

B. F. Skinner's Contributions to Applied Behavior Analysis

Edward K. Morris and Nathaniel G. Smith
University of Kansas

Deborah E. Altus
Washburn University

Our paper reviews and analyzes B. F. Skinner's contributions to applied behavior analysis in order to assess his role as the field's originator and founder. We found, first, that his contributions fall into five categories: the style and content of his science, his interpretations of typical and atypical human behavior, the implications he drew from his science for application, his descriptions of possible applications, and his own applications to nonhuman and human behavior. Second, we found that he explicitly or implicitly addressed all seven dimensions of applied behavior analysis. These contributions and the dimensions notwithstanding, he neither incorporated the field's scientific (e.g., analytic) and social dimensions (e.g., applied) into any program of published research such that he was its originator, nor did he systematically integrate, advance, and promote the dimensions so to have been its founder. As the founder of behavior analysis, however, he was the father of applied behavior analysis.

Key words: B. F. Skinner, behavior analysis, applied behavior analysis, history

Having made contributions that were both profound and practical, B. F. Skinner (1904–1990) was arguably the most eminent psychologist of the 20th century (Haggblom et al., 2002). In 1970, the behavioral pharmacologist Peter Dews described Skinner's contributions this way:

Massive advances in science can affect society either by changing man's views of himself or by leading to substantive changes in his environment. The contributions of Copernicus and Darwin profoundly affected society through their philosophical implications, though they have made little difference to the contents of one's house or how one does things. Dalton's Atomic Theory and Faraday's Electromagnetism had little influence on the nineteenth century Establishment, although they led, through chemistry and electricity, to profound changes in man's surroundings. The work of a few people has affected society both ways; Pasteur's germs af-

fecting both people's view of life and also their beer, wine, and medical treatment. Skinner's discoveries in the field of the transaction of a higher organism with its environment will have a greater and more enduring effect on man's view of himself than the views of Freud. Meanwhile, slowly but increasingly, education is being influenced by Skinner's findings, and perhaps some day they may influence broadly how men dispense justice and punishment, raise children, handle neuroses, organize an economic system and conduct international relations. (Dews, 1970, pp. ix–x)

Dews was prescient. In his research, Skinner established a science of behavior—the experimental analysis of behavior (Skinner, 1938, 1956a, 1966c). In applying his empiricist tenets and selectionist principles to this science, he formulated its philosophy—radical behaviorism (Skinner, 1945b, 1950, 1957c). Skinner was the originator of both (Schneider & Morris, 1987; Vargas, 2001, 2004). By integrating, advancing, and promoting them (Skinner, 1938, 1953a, 1974), he also founded a new system of psychology, if not a new discipline—behavior analysis (see Michael, 1985). Whether he was also the originator and founder of applied behavior analysis is, as yet, undetermined. Our purpose is to reach some

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Correspondence may be sent to the first author, Department of Applied Behavioral Science, University of Kansas, 1000 Sunnyside Avenue, Lawrence, Kansas 66045 (e-mail: ekm@ku.edu).

conclusions about these matters (on the originator–founder distinction, see Schultz & Schultz, 1987, p. 55).

What we find in the literature, to date, is varied. Some texts mention none of Skinner's applied contributions (e.g., Chance, 1998; Kazdin, 2001), whereas others offer assessments that range from the circumspect to the certain. Here are some examples: (a) His writings "contain insightful examples from everyday life, and they interested many people from many disciplines in applying behavior principles to a broad range of topics" (Baldwin & Baldwin, 2001, p. vii); (b) "Skinner's writings have been most influential . . . in extending the application of his principles of behavior to new areas" (Cooper, Heron, & Heward, 1987, p. 10); (c) "His many books and papers on applied technology led to the field of applied behavior analysis" (Pierce & Cheney, 2004, p. 10); (d) "B. F. Skinner (1904–1990) was a pioneer and founder of behavior modification" (Sarafino, 2001, p. 2); and (e) "Skinner's work is the foundation of behavior modification" (Miltenberger, 1997, p. 10; see also Krasner, 2001, p. 213).

Although applied behavior analysis and behavior modification should not be conflated (see J. M. Johnston, 1996; J. Moore & Cooper, 2003; Vollmer, 2001), we doubt that the authors of these comments meant to distinguish between them in this context. They were, presumably, writing in general about Skinner's contributions. Whatever their assessments, they seemingly did not base them on systematic reviews of his work. In deciding on the nature of Skinner's contributions, we offer one such review and organize it chronologically, starting with among his first publications in 1930 and ending in 1968, when the *Journal of Applied Behavior Analysis (JABA)* began publication. After that, no one can be said to have founded the field; it was founded. Our exercise is inductive. We neither propose nor test any theories about Skinner's contributions. Theories may follow from our review and be

useful in further analyzing his contributions, but they are not our present concern.

APPLIED BEHAVIOR ANALYSIS

Before beginning, we need a definition of applied behavior analysis at the time the field was founded so that Skinner's contributions can be fairly assessed against those standards, not later ones. For this, we find the following on the inside front cover of *JABA*'s first issue: "[*JABA*] is primarily for the original publication of reports of experimental work involving applications of the analysis of behavior to problems of social importance." Later in that issue, Baer, Wolf, and Risley (1968) expanded on this in their article, "Some Current Dimensions of Applied Behavior Analysis." Applied behavior analysis, they wrote, "must be *applied, behavioral, and analytic*; in addition, it should be *technological, conceptually systematic, and effective*, and it should display some generality" (p. 92). This definition excludes later refinements and advances regarding, for instance, social validity (e.g., Wolf, 1978), program integrity and treatment fidelity (e.g., L. Peterson, Homer, & Wonderlich, 1982), and the concept of context (e.g., Baer, Wolf, & Risley, 1987). We are not dismissing their importance in the evolution of applied behavior analysis, just restricting our review of Skinner's contributions to the field to the time it was founded.

We also restrict our review to *JABA*'s main focus at the time it was founded—*operant* behavioral processes analyzed *within* individuals (Agras, Kazdin, & Wilson, 1979; Martin & Pear, 1996, p. 390; Willis & Giles, 1976, pp. 15–19). At the time, the journal did not often address respondent behavioral relations (e.g., desensitization; Wolpe, 1958; but see Leitenberg, Agras, Thompson, & Wright, 1968) or applied psychology based on between-subject analyses (e.g., cognitive deficits; Fisher & Lerner, 1994; but see Guess, Sailor, Rutherford, & Baer,

1968) or public health research that employed population-based measures and methods (e.g., underage tobacco use; Biglan et al., 1995; but see Bushnell, Wrobel, & Michaelis, 1968). Thus, we mainly restrict Skinner's contributions to *JABA's* main focus. In doing so, though, we do not mean to diminish the importance of other processes and problems, and methods and levels of analysis. To the contrary, we encourage them. They were just not that much present at *JABA's* founding.

To forecast our findings somewhat, Skinner's applied contributions fall into five categories: (a) the style and content of his science, (b) his interpretations of typical and atypical behavior, (c) implications he drew from his science for application, (d) his descriptions of possible applications, and (e) his own applications to human and nonhuman behavior. In making these contributions, he also addressed the seven dimensions of applied behavior analysis. As for whether he was the field's founder or played another role—for instance, that of its father—the answer depends on how and where he incorporated the dimensions into his work, as we shall see.

THE BEHAVIOR OF ORGANISMS **(1938)**

Skinner's most fundamental contribution to applied behavior analysis was the style and content of his science. By his style, we mean his methodology, which ranges from his empirical epistemology to his experimental practices. By the content of his science, we mean what he discovered with this methodology—the basic principles of operant behavior. Both the style and content of his science were nascent in his first publications (e.g., 1930a), afterwards maturing into the behavioral system he described in his first book, *The Behavior of Organisms* (1938).

Scientific Style: Behavioral, Analytic, and Technological

Skinner's style had five characteristics (see Sidman, 1960; Skinner, 1947a,

1950, 1956a, 1966c). First, knowledge was defined as effective action, not contemplation. Effective action included reliable description, accurate prediction, and experimental control, with an emphasis on the last two—prediction and control. Second, prediction and control were not based on correlations between independent and dependent variables but on the discovery and demonstration of functional relations between them—functional analysis. Third, the discovery and demonstration of these relations were, respectively, the process and product, not of statistical analyses of between-group comparisons but of direct experimental control of the subject matter—within-individual research designs. Fourth, functional relations that had broad generality described basic principles—principles of behavior. And fifth, when those principles were integrated with one another, they constituted a theory—a theory or system of behavior.

