; O'Kelley, 1940a, 1940b; Sanders, 1937).

Freud's psychodynamic principle gave way to a more descriptive one by the 1940s: Masserman (1943) distinguished regression from "retrogression of adaptation," a return to previously successful behaviors as a response to "conflicting or extremely frustraneous [sic]" conditions. The terms "retrogression" (Barker, Dembo, & Lewin, 1941), "instrumental act regression" (Sears, 1941, 1943), and "habit regression" (Mowrer, 1940) referred to the same phenomenon. The operations said to produce the recurrence of earlier behaviors included punishment, extinction, and even satiation (Sears, 1943), though there were virtually no investigations of the latter two cases.

By far the clearest cases of extinction-induced resurgence were reported by Hull (1934). In one experiment he trained rats to run down a straight 40-ft alley for food. In earlier sessions, he observed a "speed gradient": The rats ran more and more rapidly as they approached the food. The gradient disappeared after a few days but reappeared when food was withheld. In a second experiment, rats

were first trained to run down a 20-ft alley and then down a 40-ft alley. When food was withheld on the longer alley, the rats tended to stop at the 20-ft mark.<sup>2</sup>

#### Recent Work

In all of the studies mentioned, observations of resurgence were incidental to other observations and concerns (also consider Barker et al., 1941; Leitenberg, Rawson, & Bath, 1970; Miller & Mills, 1936; Pryor et al., 1969). Epstein (1983a) reported a more direct test. Each of six pigeons was placed in a standard experimental chamber equipped with two keys. Pecks on one or the other of the keys were reinforced with food for 11 or more sessions on a variable-interval (VI) schedule and subsequently extinguished for between 1 and 12 1-hr sessions. In a test session, some alternative response, such as wing-raising or turning, was reinforced 20 times. When all reinforcement was subsequently withheld, the frequency of the alternative response decreased over intervals ranging from 21 to 195 seconds, and then each of the birds began to peck again at a relatively high rate on the key upon which pecks had been previously reinforced.

Since there was virtually no pecking on the other key (one peck by one bird during the 10-min observation period), the recurrence of pecking cannot be attributed merely to "frustration" (cf. Amsel, 1958) nor to the variability in behavior which is typically induced in extinction (Antonitis, 1951). More important, the behavior that recurred had been extinguished, and hence the result supports the strong prediction made by Staddon and Simmelhag (1971): *Even behavior that has been previously extinguished may resurge.*

Another experiment illustrates the dynamics of the process. In the first of three conditions, a pigeon's pecks on the right key of a standard 3-key chamber were reinforced with food according to a VI 1-min schedule (pecks produced food once each minute, on the average). All three of the keys were always transilluminated with white light. In the second condition the schedule of reinforcement was shifted to the center key. Responding eventually shifted to this key. The rate of responding on the right key decreased steadily over a number of sessions as responding on the center key became more stable. By the 10th 1-hr session of this condition, there were no pecks on the right key.

Finally, in the third condition, all reinforcement was withheld. There was little responding on the left key, upon which pecks had never been reinforced. The rate of responding on the center key was high for the first 40 min of the first test session and decreased thereafter. There were no pecks on the right key during the first 40 min of the session, and then, just as the rate of responding on the center key began to fall, pecking appeared at a high rate on the right key (Figure 1), the key correlated with a history of reinforcement. The effect was also obtained with three other birds (Epstein, 1983b; cf. Leitenberg et al., 1970).

<sup>1</sup> J. Cautela (personal communication) points out that the first of Jost's (1897) laws may also be relevant. The law states that the older of two associations of equal strength loses strength less rapidly than the newer. Though functionally similar to resurgence, this law applies to forgetting (the decrement in responding that occurs as a function of the passage of time), not extinction (the decrement in responding that occurs as a function of nonreinforced responding). The distinction seems worthwhile, in part because it seems that behavior that has been eliminated by nonreinforcement is not "forgotten," which is to say that it will recur under appropriate conditions (cf. Epstein & Skinner, 1980).

<sup>2</sup> There are by current standards a number of deficiencies in the Hull (1934) report: His conclusions are based on averages of hundreds of observations, yet no variability is reported and no statistics are given. He notes that, soon after food was withdrawn, many animals would not run and that a number of animals naturally tended to stop at the halfway point in the alley even before food was withdrawn.