These characteristics were not, individually, unique to Skinner. He acquired them from a number of sources: the empiricist philosopher Francis Bacon (1620/1960; Smith, 1996); Claude Bernard, the father of experimental medicine (1865/1949; see Thompson, 1984); the Nobel laureate physiologist Ivan P. Pavlov (1927; see Catania & Laties, 1999); the philosophical pragmatist C. S. Peirce (1878; see Moxley, 2002); Ernst Mach, the physicist-philosopher of science (1883/1942; see Marr, 1985); the experimental biologist Jacques Loeb (1916; see Hackenberg, 1995); and the general physiologist and Skinner's mentor W. J. Crozier (1928; see Kazdin, 1978, pp. 91–93). In the aggregate, however, these characteristics were an original synthesis of modern advances in science and philosophy that Skinner uniquely extended to behavior as a subject matter in its own right (J. M. Johnston & Pennypacker, 1993; Sidman, 1960; see Lattal & Chase, 2003; Smith, 1986, pp. 257–297).

Skinner's style of science allowed him to describe and even make appli-

cations that were unlikely to have arisen in the research programs of his neo-behaviorist colleagues (e.g., Hull, 1943; Tolman, 1932). In fact, his style made applied behavior analysis almost inevitable. It only need be extended to behavior of relatively immediate social importance, as sometimes seen in the early volumes of the *Journal of the Experimental Analysis of Behavior* (*JEAB*, established in 1958; e.g., Ayllon & Michael, 1959). His style was, moreover, foundational to the three dimensions of applied behavior analysis that made the field scientific. It was behavioral, employing precise, quantifiable, and accurate measurements (Baer et al., 1968, p. 93). It was analytic, demonstrating direct and reliable experimental control (pp. 93–95). And, it was technological, thoroughly describing its experimental preparations, procedures, and materials (pp. 95–96; see Iversen & Lattal, 1991; Lattal & Perone, 1998; Skinner, 1966c).

Scientific Content: Conceptually Systematic

As already noted, the content of Skinner's science was the principles of behavior. In *The Behavior of Organisms* (1938), he addressed these in chapters on what we know of today as operant reinforcement and extinction, response differentiation, schedules of reinforcement, stimulus control, and establishing operations. In these and other chapters, he addressed respondent conditioning and extinction, aversive control, conditioned reinforcement, chaining, stimulus generalization, and response induction. Although the content of Skinner's science naturally evolved after 1938 (see Mazur, 2002; Pear, 2001), the principles he described in his book are found in every modern textbook on applied behavior analysis (e.g., Miltenberger, 1997).

These principles were also the basis of the field's conceptually systematic dimension. As Baer et al. (1968) remarked, "The field . . . will probably advance best if the published descrip-

tions of its procedures are not only precisely technological, but also strive for relevance to principle" (p. 96). The examples they provided were operant: reinforcement, fading, and errorless discrimination. Baer et al. continued: Relating technological descriptions to a conceptual system shows how "procedures may be derived from basic principles. This can have the effect of making a body of technology into a discipline rather than a collection of tricks" (p. 96). This point is conveyed by the Chinese proverb, "Give a man a fish and you feed him for a day. Teach a man to fish and you feed him for a lifetime." Recast in our context, we have, "Give students a behavioral technology, and they can solve today's problems. Teach them behavioral principles, and they can solve tomorrow's."

In any event, by 1938, Skinner had established a science of behavior whose style and content were foundational to four of the seven dimensions of applied behavior analysis. Its style was behavioral, analytic, and technological. Its content was conceptually systematic.

BEFORE THE BEHAVIOR OF ORGANISMS: 1930–1938

Toward the end of *The Behavior of Organisms*, Skinner (1938) forecasted the emergence of applied behavior analysis in the following statement:

The reader will have noticed that almost no extension to human behavior is made or suggested. This does not mean that he is expected to be interested in the behavior of the rat for its own sake. The importance of a science of behavior derives largely from the possibility of an eventual extension to human affairs. (p. 441)

Although he warned that applications should not be overly emphasized in the early stage of this science, he continued,

It would, of course . . . have been possible to suggest applications . . . in a limited way at each step. This would probably have made for easier reading, but it would have unreasonably lengthened the book. Besides, the careful reader should

be as able to make applications as the writer. . . . Let him extrapolate who will. (pp. 441–442)

Skinner himself “was soon extrapolating” (Skinner, 1989a, p. 131). What he meant by extrapolation, extension, and application, however, was broader than what *applied* meant when applied behavior analysis was founded. They encompassed the remaining four categories of his contributions: his interpretations of typical and atypical behavior, implications he drew from his science for application, his descriptions of possible applications, and his own applications.

Earliest Applications

At first, at Harvard University (1928–1936), Skinner’s applications were not as closely aligned with the eventual style and content of his science as we might expect, but this is not unusual in a young science. Research methods are often, at first, exploratory, and the subject matter is not always well defined. A distinctive program of research may take a while to evolve. As a result, early applications may be little more than exercises in critical thinking, not extensions of established methods and content. This was true for Skinner as well (see Coleman, 1984).

For example, one of his earliest contributions—“On the Inheritance of Maze Behavior” (Skinner, 1930b)—was a critique. He criticized (a) the methods used in a study of the relation between genetic strains of mice and reaction times and learning, and (b) the conclusions drawn from the resulting data (see Vicari, 1929). Skinner’s critique was socially important and thus “applied” in that, at the time, genetics had dark implications for cultural practices, among them, eugenics (Garth, 1930; see Gould, 1981; Leahey, 2004, pp. 460–468). Skinner was also critical of research on extrasensory perception. For instance, in a review of J. B. Rhine’s (1937) *New Frontiers of the Mind* (Skinner, 1937b), he pointed out methodological flaws and biases in the studies of clairvoyance and telepathy

in card-guessing tasks. Turning to perception, he described how, under low illumination, white circles appeared to be tinted when set against a black background (Skinner, 1932). In explaining this, he offered a physiological “functional-element theory of color vision” that, he urged, needed testing. Skinner’s other applications at this time fell into three areas to which he would contribute more substantively throughout his career: verbal behavior, behavioral pharmacology, and behavioral engineering.

Verbal Behavior

In 1934, Skinner began working on *Verbal Behavior* (1957c). In the first of his related publications—“Has Gertrude Stein a Secret?” (Skinner, 1934)—he pointed out that Stein’s prose style was the result of “automatic writing.” This is writing in which reading and writing occur simultaneously yet independently of one another, with the content of the writing being often unconscious. This was Skinner’s first publication in the popular press (the *Atlantic Monthly*). Afterward, most of his popular press publications addressed applications, and many of his applied publications appeared in the popular press (see Rutherford, 2004).

Skinner’s (1936) next relevant publication was “The Verbal Summator and a Method for the Study of Latent Speech.” Through accident and ingenuity, he invented a recording of vowel sounds (e.g., “uh-oh-ah-uh”) that, with instructions to listeners to report what they heard, often yielded responses that were “significant,” for instance, about a listener’s work and worries. The summator was soon adopted and adapted in clinical psychology as a projective technique, an auditory version of the Rorschach test (Shakow & Rosenzweig, 1940), but it eventually fell out of favor for practical and methodological reasons (e.g., efficiency; see Rutherford, 2003a). Finally, in “The Distribution of Associated Words,” Skinner

(1937a) described a logarithmic distribution for the rank order of verbal responses associated with verbal stimuli. He referred to the associations as "simple units in the dynamics of verbal behavior" (p. 72).

Behavioral Pharmacology

After Skinner moved to the University of Minnesota (1936–1945), he and W. T. Heron (1937) published what has been regarded as the first paper in behavioral pharmacology—"Effects of Caffeine and Benzedrine upon Conditioning and Extinction" (Laties, 2003; Poling, 2000, pp. 16–20). They applied the style and content of Skinner's science to analyze the effects of drugs on behavior and vice versa. Although the study had no discernible influence on pharmacology at the time (Dews, 1987), Skinner was afterward a strong advocate of such applications (Morse, 2005).

Behavioral Engineering

Also in 1937, Skinner made his first public demonstration of behavioral engineering, that is, of the power of his science to achieve certain ends, usually practical ones. He systematically replicated a study in which chimpanzees learned to exchange poker chips for food (Cowles, 1937) by training a rat named Pliny the Elder to pull a string to obtain a marble that Pliny lifted up and dropped down a tube, which produced food. Although not an application of Skinner's science to human behavior, it was a demonstration of the effectiveness of positive reinforcement, a test of the validity of his science, and a microcosm of the token economy (see Ayllon & Azrin, 1968; Kazdin, 1977). Although the demonstration drew national attention through an article in *Life* magazine ("Working Rat," 1937), Skinner's only report of it at the time was a brief mention in *The Behavior of Organisms* (1938, pp. 339–340).

AFTER THE BEHAVIOR OF ORGANISMS: 1939–1945

After publishing *The Behavior of Organisms* (1938), Skinner continued to address the foregoing topics and others, but they remained varied. Only Skinner's basic research was systematic. Nonetheless, some of his applications were significant and others became famous.

Inheritance

A decade after Skinner had critiqued research that reportedly demonstrated the inheritance of maze behavior, he himself studied inheritance. Heron and Skinner (1940) studied the extinction of bar pressing in strains of maze-bright or maze-dull rats. Although the strains differed in their response rates, Heron and Skinner attributed this to differences in "drive"—a heightened effect of food deprivation that was correlated with maze brightness—rather than to inherited differences in learning per se (see J. L. Fuller & Thompson, 1978, pp. 132–151). In light of this research and the misconception that Skinner was a radical environmentalist (e.g., de Waal, 2001, p. 57; Pinker, 2002, p. 20; contra. Morris, Lazo, & Smith, 2004), Heron's (1935) research on selective breeding is, ironically, now cited as having been "holding a place for behavioral genetics during the period of an ascendant environmentalism in psychology" (McClearn & Foch, 1988, p. 686).

Verbal Behavior

Skinner was also studying verbal behavior. He and Stuart Cook systematically replicated his earlier study on the distribution of associated words, this time discovering factors that correlated with the distributions, for instance, the frequency of the words in everyday speech (Cook & Skinner, 1939). In addition, he analyzed alliteration in Shakespeare's sonnets, seeking evidence that words beginning with consonants strengthened the probability that the same first consonants would

appear in words that followed. He found no such effects beyond those expected by chance, and concluded that, for Shakespeare, alliteration was not the product of a poetic process (Skinner, 1939). In later extending these methods to Swinburne's poetry, though, he did find evidence for formal strengthening in assonance (1941b).

In addition, Skinner (1942) analyzed data from a national study on guessing; guessing was for him "a special kind of (usually verbal) behavior" (p. 495). After challenging a Gestalt interpretation of the patterns of sequential guesses, he offered a contingency-based account: Preceding guesses affected the probability of subsequent guesses. He elaborated,

Studies of formal patterning in speech have frequently indicated a substantial tendency to repeat a response already made (see, for example, [Skinner, 1941b]), and various lines of evidence suggest that this is a primary characteristic of verbal behavior. Nevertheless, a tendency is set up in the growing child, through readily observable processes of conditioning, which opposes repetition. (pp. 499-500)

In a footnote on this point, he wrote,

Reinforcements applied to speech to oppose prior tendencies are fairly common and, indeed, give rise to some of the most important properties of verbal behavior. There is a special problem involved in separating opposed effects for measurement, but it is not insolvable. (p. 500)

Skinner's (1943) response to criticisms of this paper was among his final publications on verbal behavior before his book was published (see also Skinner, 1948a).

Perception

In a chapter titled "The Psychology of Design," Skinner (1941a) again evinced interest in perception. He argued that, although drawings and paintings could be analyzed formally, art and its appreciation were neither physics nor mathematics. They were biology and behavior. They concerned, for example, (a) the effects of visual patterns on "looking"; (b) how the phi phenomenon was manifested by eye movements between spots on a canvas,

giving its content the appearance of motion; (c) the role of "learned reactions" in art appreciation; and (d) the effect of visual patterns in eliciting unconscious and conscious "emotional reactions."

Anxiety

In a paper with William Estes, "Some Quantitative Properties of Anxiety" (Estes & Skinner, 1941), Skinner for the first time experimentally analyzed, not just interpreted, an ordinary-language category of action: emotion. Today, we would call this an animal model of human behavior (Overmier, 1992). Estes and Skinner began by describing the received view on anxiety. It was thought to have two characteristics: "(1) It is an emotional state . . . and (2) the disturbing stimulus which is principally responsible for it does not precede or accompany the state but is 'anticipated' in the future" (p. 390). They then recast these characteristics, arguing, first, that because a future stimulus cannot control present behavior, the emotional state must be due to a current stimulus, one that had in the past been followed by the "disturbing" stimulus. Second, they expanded the concept of emotional "state" to include not just elicited reactions to current stimuli but also the effect of those stimuli on ongoing operant behavior. Estes and Skinner then experimentally analyzed (a) the suppressive effect of conditioned preaversive stimuli on schedule-maintained behavior as a function of (b) different levels of drive, response maintenance and extinction conditions, and the presence and absence of the unconditioned aversive stimulus. In the 1950s and 1960s, this study became foundational for alternatives to structural, physiological, and purely Pavlovian models of emotion (see Fantino, 1973, pp. 299-302; Mil-lenson, 1967, pp. 441-455; Skinner, 1959c), as well as for research that assessed the effects of pharmacological agents in relieving emotional distress

(see Millenson & Leslie, 1979, pp. 413–433).

Project Pigeon: 1940–1944

During World War II, Skinner undertook a program of applied research in which he trained pigeons to guide simulated bombs to precise destinations. Funded by the General Mills Company and the United States Office of Scientific Research and Development (OSRD) and called “Project Pigeon” (Skinner, 1960b), this was Skinner’s first sustained program of behavioral engineering. Although he could not overcome differences between his style of science and his disciplinary outlook and those of the OSRD engineers (Capshaw, 1996), Skinner and his colleagues (Estes, Norm Guttman, and Keller and Marian Breland) conducted significant use-inspired basic research over the course of the project on schedules of reinforcement, stimulus control, and establishing operations (e.g., food deprivation, oxygen pressure, and temperature).

In the course of the project, Skinner, Guttman, and Keller Breland discovered shaping (Skinner, 1958a, 1972d; see G. B. Peterson, 2004). Although Skinner had used lever pressing in rats as a dependent variable since 1930, apparently he had never directly shaped it. He simply placed his rats in their chambers and waited for lever pressing to occur, sometimes putting food on the lever to induce it. He also did not directly shape the feats of Pliny the Elder. Instead, he modified Pliny’s physical environment (e.g., drop-off edges), waited for an appropriate response to occur, reinforced it to strength, and then modified the physical environment again. Similarly, in the research reported in *The Behavior of Organisms* (1938) on the differentiation of response intensity and duration, he engineered the physics of the response requirements (e.g., the force required to press the lever), waited for a response that met those requirements, and reinforced it.

Only in a lighter moment in Project Pigeon did Skinner discover shaping as we know it today. He and his colleagues sought to train a pigeon to bowl by having it swipe its beak at a ball. Although they set up the requisite physical environment, the pigeon did not swipe at the ball before they grew tired of waiting. Skinner thus reinforced the pigeon’s first approximation of a swipe and then others that successively approached its final form. The results “amazed” him (Skinner, 1958a, p. 94). He had never previously observed such rapid, effective, and directed change in behavior. On the basis of this discovery, he reformulated his account of verbal behavior to emphasize the role of reciprocal social contingencies and began more resolutely to extend his science to human behavior (G. B. Peterson, 2004). Although he did not use the term *shaping* until 1951 (Skinner, 1951b), it has become a technical term for an indispensable procedure for establishing new behavior (Kazdin, 2001, pp. 43–46, 274–276; Martin & Pear, 1996, pp. 64–76), and applications in behaviorally based robotics (Savage, 2001).

Project Pigeon was Skinner’s first application of his science beyond his own teaching and research. As he later related, “The research that I described in *The Behavior of Organisms* appeared in a new light. It was no longer merely an experimental analysis. It had given rise to a technology” (Skinner, 1979, p. 274). In later turning to education, he noted the “direct genetic connection between teaching machines and Project Pigeon” (Skinner, 1960b, pp. 36–37), that is, the engineering of behavior. A more extended application of Skinner’s science was the Brelands’ (1951) founding of Animal Behavior Enterprises in 1947 to train animals for entertainment and commercial purposes (e.g., circuses, advertising). Perhaps the ultimate test, though, was the National Aeronautics and Space Administration’s use of Skinner’s science to train chimpanzees for its Project Mer-

cury flights in the late 1950s and early 1960s (see Rohles, 1966, 1992).

Baby in a Box

Skinner's next application—referred to as the “air crib,” “baby tender,” and “heir conditioner”—was actually not much of a behavioral application. As described in his 1945 article, “Baby in a Box” (Skinner, 1945a), the air crib was a self-contained, sound-attenuating living space with a full front window, air filters, controls for heat and humidity, and a continuous roll of sheeting for changing the bed. Skinner constructed it in 1944 for his wife, Eve, and their second daughter, Deborah, to enhance Deborah's comfort, health, and development, and make infant and child care more enjoyable (e.g., increasing the opportunities for joint play by reducing the time spent washing clothes; see Benjamin & Nielsen-Gammon, 1999; Jordan, 1996).

Although a contribution to domestic engineering, as well as another of Skinner's inventions, the air crib served biological functions as much as behavioral ones, and was equally a test of materials science in the mid-1940s as a test of behavioral science. In fact, Skinner conducted no experiments with Deborah beyond adjusting the crib's heat and humidity so that she would play and sleep comfortably. “Baby in a Box” was, at best, a case study of the air crib's contributions to Deborah's and Eve's health and happiness. Today, the application that most closely resembles the air crib is medical—isolettes used in neonatal infant care units.