## Applications

Epstein and Medalie (1983) described an instance of what might reasonably be called the spontaneous use of a tool by a pigeon.<sup>3</sup> A pigeon was trained to push a small flat box toward a green target placed at random positions around the base of a large cylindrical chamber. It was then confronted with what might be called "the marble under the couch" problem: Pecking a small metal plate positioned at the base of a clear Plexiglas wall was reinforced with food. Then

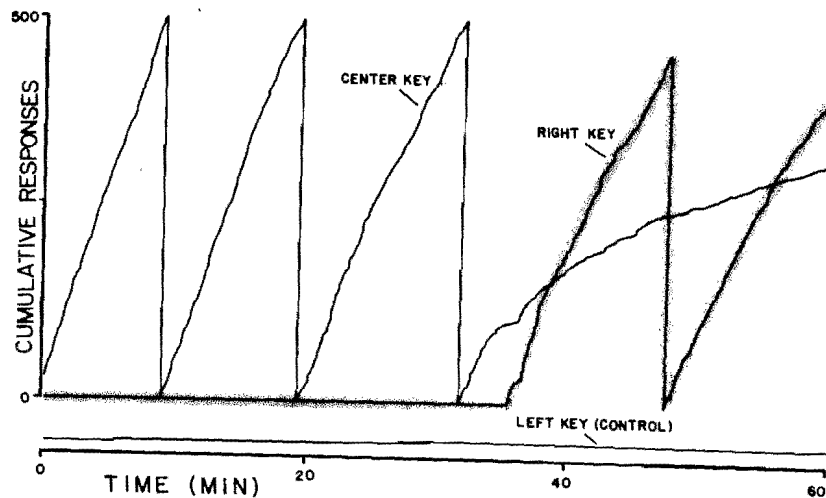


Figure 1. Cumulative record segments from the first session in which reinforcement was withheld on all keys for Bird 13YP. Each of the three segments shows responding on one key. Responding on the center key had been recently reinforced according to a variable-interval 1-min schedule. During the first half of the session, a high steady rate of responding was maintained on this key. It became less stable after the first 1000 responses. A smooth deceleration is apparent during the last 20 min. (Note that the pen resets downward after 500 responses.) The lower line corresponds to the left key, upon which pecking had never been reinforced. The pigeon pecked this key only 7 times during the hour. The shaded line corresponds to the right key where there was a history of VI 1-min reinforcement. No responses occurred on this key while responding on the center key was strong, but the pigeon began pecking it at a high rate at about 40 min into the session. It pecked the key nearly 900 times during the last 20 min.

the plate was moved several inches behind the wall so that the pigeon had to stretch its head beneath the wall to reach the plate. The box was placed on the pigeon's side of the wall and behavior with respect to it was extinguished, while pecks to the plate were reinforced. Finally, the plate was moved just out of the pigeon's reach behind the wall.

The pigeon's performance at this point was remarkably human-like. It stretched

<sup>3</sup> The report describes the performance of only one bird. Similar performances have since been achieved with two others.

repeatedly toward the plate. It behaved emotionally—it scraped its feet on the floor, pressed against the wall, and so on. At about 30 s into the session, it pecked weakly at the box, then stretched again under the wall. Finally, at 90 s into the session, in one continuous sequence of movements, it pushed the box directly toward the wall, pushed it somewhat awkwardly underneath, and, after some adjustments, thrust it firmly against the metal plate. It then pecked repeatedly at the box, which was now in contact with the plate. It would seem that the bird had spontaneously used the box as an extension of its own beak.

Note that the bird had never been trained to push the box toward the plate or under a wall and, more important, that the bird had not pecked the box under these conditions for at least five consecutive daily sessions. Why did the bird start to push when the plate was out of reach? In casual discourse we might appeal to a concept such as "need," but extinction-induced resurgence would seem to be a more useful explanation. With the plate out of reach, behavior with respect to it was extinguished; pushing the box, a previously reinforced behavior, recurred. (For a discussion of why the bird pushed *toward* the plate, see Epstein and Medalie, 1983, and Epstein, Kirshnit, Lanza, and Rubin, 1984).