The air crib, of course, is the subject of urban legends, a recent one appearing in Slater's (2004) *Opening Skinner's Box: Great Psychological Experiments of the Twentieth Century*. Here, Skinner had allegedly confined Deborah to the air crib for 2 years and meted out rewards and “mean punishments,” making her psychotic, which led her to commit suicide by gunshot at the age of 31 in a bowling alley in Billings,

Montana. Deborah Skinner Buzan afterward cogently refuted this story in a letter to the editor of *The Guardian* (Buzan, 2004).

WALDEN TWO

We now come to Skinner's (1948d) novel, *Walden Two*, written in 1945 and published in 1948. The book was patterned, in part, after Bacon's (1624/1942) utopian work, *New Atlantis*, in which the physical and biological sciences were used to improve the human condition. In *Walden Two*, behavioral science was applied to the same end. The impetus for Skinner's book was, in part, both social and personal. First, in the course of a dinner conversation with a friend whose son-in-law was stationed in the South Pacific, Skinner mused about what young people would do when World War II ended. “What a shame,” he said, “that they would abandon their crusading spirit” (Skinner, 1979, p. 292). When asked what they should do, he responded, “They should experiment: They should explore new ways of living, as people had done in the communities of the nineteenth century.” Although many of those communities had failed, Skinner was optimistic: “Young people today might have better luck. They could build a culture that would come closer to satisfying human needs than the American way of life” (1979, p. 292). The personal impetus for writing the book lay in dissatisfactions with Skinner's own life:

I had seen my wife and her friends struggling to save themselves from domesticity, wincing as they printed “housewife” in those blanks asking for occupation. Our older daughter had just finished first grade, and there is nothing like a first child's first year in school to turn one's thoughts to education. (Skinner, 1976, p. v)

Applications: Cultural Practices

Given Skinner's interest in extending his science to human behavior, his optimism about cultural design, and his dissatisfaction with the status quo, we would expect him to have described

the *process* of establishing community practices (i.e., the style of Skinner's science), not so much the community's already established *practices*. His book, however, mainly described the latter. Among these were practices in childrearing (e.g., group care), education (e.g., learning by discovery), work (e.g., labor credits), and environmental stewardship (e.g., sustainable agriculture). Given that the book described established practices, it likely had little direct influence on the process of deriving, implementing, and validating specific behavioral technologies. In fact, terms such as the "principles" of behavioral engineering were used sparingly throughout the book, the "science of behavior" only twice, and "reinforcement theory" seemingly just once.

*Skinner's Utopian Vision:
Processes or Practices*

Perhaps because *Walden Two's* (1948d) practices were established and the process mainly implied, the practices have been taken to be Skinner's utopian vision and thus a blueprint for intentional communities (Altus & Morris, 2004). Skinner, however, had no blueprint, which is a common misunderstanding (e.g., Kuhlman, 2005), and his utopian vision was different. His vision was that intentional communities take an empirical approach to discovering and demonstrating cultural practices that worked. On this view, *Walden Two's* practices were contingent, not essentialist. They were contingent on what worked in the community's historical and then-current American context. Experimentation was the only constant. Skinner made this point several times through the character of T. E. Frazier. For example, "The actual achievement is beside the point. The main thing is, we encourage our people to view every habit and custom with an eye to possible improvement. A constantly experimental attitude toward everything—that's all we need" (p. 25). And, "I've very

much misrepresented the whole system if you suppose that any of the practices I've described are fixed. We try out many different techniques. Gradually we work toward the best possible set" (p. 106). In speaking to this theme later, Skinner commented,

I had no idea how the principles could be applied to real live people in a fairly complex organism, but we've found out since then. . . . Today we have much more relevant information in setting up communities like *Walden Two* and, by experimenting, I am sure we could arrive at a viable pattern. If it turns out to be the pattern of *Walden Two*, I'll have made one of the most remarkable guesses in history. (Hall, 1972, p. 71)

Skinner's vision, then, was not about particular community practices but about an empirical approach to deriving, implementing, and validating practices that worked.

Like the practices in *Walden Two* (1948d), the practices now so often identified with applied behavior analysis—for instance, discrete-trial behavioral interventions for children with autism (e.g., Lovaas, 1981, 1987) and "behavior modification" in general (Kazdin, 2001; Sarafino, 2001)—are also not essentialist, but contingent. They have been selected for by their effectiveness in biological, individual, social, and cultural contexts. The only constant is the process of deriving, implementing, and validating those practices through the experimental analysis of behavior (Baer, 2001). On this view, there are no "ABA" interventions, only interventions that have been discovered and demonstrated to be effective through empirical research. Even though these applied practices (behavior modification) and experimental analyses of them (applied behavior analysis) may share a common conceptual system, they are different activities (Deitz, 1978, 1983). If the distinction is not respected, then their unique contributions to improving the human condition may be misunderstood in the behavioral, social, and cognitive sciences, and by funding agencies, to the detriment of the discipline and the culture

at large (J. M. Johnston, 1996; J. Moore & Cooper, 2003; Vollmer, 2001).

Applications: Scientific Processes

Although *Walden Two's* (1948d) practices were mainly established, Skinner did occasionally describe the process of how his science could be applied to solving problems. The more conspicuous of these practices, though, were aversive. Although not now normative in applied behavior analysis, aversive practices were evident in *JABA's* first issue (e.g., Powell & Azrin, 1968; Risley, 1968). One such practice in *Walden Two* was the use of an electric fence to control the grazing patterns of sheep (pp. 14–15). Of this use of punishment, Frazier commented dismissively, “It’s a primitive principle of control” (p. 251). As for punishment with humans, he noted, “we don’t punish. We never deliver an unpleasantness in the hope of repressing or eliminating undesirable behavior” (p. 104). Some of *Walden Two's* applications, though, did use negative reinforcement, for instance, to teach self-control and to reduce destructive emotions through systematic desensitization, but this was far from the norm for Skinner. Although he did not deny the usefulness of aversive control in extreme cases (e.g., to suppress life-threatening self-injurious behavior; Skinner, 1988b), he was deeply critical of punishment as a personal, social, or cultural practice (Skinner, 1971b, pp. 62–100; 1973a).

Aversive conditioning and desensitization were not new in 1945, of course. In the 1920s, John B. Watson and Rosalie Rayner (1920) had conditioned a child’s fear of a rat (see B. Harris, 1979) and, under Watson’s oversight, Mary Cover Jones (1924b) eliminated a child’s fear of a rabbit (see also Jones, 1924a; Ollendick & King, 1998). In 1935, Hobart and Molly Mowrer (1938) developed the bell-and-pad method for treating nocturnal enuresis (see Houts, 2003). A few years later, Mowrer’s (1939) article, “A

Stimulus-Response Analysis of Anxiety and Its Role as a Reinforcing Agent,” offered an interpretation of psychoanalysis based on Pavlov’s (1927) research on conditioned reflexes and Hull’s (1943) drive-reduction theory of instrumental conditioning (see Dollard & Miller, 1950; Miller & Dollard, 1943). These theories and this research contributed in important ways to the emergence of behavior therapy in the late 1950s (e.g., Eysenck, 1960; Franks, 1964; Wolpe, 1958; see O’Donohue, Henderson, Hayes, Fisher, & Hayes, 2001), but played less of a role in applied behavior analysis. The scientific style and content of behavior therapy in the 1960s—for instance, statistical rather than experimental control, and respondent behavioral processes—were not the focus of applied behavior analysis.

Notwithstanding Kazdin’s (1977) comment that Skinner’s “most ambitious extension of operant principles was in . . . *Walden Two*” (p. 22) or Krasner’s (2001, p. 217) more recent remark that “behavior therapy was given [its] classic expression” in the book, the book described little about therapy per se. Its main contribution was the very idea of application—a behavioral zeitgeist for those who would later apply Skinner’s science.

Applied and Effective

Skinner did describe one practice in *Walden Two* (1948d) that became foundational to applied behavior analysis, specifically to its applied and effective dimensions. By *applied*, Baer et al. (1968) meant that “the behavior, stimuli, and/or organism under study are chosen because of their importance to man and society, rather than their importance to theory” (p. 92). By *effective*, they meant that an application’s “practical importance, specifically its power in altering behavior enough to be socially important, is the essential criterion” (p. 96). As for the instantiation of these dimensions in *Walden Two*, its members were surveyed about

their "satisfaction" with community practices, that is, with the importance and effectiveness of those practices. In this, Skinner anticipated the role of consumer satisfaction more than two decades before Baer et al. (1968) addressed the ethical basis of social interventions and three decades before Wolf (1978) made a case for what we know today as social validity.

AFTER WALDEN TWO: 1945–1953

Between writing *Walden Two* in 1945 and publishing *Science and Human Behavior* in 1953, Skinner returned to topics he had addressed earlier (e.g., Skinner, 1951a) and took up new ones. After moving to Indiana University (1945–1947), he criticized analyses of human nature based in folk psychology rather than in natural science (Skinner, 1946); social sciences that gathered facts but did not establish functional relations among them (Skinner, 1948b); and "thinking machines" that modeled human action on cybernetics rather than on the principles of behavior (Skinner, 1951c).

Superstition

Perhaps because of its simplicity and inherent interest, Skinner's most widely cited research at this or perhaps any time was another animal model, this one of superstition (Skinner, 1948c; see Todd & Morris, 1983). He found that fixed-time, response-independent deliveries of reinforcers produced idiosyncratic, yet often stable, patterns of behavior in pigeons, for example, "a pendulum motion of the head and body" (p. 168). He likened these actions to human "rituals for changing one's luck at cards" and a bowler's "twisting and turning his arm and shoulder" after releasing the ball (p. 171). For a modern review of this and related research, see Vyse's (1997) *Believing in Magic: The Psychology of Superstition*.

Paranormal Phenomena

Skinner (1947c) was also again critical of research on paranormal phenomena, this time on psychokinesis, that is, the purported ability of the mind to control matter, for instance, to bend spoons. In addition to raising his earlier objections about the lack of experimental control, he noted that, by their very definition, paranormal phenomena were "out of reach of scientific inquiry" (p. 34). They were part of a literally dualistic worldview (see also Skinner, 1947a). He voiced these criticisms again a year later in a letter to the *American Scientist*, objecting to its having published a column on "precognitive telepathy" (Skinner, 1948a).

Applied Psychology

In 1947, Skinner (1947b) published a remarkable chapter titled "Experimental Psychology," in which he defined the field as the functional analysis of behavior. Its goal was to understand behavior through prediction and control, where prediction and control were a means for understanding, not ends in themselves. He then criticized applied psychology for not being experimental, that is, for using correlational methods—prediction without control. Yet, he was optimistic: Applied psychology would become experimental when its practitioners started working with behavior directly. This was not a "matter of bringing the world into the laboratory, but of extending the practices of an experimental science to the world at large. We can do this as soon as we wish" (p. 24). Until this happens, though, he wrote, "Our definition of the experimental field is . . . not yet complete, since [experimental psychology] does not exclude the applied interest in functional control" (p. 26).

In Skinner's view, applied psychology should be experimental psychology, a psychology that enhances our understanding of behavior through discoveries and demonstrations of how it is controlled and how it can be controlled in everyday life. In this, he was

proposing that applied psychology be behavioral, analytic, and technological—the three dimensions needed for it to become a science. Soon afterward, Paul Fuller (1949), a graduate student at Indiana, conducted a pioneering study on the application of operant reinforcement. He selectively increased arm movements in an institutionalized 18-year-old “vegetative human organism” who was thought incapable of any learning at all. The application of Skinner’s science was in the air.

Application

Only after returning to Harvard in 1947 did Skinner (1951b) publish his first paper describing actual applications—“How to Teach Animals.” In it, he related how “some simple techniques of the psychological laboratory can also be used in the home” (p. 26) (a) to train dogs, with a clicker, to lift their heads and turn around; (b) to teach pigeons to “read” words and play a toy piano; and (c) to instruct parents on how to extinguish their children’s “annoying behavior” through the differential reinforcement of other behavior.

The article prompted a writer from *Look* magazine to have Skinner demonstrate these “simple techniques,” leading Skinner to undertake another demonstration of behavioral engineering. He taught a dog to leap to a prescribed height and to press a pedal to lift the lid of a trash can (“Harvard Trained Dog,” 1952; see G. B. Peterson, 2001). Pryor (1994, 1999) has since developed and disseminated behavioral technologies for zoos and theme parks, the everyday pet owner, and therapy animals for people with disabilities (see the Special Interest Group for Applied Animal Behavior in the Association for Behavior Analysis; www.abainternational.org).

Ethics and Values

Just before publishing *Science and Human Behavior* (1953a), Skinner participated in a forum that explored the

ethical implications of the social and behavioral sciences. In the resulting article, “The Application of Scientific Method to the Study of Human Behavior” (Brinton, Krutch, Kroeber, Skinner, & Haydn, 1952), he argued that a science of behavior could help “make decisions on some very important problems” (p. 209) that had not been solved by the social sciences or humanities. Although these disciplines might bring actuarial data and case studies to bear on societal problems, they offered no principles of individual behavior.

He also pointed out that a science of human behavior can help address the “naturalistic fallacy” (G. E. Moore, 1903/1966). This is the fallacy that we can derive ethics and values about how the world “ought” to be (e.g., that we ought to do something about global warming) from statements about how the world “is” (e.g., the global temperature is rising). Only ethics is thought capable of addressing the former, and only science the latter. In Skinner’s view, though, a science of human behavior could address both. “Ought” statements are verbal behavior about values; values concern short- and long-term positive and negative reinforcers; and reinforcers are the consequences of actions. Skinner’s science was a science of action, reinforcers, and verbal behavior. It offered an empirical basis for informing us about what practices might—but not must—produce valued consequences for the individual, social group, or ultimately the culture (Skinner, 1971b). For a review of naturalized ethics, see Vogelanz and Plaud (1992).

SCIENCE AND HUMAN BEHAVIOR (1953a)

We turn now to *Science and Human Behavior* (1953a) Skinner’s first extension of his science and philosophy to psychology as a whole. In it, he devoted entire chapters to application: individual practices, such as self-control and thinking; social practices, includ-

ing personal and group control; and cultural practices, among them psychotherapy and education. Other chapters contained sections explicitly titled "the practical use of . . .," for instance, of drives, emotion, aversive stimuli, and multiple causation.

Given Skinner's treatment of these topics, his book has been viewed as foundational to applied behavior analysis. Twenty-five years ago, for instance, Wilson and O'Leary (1980) described it as "particularly significant [in] the extension of operant principles to human problems," especially in its critique of psychoanalysis and the "conceptualization of psychotherapy in behavioral terms" (p. 11). More recent assessments also support this view (Pilgrim, 2003): (a) "Skinner's (1953) book . . . was the first to provide extensive examples of behavior principles in everyday life" (Baldwin & Baldwin, 2001, p. 10); (b) its "interpretations influenced others to begin examining the effects of reinforcement variables on human behavior in a number of experimental and applied settings" (Martin & Pear, 1996, p. 383); (c) it "contains early expressions of much that was to come: . . . the entire field of applied behavior analysis" (Marr, 2003, p. 311); and (d) "as we survey the contemporary scene, we can point to many applications traceable in one way or another to *Science and Human Behavior*" (Catania, 2003, p. 319; see also Cooper et al., 1987, p. 11; Miltenberger, 1997, p. 10).

Michael (1980) has been especially outspoken in this regard. As for the effect of the book on him personally, he has noted, "I came at the applied area primarily from extensive study of . . . *Science and Human Behavior*; not from the rat lab" (Michael & Malott, 2003, p. 115). As for the book's broader influence, he has observed,

Skinner's *Science and Human Behavior* appeared in 1953 and was, it seems to me, the main factor responsible for the development of the area called behavior modification. Though all the basic principles had been available in *The Behavior of Organisms*, and were later available

in a more easily understood form in Keller and Schoenfeld [1950], the development of the behavior modification movement needed Skinner's own bold extrapolation to all aspects of human behavior. Most experimental psychologists are inherently conservative in describing the relevance of their work to practical situations, but not Skinner. In *Science and Human Behavior*, using only the basic concepts of behavior analysis that appeared in *The Behavior of Organisms*, some results of his subsequent work with pigeons, and the material which ultimately went into *Verbal Behavior*, he managed to deal with a wide variety of human situations from a completely behavioral point of view, and very convincingly at that. It was this extension to all aspects of human activity that, I think, provided behaviorists with the encouragement necessary for them to begin contributing to the areas of mental illness, mental retardation, and other applied fields. (pp. 3-4; see also Michael, 1984, p. 364)

As an aside, Baer et al. (1968) included just three references in their paper on the dimensions of applied behavior analysis: Sidman's (1960) *Tactics of Scientific Research, JEAB*, and *Science and Human Behavior*. Sidman's book described the style of Skinner's science, *JEAB* its content, and *Science and Human Behavior* his system. Baer et al. thus apparently viewed the book as one of the field's three most important foundations.

Although the foregoing quotations speak strongly to the book's influence on applied behavior analysis, beyond these testimonials the evidence could be stronger. Historiography needs to be prospective from the past about the past, not retrospective from the present (Stocking, 1965). The validity of the foregoing quotations about the book's influence, for instance, might be assessed by analyzing references to it in the first volume of *JABA*, as well as in the important pre-1968 applied publications (e.g., Ayllon & Michael, 1959; Wolf, Risley, & Mees, 1964). Another approach would be to analyze citations to the book in today's applied textbooks and those that address the field's history. For example, although Kazdin (1978) commented on the book a number of times in *History of Behavior Modification* (e.g., pp. 146, 175, 180,

202), his only observation about its influence was not telling:

Skinner's [1953] extension of operant principles to human behavior, particularly to clinically relevant behaviors, suggested the utility of a behavioral approach as an alternative to the psychiatric model. The application of operant methods to achieve clinical changes followed several years after his pronouncements. (p. 146)

In O'Donohue et al.'s (2001) recent *A History of the Behavioral Therapies: Founders' Personal Histories*, most chapters neither cite nor refer to Skinner's book (e.g., Julie Vargas on Skinner, the autobiographies by Lindsley and Baer). The chapters that do are Poppen's biography of Wolpe and the autobiographies by Bijou, Krasner, Mischel, Risley, and Wolf.