Other problem-solving performances also seem amenable to such an analysis. Pigeons with appropriate experiences will solve one of Köhler's (1925) classic box-and-banana problems (Epstein, 1981; Epstein et al., 1984). In one variation of this problem, Au and Epstein (1982) trained a bird to climb onto a box and peck a small facsimile of a banana, as well as to push a box toward a green target placed at random positions around the base of a large cylindrical chamber. Flying toward the banana was extinguished. Then the banana was placed within the bird's reach and pecking it was reinforced. The box was available in the chamber, but pecking it was extinguished. When there had been no pecks to the box under these conditions for five consecutive days, the banana was raised out of the bird's reach. It showed signs of "confusion": It stretched repeatedly toward the banana, turned in circles beneath it, and so on. It glanced more and more frequently toward the box, and then, finally, began to push the box toward the banana. It stopped pushing when the box was beneath the banana, climbed, and pecked. The entire performance took under 4 min. A complete analysis of this performance is beyond the scope of this paper, but the first part of it at least, the initial pushes, would seem to be extinction-induced.

## Anomalies

The resurgence principle is generally not invoked in the experimental animal literature, even when it would be useful in interpreting results that otherwise appear anomalous. For example, key pecking that has been established through autoshaping and then eliminated when the food and key light are presented independently of each other reappears at a high rate when food presentations are terminated (Epstein & Skinner, 1980; Lindblom & Jenkins, 1981). The effect has proved difficult to explain. The resurgence principle provides a simple account: When a high rate of pecking is established during the autoshaping procedure, pecks are adventitiously reinforced. When key-light presentations are no longer paired with food presentations, other behaviors are adventitiously rein-

forced and key pecks are extinguished. Finally, when food presentations are terminated, the recently reinforced behaviors undergo extinction, which takes some time; when they are sufficiently weak, pecking the illuminated key, a previously reinforced behavior, resurges. A pause of several minutes reliably precedes the recurrence of responding that occurs in the autoshaping procedure (Epstein & Skinner, 1980). This account could be tested either by analyzing videotapes of such performances or by establishing a known response during the second phase of the experiment.

Enkema, Slavin, Spaeth, and Neuringer (1972) reported another case of recovery which lends itself to a similar account. They reinforced pigeons' key pecks with food and then eliminated key pecking by no longer reinforcing it and by making a container of free food available in the rear of the experimental chamber. When the free food was removed from the cup, key pecking returned at a high rate. Presumably the free food quickly established approach and feeding behaviors toward the cup. When the food was removed, these behaviors were presumably extinguished over some period of time, and a previously successful response, key pecking, reappeared. Again, a pause, perhaps on the order of several minutes long, should have occurred before the resumption of key pecking.

I. Iverson (personal communication) has suggested a more subtle case. Catania and Keller (1981) brought pigeons' pecks under the control of a VI schedule of reinforcement and then presented the reinforcers independent of behavior (a variable-time or VT schedule). Under the VT schedule, the rate of pecking decreased dramatically. Upon reexposure to the VI schedule a high rate of pecking was restored, and the rate decreased dramatically again upon a second exposure to the VT. With each successive exposure to the VT schedule, the rate of pecking decreased more rapidly.

A simple account may be given in terms of resurgence: As in the studies described herein, free food during the first VT probably strengthened some behaviors other than key pecking (cf. Henton & Iversen, 1978). During the subsequent VI, there should have been a pause, during which the frequency of the new behaviors decreased, before key pecking reappeared. Upon reexposure to the VT, the alternative behaviors (strengthened during the previous VT) were presumably available to resurge and hence were established more rapidly than they had been during the previous VT. Hence the rate of key pecking declined more rapidly than it did during the previous VT, and subsequent exposures to the VT produced even more rapid decrements.

#### Further Implications

Resurgence probably occurs in any domain in which behavior is sometimes ineffective (along with other extinction effects). Both single and concurrent schedules of intermittent reinforcement should produce extinction effects, since many or most of the responses that occur are not successful. Animals that are earning food by pressing levers or pecking keys do far more than press or peck. One observes partial responses ("air pecks," "rim pecks," weak presses, and so on), partial turns, full turns, tilts of the head, grooming, preening, and many

other behaviors besides the one the equipment is recording. Sequences such as turn-and-peck are often established adventitiously, subsequently extinguished, later reestablished, and so on. The characteristic rates and patterns of responding which are produced by particular schedules may be generated in part by the continual resurgence of previously reinforced sequences when responses are not reinforced (cf. Henton & Iversen, 1978). Changeovers on concurrent schedules may occur in part as the result of extinction of responding at one location.<sup>4</sup>