The autobiographies, though, are not compelling about the book's impact. Bijou (2001), for instance, commented only that he had audited the course Skinner taught at Harvard based on *Science and Human Behavior*, and Wolf (2001) only that he had read the book at Michael's "suggestion." Krasner (2001) offered a general assessment, observing that Skinner's publications, *Science and Human Behavior* among them, were "overwhelmingly influential" in the field of instrumental conditioning, which was "the most influential stream in the development of behavior therapy" (p. 208). Only Risley (2001) described how the book affected him directly:

I was most influenced by Skinner's urgings for the development of behavioral and social technology to overcome our genetic predilections and our cultural superstitions. The first three chapters of *Science and Human Behavior* (1953[a]), Skinner had outlined an agenda for an inductive, empirical approach to a science of human behavior. (Which was followed by 26 chapters of a deductive, logical explanation of uninvestigated human behavior.) (p. 271)

This is a sample of today's referencing practices and comments regarding *Science and Human Behavior*. They do not address the question of how the book directly influenced applied behavior analysis. More research remains.

Significance

Foundational or not on this point, *Science and Human Behavior* remains one of Skinner's most significant books. First, as Michael (1980) noted, it offered compelling and wide-ranging interpretations of socially important behavior and descriptions of possible applications. Although Skinner (1938, p. 442) had written that "the careful reader should be as able to make applications as the writer," apparently no one did this as well as Skinner before 1953, except perhaps Keller and Schoenfeld (1950). Second, the book was reviewed not only by psychologists but also by anthropologists, biologists, ethicists, philosophers, and sociologists (e.g., Birdwhistell, 1954; Eng, 1955; Fleming, 1953; Prosch, 1953; Strong, 1954), thereby broadening its influence (see Pilgrim, 2003). Third, it was, in its day, an introductory psychology textbook (Skinner, 1983b, p. 45; see Bjork, 1993, p. 153), and thus was read by several generations of students, some of whom earned advanced degrees in psychology and related fields (e.g., education).

Fourth, Michael read the book (Michael, 2003)—Michael who was to Skinner what T. H. Huxley was to Charles Darwin (1859). Huxley, an important 19th century naturalist, was known as Darwin's "bulldog" for his avid defense of and popularization of evolutionary biology (Huxley, 1863/1954; see Leahey, 2004, pp. 200, 204–205). After Michael read *Science and Human Behavior*, this was his role vis-à-vis Skinner and behavior analysis. In addition, Michael was the teacher, adviser, mentor, and colleague of many of the first generation of applied behavior analysts (see Goodall, 1972; Kazdin, 1978, pp. 233–274; Michael, 2003).

Fifth, *Science and Human Behavior* (1953a) has been considered essential for establishing a "minimal doctoral repertoire in behavior analysis" (Michael, 1980, p. 17) and is today highly rated and ranked by editorial board members of *JEAB* and *JABA*. In a re-

cent survey, three quarters of the respondents listed the book as one of the “essential readings for students who are being trained in the experimental analysis of behavior, applied behavior analysis, and related disciplines” (Saville, Beal, & Buskist, 2002, p. 30). The *JEAB* board members ranked it first, and the *JABA* board members ranked it second only to Baer et al. (1968). It is also steadily and highly cited in citation indexes (Pilgrim, 2003). The book’s importance is obvious, even if its direct influence on applied behavior analysis requires further support.

APPLICATIONS AND APPLIED RESEARCH: 1953–1959

Applications

After publishing *Science and Human Behavior*, Skinner turned even more toward application. He extended his animal model of superstition to a second type (Morse & Skinner, 1957)—responding under adventitious stimulus control. In writing about the experimental analysis of behavior, he addressed such topics as attention, motivation, gambling, social relations, psychotic behavior, psychotherapy, school discipline, education, and industry (e.g., Skinner, 1953b, 1956a, 1957a, 1958b, 1959d). However, he focused most directly on (a) behavioral pharmacology; (b) verbal behavior; (c) psychoanalysis, psychotherapy, and mental disease; and (d) ethics in the control of human behavior.

Behavioral pharmacology. Throughout the 1950s, Skinner actively promoted the use of operant methods in pharmacology, drawing on examples from J. V. Brady (1956) and Dews (1956; Dews & Skinner, 1956) and his own work with Ferster (e.g., Ferster & Skinner, 1957, pp. 83–85, 385–390, 413–414, 596–597, 627–629, 695, 716–718; Skinner, 1957a; see Bergman, Katz, & Miczek, 2002; Laties, 2003; Skinner, 1983b, pp. 99–101). Over time, his style of science—in particular, his steady-state methods—became fundamental to the field.

Nonetheless, he at first urged caution about pharmacological applications. In “Animal Research in the Pharmacotherapy of Mental Disease,” he argued that, although drugs might be “important in the management and treatment of mental disease” (Skinner, 1959a, p. 224), pharmacology first has to be grounded on principles derived from the experimental analysis of human behavior. These principles assured that explanations of a drug’s “mode of action” were based not just on the drug itself, but also on behavior, that is, on behavioral history and prevailing contingencies (e.g., appetitive vs. aversive control). The principles also provide explanations of behavior based not on mental processes and personality traits but on naturalistic accounts of human behavior, that is, on biology, environment, and history. Grounding applied behavior analysis on Skinner’s science had similar effects. It provided an account of atypical behavior based on historical and current contingencies in biological and environmental context, not on mind, personality, or pure physiology.

Verbal behavior. In psychology, Skinner’s most famous extension of his science to human behavior was *Verbal Behavior* (1957c), which he believed was his “most important work” (1977, p. 379). The book was also more applied than is typically appreciated. As Skinner put it, “The formulation is inherently practical and suggests immediate technological applications at almost every step” (1957c, p. 12). Technological applications were, in turn, an arbiter of how well the book explained verbal behavior:

The extent to which we understand verbal behavior in a “causal” analysis is to be assessed from the extent to which we can predict the occurrence of specific instances and, eventually, from the extent to which we can produce or control such behavior by altering the conditions under which it occurs. In representing such a goal it is helpful to keep certain engineering tasks in mind. How can the teacher establish the specific verbal repertoires which are the principal end-products of education? How can the therapist uncover latent verbal behavior in a therapeutic

interview? How can the writer evoke his own verbal behavior in the act of composition? How can the scientist, mathematician, or logician manipulate his verbal behavior in productive thinking? Practical problems of this sort are, of course, endless. To solve them is not the immediate goal of a scientific analysis, but they underline the kinds of processes and relationships which such an analysis must consider. (p. 3)

And consider them, Skinner did. *Verbal Behavior* (1957c) is replete with interpretations, implications, and descriptions of applications. These include (a) material on the reinforcement and punishment of the basic verbal operants (e.g., mands, tacts, intraverbals), their stimulus controls (e.g., audience effects), and their motivation (e.g., deprivation); (b) references to relevant research (e.g., the verbal summator); and (c) material that addressed the "practical control" of speaker behavior through prompts and probes (pp. 254–268), instructions (pp. 362–367), self-strengthening (pp. 403–417), and its construction (pp. 422–431). He also cited Greenspoon's (1955) research on the conditioning of adult verbal behavior with generalized social reinforcement, which presaged the implications of conditioning for conversations (see Verplanck, 1955) and psychotherapy (Greenspoon, 1962; Truax, 1966; see Glenn, 1983).

According to Michael (1984), however, *Verbal Behavior* (1957c) was so speculative that it was often an embarrassment to "operant researchers" (p. 369) and of little value to those who undertook the first empirically based applications of Skinner's science. Thus, the book probably had little influence on the founding of applied behavior analysis. Today, however, it plays an increasing role in the treatment of communication disorders in children with developmental disabilities (Sundberg & Michael, 2001; Sundberg & Partington, 1998).

Psychoanalysis, psychotherapy, and mental disease. Although Skinner had addressed psychotherapy in *Science and Human Behavior* (1953a), he addressed it mainly as a cultural practice.

Shortly afterward, he published three papers more directly relevant to the process of therapy. In the first, "Critique of Psychoanalytic Concepts and Theories" (1954a), he pointed out that Freud's independent variables were hypothetical representations of the products of behavioral ontogeny (e.g., the superego), and that Freud's proximal dependent variables were hypothetical processes (e.g., repression), neither of which was measurable or manipulable. On these accounts, behavior was a symptom of the representations and processes, not a subject matter unto itself. For Skinner, in contrast, the representations and processes were but shorthand descriptions of the history and dynamics of public and private behavior. Skinner's second publication—"What Is Psychotic Behavior?" (1956b)—extended this critique. He likened psychoanalytic explanations to psychology's generally mentalistic and reductionistic explanations. Psychology had failed, he thought, to apply science to human behavior, which was for him its "primary object" (p. 79).

In his third publication, "The Psychological Point of View" (1957b), Skinner was more constructive. He argued that the experimental analysis of behavior could be integrated with genetic and organic approaches to understanding psychiatric illness. In particular, it could offer precise laboratory-based measures of, for instance, sensory control, motor behavior, emotional behavior, motivation, and learning. It could provide "a base-line upon which the effect of genetic, organic, and other variables may be observed" (p. 132). And, it could "change the behavior of the mentally diseased" (p. 132) through respondent and operant conditioning. Skinner concluded this way:

That there are etiological facts lying beyond [experimental psychology] is doubtless true. . . . A certain practical hierarchy of causes may, however, be pointed out. Although genetic and organic factors can be efficiently evaluated only by holding environmental factors constant, and although environmental factors can be correctly

evaluated only against a stable genetic and organic condition, it is probably a useful practice to explore environmental factors first to see whether any behavioral manifestations remain to be attributed to genetic and organic causes. (p. 133)

This optimism about behavior's environmental determinants was evident in the founding of applied behavior analysis and remains so today.

Ethics in the control of human behavior. During this period, Skinner returned to ethical issues in three important articles: "The Control of Human Behavior" (1955), "Freedom and the Control of Men" (1955–1956), and his symposium with Carl Rogers, "Some Issues Concerning the Control of Human Behavior" (Rogers & Skinner, 1956). He had touched on these themes earlier, but as the applied implications of his science became more apparent, as the Cold War heightened, and as his critics grew more vocal (e.g., Krutch, 1954), he addressed these themes more frequently.

First, Skinner (1955) noted that, whether we admit it or not, behavior is controlled on a daily basis through processes and practices involving positive reinforcement, motivational control, emotional conditioning, and "knowledge of the individual" (e.g., government databases). He was concerned that the culture's "outworn conception of human nature" discouraged the analysis of these factors, thus obscuring the need for their countercontrol.

Second, he defended the science of behavior, its implications, and its application (Skinner, 1955–1956). In particular, he addressed pertinent issues in the philosophy of science (e.g., determinism) and fears about the use of the science in cultural design (e.g., despotism). However, he concluded optimistically,

Far from being a threat to the tradition of Western democracy, the growth of a science of man is a consistent and probably inevitable part of it. In turning to the external conditions which shape and maintain the behavior of men, while questioning the reality of the inner qualities and faculties to which human achievements were once attributed, we turn from the ill-defined and re-

mote to the observable and manipulable. Though it is a painful step, it has far-reaching consequences, for it not only sets higher standards of human welfare but shows us how to meet them. . . . Possibly the noblest achievement to which man can aspire . . . is to accept himself for what he is. (pp. 64–65)

Third, Skinner described how the outworn conceptions of human behavior were harmful to personal relations, education, and government: because their modes of control were aversive (Rogers & Skinner, 1956). A scientifically based conception showed how aversive control could and should be replaced with positive reinforcement. In response to Rogers' argument that values and free choice determined human behavior, Skinner pointed out that values specify reinforcing events, conditions, and activities; that choice was not free, but also determined; and that we must overcome our fear of the control implicit in science. In overcoming it, he wrote, perhaps tongue-in-cheek, "we shall become more mature and better organized and shall, thus, more fully actualize ourselves as human beings" (p. 1065). Topics such as these gained Skinner's further attention in the 1960s and 1970s, when he addressed freedom and dignity (Skinner, 1971b), humanism (e.g., Skinner, 1972c), and the design of cultures (Skinner, 1973b).

Applied Research

The same year *Science and Human Behavior* (1953a) was published, Skinner began his two most "noteworthy" and "influential" extensions and applications of his science to human behavior (Kazdin, 1978, pp. 177, 242). One was an experimental analysis of the behavior of patients in a psychiatric institution; the other was a technology of teaching.

The behavior of psychiatric patients. Skinner's extension of his science to psychiatric patients was his 1953–1965 collaboration with Ogden Lindsley (Lindsley & Skinner, 1954; see Lindsley, 2001; Rutherford, 2003b). Although meant to be a systematic rep-

lication of the style and content of Skinner's science (e.g., within-subject analyses, schedules of reinforcement), the project had obvious applied implications. It was called, at first, "Studies in Behavior Therapy"; the research participants presented problems of clear social importance; Lindsley (1960, 1963) wrote about the clinical relevance of the research; and Skinner's only article from the project was published in a clinical journal (the *Journal of Nervous and Mental Diseases*; Skinner, Solomon, & Lindsley, 1954). Thus, even though the project's intent was to extend Skinner's science, it was viewed as an advance in the inevitable progress from basic to applied research. As applied research, though, Skinner's article did not describe the advance in such a manner that the dimensions of applied behavior analysis could be discerned.

Lindsley's research was not the only programmatic extension of Skinner's science at the time. Others included Bijou's human operant research with atypically developing children (Bijou & Orlando, 1961; Orlando & Bijou, 1960) and Ferster's work with children with autism (Ferster, 1961; Ferster & DeMeyer, 1961, 1962). The latter more clearly presaged application: Ferster used a token reinforcement system to establish operant repertoires that were incompatible with behavioral excesses (DeMeyer & Ferster, 1962). Other notable laboratory-based extensions were Baer's (1962) on thumb sucking; Barrett and Lindsley's (1962) on children and adults with mental retardation, J. P. Brady, Nurnberger, and Tausig's (1961) on schizophrenic patients; Goldiamond's (1962) on stuttering; and Staats's on reading established and maintained though token reinforcement (e.g., Staats, Staats, Schultz, & Wolf, 1962; see Kazdin, 1978, pp. 246–256).

Teaching machines and programmed instruction. As for Skinner's application of his science to education, this preoccupied him for the next two decades (Morris, 2003). Its focus was on the development of yet another in-

vention—the teaching machine—as well as pioneering research on programmed instruction (Benjamin, 1988). Its impetus was Skinner's November 11, 1953, visit to Deborah's fourth grade arithmetic class, from which he came away distraught: "The teacher was violating two fundamental principles: the students were not being told at once whether their work was right or wrong . . . and they were all moving at the same pace regardless of preparation or ability" (Skinner, 1983b, p. 64).

In a matter of days, he constructed prototypes of teaching machines and their programs. Within a few months, he demonstrated their effectiveness in teaching arithmetic and spelling. Within a year, he published his first article on education, "The Science of Learning and the Art of Teaching" (1954b). He there described recent developments in basic research, critiqued current educational practices, described how to improve them through his science, and defended those applications. Over the course of the next four years, he undertook research on programmed instruction with Homme, Meyer, and Holland; secured research space at Harvard and funding from the Ford Foundation; and used programmed materials in his courses to good effect. Of his subsequent papers on education, though, only two appeared (1958b, 1959e) before research emerged that was the beginning of applied behavior analysis. But, as with Skinner's paper on psychotic patients, his articles on education did not describe his research in a way that the dimensions of applied behavior analysis could be discerned.

THE EMERGENCE OF APPLIED BEHAVIOR ANALYSIS: 1959–1967

By 1959, Skinner had amassed more than 30 publications in which he had extended or applied his science. He offered interpretations of typical and atypical behavior, drew implications

from his science for application, described possible applications, and reported successful applications in animal behavior and education. Some of this work was a precursor to applied behavior analysis; other of it contributed to a zeitgeist that made application almost inevitable. In the same decade that Skinner extended his science to psychotic patients and applied it to education, two independent programs of research were begun that yielded, arguably, the first systematic applications of his science. One was Ayllon's work at Saskatchewan Hospital in Weyburn, Saskatchewan, Canada; the other was Wolf's at the University of Washington in Seattle, Washington.

These were not the first applications, of course. We have already noted P. R. Fuller's (1949) early demonstration of operant conditioning in a "vegetative human organism." Other applications were being made concurrently to eliminate a child's tantrums (Williams, 1959), reinstate verbal behavior in mute psychotics (Isaacs, Thomas, & Goldiamond, 1960), and establish productive classroom behavior (Zimmerman & Zimmerman, 1962). In addition, at Arizona State University (ASU), Staats (1957) was extending his research to applied issues in reading (e.g., Staats & Butterfield, 1965; Staats, Minke, Goodwin, & Landeen, 1967; see Staats, 1965, 1996). Wolf's work with Staats, when Michael was also at ASU, when ASU was known as "Fort Skinner in the Desert" (Goodall, 1972), also likely influenced Wolf's applications at Washington. Staats's overall contribution to founding applied behavior analysis is, however, difficult to gauge. Much of his research was published after Ayllon's and Wolf's, and was more analytic than interventionist. As for whether Ayllon or Wolf may be said to have founded applied behavior analysis, the answer lies beyond the scope of our paper. Their contributions, though, serve as a baseline against which to judge Skinner's because they addressed, to a consider-

able degree, most of the seven dimensions of applied behavior analysis.