There are undoubtedly other clinical applications, but one topic that certainly bears some mention is symptom substitution. Psychodynamic psychologists and psychiatrists, beginning with Freud himself, have, with few exceptions, maintained that abnormal behavior is symptomatic of underlying conflict. Treating the behavior alone, therefore, should not be effective; the underlying conflict should produce other behavioral manifestations—either "symptom substitution" or a recurrence of the original behavior. Freud rejected hypnosis on these grounds: It "forbid[s] the symptoms . . . but leaves all the processes that have led to the formation of symptoms unaltered" (Freud, 1966, pp. 450-451). Behavior therapists rejected the Freudian view and asserted that the focus of therapy should be the behavior itself (e.g., Yates, 1958). One extreme statement of this position is captured in Eysenck's dictum: Get rid of the symptoms and you have eliminated the neurosis.

The resurgence principle suggests at least one situation in which a substitution of sorts should occur: Removal of a behavior through nonreinforcement should lead to the emergence of other behaviors that have previously been effective under similar circumstances (cf. Yates, 1970, pp. 399-400), and clinical studies suggest that this occurs (e.g., Herbert et al., 1973; Sajwaj, Twardosz, & Burke, 1972). There is a practical corollary: A therapist might deliberately induce previously established behaviors by establishing and then extinguishing new behaviors.

Behaviors interact, and research with animals suggests that the interactions are orderly (e.g., Dunham & Grantmyre, 1982). It is not entirely unreasonable to assert that one cannot alter one behavior without affecting others. If so, a fuller understanding of such interactions should greatly enhance the effectiveness of existing therapies (Kazdin, 1982; cf. McDowell, 1982). The process of resurgence is one of many possible interactions.

Biologists have for some time been interested in the manner in which animals forage for food in the wild, and formal models of such behavior have been proposed (e.g., Krebs, 1978; Lea, 1979). Such models predict, among other things, the average time an animal will spend in some relatively isolated patch of food as a function of prey type and density, "handling time," travel time between patches, and so on. Resurgence suggests a simple mechanism that should produce switching from one patch to another: Foraging behavior is extinguished

<sup>4</sup> Heyman (1979) reported that changeover probabilities in concurrent VI schedules do not change as a function of previous responding, or, more specifically, that pigeons are not more likely to switch from one key to another after a run of many nonreinforced pecks. The observation is based, however, on "steady state" responding, achieved after 20 and, in some cases, 30 or more sessions of exposure to a given schedule. Heyman's report (e.g., p. 43) suggests that the observation does not apply to sessions before the steady state is achieved.

when prey are unavailable, and previously effective behaviors, for example, traveling to other patches, should result. Prevailing theory suggests that after an animal leaves a patch it will sample new ones. The resurgence principle predicts, however, that if an animal is fed at Patch A and then food is withdrawn and that if it is then fed at Patch B and food is again withdrawn, it will return to Patch A before moving to another available patch. Indeed, other things being equal, the animal should switch back and forth repeatedly between A and B before moving on.

When, in the natural environment, some behavior is ineffective, more than one behavior is probably available to resurge. One's genetic and environmental histories may have established dozens of behaviors relevant to a given situation. Thus, when one is unable to turn a knob that has always opened easily, a variety of behaviors appear in rapid succession: One may turn harder, lift, push down, pound on the door, kick, shout for help, and so on. Presumably the more behaviors that have been established, the more that will recur. This process is undoubtedly invaluable in problem solving. Artificial intelligence programs may fail as models of human intelligence (Minsky, 1975) because they neglect this aspect of the behavior of organisms.

The principle I have described in no sense explains *why* previously reinforced behavior recurs during extinction. But in identifying what appears to be a reliable set of relationships between certain events in behavior and the environment, it provides at the level of the events observed an explanation for higher order phenomena that entail these relationships. For example, the first pushes by the "tool-using" bird seem mysterious until one notes that the procedure entails extinction and that one common effect of extinction is the recurrence of previously reinforced behavior. When we have determined the many parameters and variables that determine when and whether a response will resurge and the order in which multiple behaviors will recur (cf. Epstein, 1983a), we should be able not only to provide plausible explanations for a variety of behavioral phenomena but also to predict recurrences in new situations.

I have pointed to many possible applications of the resurgence principle in both experimental analysis and clinical interpretation, but its most profitable application may prove to be in our understanding of the emergence of novel behavior. An important source of novelty in the behavior of organisms appears to be the interconnection of repertoires (Chance, 1960; Epstein, 1981, in press-b; Epstein & Skinner, 1981; Epstein et al., 1984; Hull, 1935; Maltzman, 1955); behaviors that have been established separately by any means, can, in new situations, come together to produce new sequences of behaviors, behaviors that have new functions, or behaviors that have new topographies. Resurgence may be one of only a small number of phenomena that can make multiple behaviors available (cf. Epstein, in press-a).

The extinction-induced resurgence of previously established behaviors appears to be an orderly process by which the history of an organism manifests itself in new situations, a phenomenon that has been underemphasized in many investigations of learning. It suggests that, just as the genome brings to an organism the history of a species, the organism as a whole brings to new envi-

ronments its ontogenic history and is hence capable of complex adaptations that reflect this history.<sup>5</sup>

## References

- AMSEL, A. (1958). The role of frustrative nonreward in noncontinuous reward situations. *Psychological Bulletin*, 55, 102-119.
- ANTONITIS, J. J. (1951). Response variability in the white rat during conditioning, extinction, and reconditioning. *Journal of Experimental Psychology*, 42, 273-281.
- AU, R., & EPSTEIN, R. (1982). Problem solving in the pigeon. Paper presented at the 62nd annual meeting of the Western Psychological Association, Sacramento, April.
- BARKER, R. G., DEMBO, T., & LEWIN, K. (1941). *Studies in topological and vector psychology. No. 2. Experiments on regression and frustration*. Iowa City: Iowa University.
- BOWER, G., & HILGARD, E. (1981). *Theories of learning* (5th ed.). Englewood Cliffs, NJ: Prentice-Hall.
- CATANIA, A. C. (1979). *Learning*. Englewood Cliffs, NJ: Prentice-Hall.
- CATANIA, A. C., & KELLER, K. (1981). Contingency, contiguity, correlation, and the concept of causation. In P. Harzem & M. D. Zeiler (Eds.), *Advances in the analysis of behavior, Vol 2: Predictability, correlation, and contiguity*. New York: John Wiley.
- CHANCE, M. R. A. (1960). Köhler's chimpanzees—How did they perform? *Man*, 60, 130-135.
- DONAHOE, J. W., & WESSELLS, M. G. (1980). *Learning, language, and memory*. New York: Harper & Row.
- DUNHAM, P. J., & GRANTMYRE, J. (1982). Changes in a multiple-response repertoire during response-contingent punishment and response restriction: Sequential relationships. *Journal of the Experimental Analysis of Behavior*, 37, 123-133.
- ENKEMA, S., SLAVIN, R., SPAETH, C., & NEURINGER, A. (1972). Extinction in the presence of free food. *Psychonomic Science*, 26, 267-269.
- EPSTEIN, R. (1981). On pigeons and people: A preliminary look at the Columban Simulation Project. *The Behavior Analyst*, 4(1), 43-55.
- EPSTEIN, R. (1983a). Resurgence of previously reinforced behavior during extinction. *Behaviour Analysis Letters*, 3, 391-397.
- EPSTEIN, R. (1983b). An experimental analysis of "cognition." Paper presented at the 63rd annual meeting of the Western Psychological Association, San Francisco, April.
- EPSTEIN, R. (in press-a). Simulation research in the analysis of behavior. In A. Poling, R. W. Fuqua, & R. Ulrich (Eds.), *Research methodology in the analysis of behavior*. New York: Plenum. (Preprinted in *Behaviorism*, 1984, Vol. 12).

<sup>5</sup> A personal note: The origin of the resurgence principle in my own behavior would seem in part to exemplify the principle. I was watching a student train a bird for the "tool use" experiment (Epstein & Medalie, 1983). To my knowledge at that time, I had never heard or read of a principle such as resurgence (several months passed before someone pointed out the connection to regression), and I was perplexed by the reappearance of box pushing that had occurred in a previous test. My account was inadequate, or, in other words, I was behaving ineffectively with respect to what I was observing. I repeated the word "reappearance" more than once, and then less common synonyms occurred to me in quick succession: "reoccurrence," "recurrence," "resurgence." Skinner and I had used the latter term to describe the autoshaping phenomenon heretofore described in the text (Epstein & Skinner, 1980). Though a year had passed since the autoshaping paper had been published, I was still puzzled by the effect we had reported. I now found myself thinking about *both* experiments. Over the next day or so, common elements occurred to me and then a simple rule that seemed to account for both results. A variety of scientific discoveries may come about as a result of similar processes (Epstein, in press-b). F. S. Keller (personal communication) has pointed out a similar case in Zwaardemaker's (1930) account of his invention of the olfactometer.

- EPSTEIN, R. (in press-b). Bringing cognition and creativity into the behavioral laboratory. In T. J. Knapp & L. Robertson (Eds.), *Contemporary views of cognition*. Hillsdale, NJ: Erlbaum.
- EPSTEIN, R., KIRSHNIT, C., LANZA, R. P., & RUBIN, L. (1984). "Insight" in the pigeon: Antecedents and determinants of an intelligent performance. *Nature*, 308, 1 March, 61-62.
- EPSTEIN, R., & MEDALIE, S. D. (1983). The spontaneous use of a tool by a pigeon. *Behaviour Analysis Letters*, 3, 241-247.
- EPSTEIN, R., & SKINNER, B. F. (1980). Resurgence of responding after the cessation of response-independent reinforcement. *Proceedings of the National Academy of Sciences, U.S.A.*, 77, 6251-6253.
- EPSTEIN, R., & SKINNER, B. F. (1981). The spontaneous use of a memoranda by pigeons. *Behaviour Analysis Letters*, 1, 241-246.
- EVERALL, E. E. (1935). Perversion in the rat. *Journal of Comparative Psychology*, 19, 343-369.
- FANTINO, E., & LOGAN, C. (1979). *The experimental analysis of behavior: A biological perspective*. San Francisco: W. H. Freeman.
- FERSTER, C. B., CULBERTSON, S., & BOREN, M. C. P. (1975). *Behavior principles* (Rev. ed.). Englewood Cliffs, NJ: Prentice-Hall.
- FREUD, S. (1920). *A general introduction to psychoanalysis*. New York: Boni & Liveright.
- FREUD, S. (1966). *Introductory lectures on psychoanalysis*. New York: W. W. Norton.
- HAMILTON, J. A., & KRECHEVSKY, I. (1933). Studies in the effect of shock upon behavior plasticity in the rat. *Journal of Comparative Psychology*, 16, 237-253.
- HENTON, W. W., & IVERSEN, I. H. (1978). *Classical conditioning and operant conditioning: A response pattern analysis*. New York: Springer-Verlag.
- HERBERT, E., PINKSTON, E., HAYDEN, M., SAJWAJ, T., PINKSTON, S., CORDUA, G., & JACKSON, C. (1973). Adverse effects of differential parental attention. *Journal of Applied Behavior Analysis*, 6, 15-30.
- HEYMAN, G. M. (1979). A Markov model description of changeover probabilities on concurrent variable-interval schedules. *Journal of the Experimental Analysis of Behavior*, 31, 41-51.
- HINTZMAN, D. L. (1978). *The psychology of learning and memory*. San Francisco: W. H. Freeman.
- HULL, C. L. (1934). The rat's speed-of-locomotion gradient in the approach to food. *Journal of Comparative Psychology*, 17, 393-422.
- HULL, C. L. (1935). The mechanism of the assembly of behavior segments in novel combinations suitable for problem solving. *The Psychological Review*, 42, 219-245.
- JOST, A. (1897). Die Associationsfestigkeit in ihrer Abhängigkeit von der Verteilung der Wiederholungen. *Zeitschrift der Psychologie*, 14, 436-472.
- KAREN, R. L. (1974). *An introduction to behavior theory and its applications*. New York: Harper & Row.
- KAZDIN, A. E. (1982). Symptom substitution, generalization, and response covariation: Implications for psychotherapy outcome. *Psychological Bulletin*, 91, 349-365.
- KÖHLER, W. (1925). *The mentality of apes*. London: Routledge and Kegan Paul.
- KREBS, J. R. (1978). Optimal foraging: Decision rules of predators. In J. R. Krebs & N. B. Davies, *Behavioral ecology*. Sunderland, MA: Sinauer Associates.
- LEA, S. E. G. (1979). Foraging and reinforcement schedules in the pigeon: Optimal and non-optimal aspects of choice. *Animal Behaviour*, 27, 875-886.
- LEITENBERG, H., RAWSON, R. A., & BATH, K. (1970). Reinforcement of competing behavior during extinction. *Science*, 169, 301-303.
- LINDBLOM, L. L., & JENKINS, H. M. (1981). Responses eliminated by noncontingent or negatively contingent reinforcement recover in extinction. *Journal of Experimental Psychology: Animal Behavior Processes*, 7, 175-190.
- MALTZMAN, I. (1955). Thinking: From a behavioristic point of view. *Psychological Review*, 62, 275-286.
- MARTIN, R. F. (1940). "Native" traits and regression in rats. *Journal of Comparative Psychology*, 30, 1-16.
- MASSERMAN, J. H. (1943). *Behavior and neurosis*. Chicago: University of Chicago Press.
- MCDOWELL, J. J. (1982). The importance of Herrnstein's mathematical statement of the law of effect for behavior therapy. *American Psychologist*, 37, 771-779.
- MILLER, N. E., & MILES, W. R. (1936). Alcohol and removal of reward: An analytical study of rodent maze behavior. *Journal of Comparative Psychology*, 21, 179-204.
- MINSKY, M. (1975). A framework for representing knowledge. In P. H. Winston (Ed.), *The psychology of computer vision*. New York: McGraw-Hill.
- MOWRER, O. H. (1940). An experimental analogue of "regression" with incidental observations on "reaction-formation." *Journal of Abnormal and Social Psychology*, 35, 56-87.
- NOTTERMAN, M. (1970). *Behavior: A systematic approach*. New York: Random House.
- O'KELLEY, L. I. (1940a). An experimental study of regression. I. Behavioral characteristics of the regressive response. *Journal of Comparative Psychology*, 30, 41-53.
- O'KELLEY, L. I. (1940b). An experimental study of regression. II. Some motivational determinants of regression and perseveration. *Journal of Comparative Psychology*, 30, 55-95.
- O'LEARY, K. D., & WILSON, G. T. (1975). *Behavior therapy: Application and outcome*. Englewood Cliffs, NJ: Prentice-Hall.
- PRYOR, K. W., HAAG, R., & O'REILLY, J. (1969). The creative porpoise: Training for novel behavior. *Journal of the Experimental Analysis of Behavior*, 12, 653-661.
- RACHLIN, H. (1976). *Behavior and learning*. San Francisco: W. H. Freeman.
- RAWSON, R. A., LEITENBERG, H., MULICK, J. A., & LEFEBVRE, M. F. (1977). Recovery of extinction responding in rats following discontinuation of reinforcement of alternative behavior: A test of two explanations. *Animal Learning and Behavior*, 5, 415-420.
- REYNOLDS, G. S. (1975). *A primer of operant conditioning* (Rev. ed.). Glenview, IL: Scott, Foresman.
- SAJWAJ, T., TWARDOSZ, S., & BURKE, M. (1972). Side effects of extinction procedures in a remedial school. *Journal of Applied Behavior Analysis*, 5, 163-175.
- SANDERS, M. J. (1937). An experimental demonstration of regression in the rat. *Journal of Experimental Psychology*, 21, 493-510.
- SEARS, R. R. (1941). Non-aggressive reactions to frustration. *Psychological Review*, 48, 343-346.
- SEARS, R. R. (1943). *Survey of objective studies of psychoanalytic concepts*. New York: Social Science Research Council.
- STADDON, J. E. R., & SIMMELHAG, V. L. (1971). The 'superstition' experiment: A reexamination of its implications for the principles of adaptive behavior. *Psychological Review*, 78, 3-43.
- YATES, A. J. (1958). Symptoms and symptom substitution. *Psychological Review*, 55, 371-374.
- YATES, A. J. (1970). *Behavior therapy*. New York: John Wiley.
- ZWAARDEMAKER, H. (1930). An intellectual history of a physiologist with psychological aspirations. In C. Murchison (Ed.), *A history of psychology in autobiography* (Vol. 1, pp. 491-516). Worcester, MA: Clark University Press.