*Saskatchewan Hospital:
Ayllon et al. (1958–1961)*

Between 1958 and 1961, Ayllon undertook one of the "most influential extensions" of Skinner's science to clinical populations (Kazdin, 1978, p. 256). These extensions yielded eight publications, the first of which has been referred to as "the formal beginnings of applied behavior analysis" (Cooper et al., 1987, p. 13; see also Birnbrauer, 1979, p. 15). This was Ayllon's dissertation for the Department of Psychology at the University of Houston, with Michael as his adviser. The publication was titled "The Psychiatric Nurse as a Behavioral Engineer" (Ayllon & Michael, 1959). In it, Ayllon and Michael described applications of the style and content of Skinner's science by psychiatric nurses and attendants to improve the behavior of their patients, for example, to increase self-feeding and reduce psychotic talk. In Ayllon's other studies, he increased meal attendance and eating (Ayllon, 1965; Ayllon & Haughton, 1962), decreased food stealing and towel hoarding (Ayllon, 1963), decreased nonorganic physical complaints (Ayllon & Haughton, 1964), and addressed other clinically relevant behavior (e.g., anorexia; see; Ayllon, Haughton, & Hughes, 1965; Ayllon, Haughton, & Osmond, 1964; Haughton & Ayllon, 1965). This was "groundbreaking real-world field research" (Risley, 2005, p. 279). When Ayllon moved to Anna State Hospital in Illinois in 1961, he collaborated with Azrin in related research (e.g., Ayllon & Azrin, 1964, 1965), the best known of which was on the token economy (Ayllon & Azrin, 1968), now considered "a landmark in the development of applied behavior analysis" (Kazdin, 1978, p. 260; see Kazdin, 1977).

*University of Washington:
Wolf et al. (1963–1967)*

Wolf's initial applications were made between 1962 and 1964 (see Bi-

jou, 2001; Risley, 2005). As noted, Bijou had already extended Skinner's science to atypically developing children, but after spending a 1961–1962 sabbatical year with Skinner, he established a broader research and training program in early childhood. In this context, Wolf undertook two lines of research. The first was a series of studies on the effects of adult attention on child behavior in which Wolf and his colleagues increased social play (Allen, Hart, Buell, Harris, & Wolf, 1964), gross motor play (M. K. Johnston, Kelley, Harris, & Wolf, 1966), and walking (F. R. Harris, Johnston, Kelley, & Wolf, 1964), and decreased operant crying (Hart, Allen, Buell, & Wolf, 1964). This work has been referred to as the “most influential application of operant techniques with children” (Kazdin, 1978, p. 264), and its evolving applied research methods have been described as “groundbreaking” (Risley, 2005, p. 280).

Wolf's second line of research is today better known. He and his colleagues applied Skinner's science to the behavior of a young boy with autism. They reduced his tantrums, throwing his eyeglasses, and bedtime and bedtime problems; they increased his wearing his glasses; and they overcame his severe language deficits (Wolf et al., 1964; see also Risley & Wolf, 1964, 1967; Wolf, Risley, Johnston, Harris, & Allen, 1967). Of these publications, Wolf et al.'s (1964) “Application of Operant Conditioning Procedures to the Behavior Problems of an Autistic Child” has been cited as “the premier study of behavior modification” (Risley, 2001, p. 269; 2005, p. 281) and as the first application of behavior analysis to autism (Wolf, 2001; see also Kazdin, 1978, p. 268). Between 1959 and 1967, applications of the style and content of Skinner's science burgeoned in both the number of research studies and research programs (see Kazdin, 1978). This work, however, was not called “applied behavior analysis.” The field awaited its formal founding.

BETWEEN APPLIED BEHAVIOR ANALYSIS AND JABA: 1959–1968

In 1959, Skinner (1959b) published his first collection of works—*Cumulative Record*—nearly two thirds of which we have cited as extensions and applications of his science. This collection and its enlarged 1961 edition (Skinner, 1961a) kept these publications in print as Ayllon and Wolf were undertaking their pioneering research and as the journals *Behaviour Research and Therapy* (established in 1964) and *JABA* (established in 1968) were founded (on the history of *JABA*, see Laties, 1987).

In addition, Skinner continued to publish papers with applied implications, some of which again concerned the philosophical implications of his science for human behavior (e.g., determinism, individuality). For instance, in his article, “Man” (1964a), he wrote,

We have reached the stage, far from a dead end, in which man can determine his future with an entirely new order of effectiveness. . . . Men control themselves by controlling the world in which they live. They do this as much as when they exercise self-control, as when they make changes in their culture which alter the conduct of others. (p. 485)

At the same time, Skinner was also addressing utopian themes, among them, utopian visions (Skinner, 1967b, 1967c) and the design of experimental communities (Skinner, 1968a) and cultures (Skinner, 1961b, 1966b). Other work concerned animal models, behavioral interpretations, and further applications to education, as follows.

Models and Interpretations

In 1960, Skinner (1960a) published his account of Project Pigeon, giving life to the early advances in behavioral engineering, both in shaping new behavior and bringing it under precise stimulus control. He also conducted more animal-model research, now on social relations and emotion. For instance, he described a classroom dem-

onstration in which he simulated (a) cooperation in pigeons by reinforcing their behavior only when it occurred at the same time and (b) competition between them in a version of ping-pong (Skinner, 1962). In research with George Reynolds and Charlie Catania, he studied unconditioned and conditioned aggression in pigeons, and stimulus control of the latter (Reynolds, Catania, & Skinner, 1963; see also Reynolds & Skinner, 1962). During this period, he further addressed verbal behavior (Richards & Skinner, 1962) and offered interpretations of cognition (Skinner, 1966a) and consciousness (Blanshard & Skinner, 1967), the latter of which forecasted later empirical research (e.g., Epstein, Lanza, & Skinner, 1980, 1981).

Education

Throughout this period, Skinner was most active in education, publishing over 15 additional works, including *The Technology of Teaching* (Skinner, 1968c; see also Skinner, 1960c, 1961c, 1963, 1964b, 1965a, 1965b, 1968b; cf. Barrett, 2002). With Holland, he also published a programmed textbook (Holland & Skinner, 1961) that contained many examples of application, for instance, "Mr. X succeeds in coercing people into reinforcing him in many *different* ways. Signs of submissiveness in others then become — which increase the frequency of new forms of coercion, independent of the particular deprivation" (p. 69). The answer: generalized reinforcers. One part of the text covered the "scientific analysis and the interpretation of complex cases," one case being "a problem in behavioral engineering"—animal training. Other parts covered self-control, personality, and psychotherapy. Here is a sample frame: "In addition to providing a nonpunishing audience, the therapist may recommend changing jobs, getting a divorce, etc. He is attempting to — environmental contingencies" (p. 329). The answer: change (manipulate, control, alter).

Skinner on Applied Behavior Analysis

Skinner's interest in applying his science notwithstanding, he never systematically integrated, advanced, or promoted "applied behavior analysis" *per se*. In fact, he seems to have only both cited and referenced it once in all of his published works. This was in "Review Lecture: The Technology of Teaching" (1965a), in which he described recent advances in the application of his science, using as examples Ayllon and Azrin's (1965) research on the token economy and Wolf et al.'s (1964) research in autism. Where he elsewhere cited and supported early applied researchers (e.g., Ayllon, Azrin, Bijou) and interventions (e.g., National Training School for Boys; Skinner, 1971c), he did not provide references (see, e.g., Skinner 1967a, 1968/2004, 1972c, 1980). When he provided references, they were in footnotes rather than in the main text. These were to Ulrich, Stachnik, and Mabry (1966, 1970) in *The Technology of Teaching* (1968c, p. 4) and *Beyond Freedom and Dignity* (1971b, p. 19). Skinner's failure to reference this literature more fully would seemingly have hindered the field's advancement, but perhaps not. Perhaps he was working strategically. He may have wanted to promote applied behavior analysis as a process, and not have it identified with specific practices (but see *Walden Two*, 1948d). He may also have wanted it to succeed as a function of its own effectiveness, not through his rule-governed advocacy of it.

AFTER JABA: 1968–1990

In the founding of *JABA*, Skinner reportedly took a direct lead. As noted by Laties (1987), the minutes of the April 6, 1967, meeting of the Society for the Experimental Analysis of Behavior, *JEAB*'s publisher, contained the following: "A discussion of a need for a journal with high scientific standards for publication of applications to behavior modification was initiated by B.

F. Skinner" (p. 505). When *JABA* was founded, Skinner was on its editorial board and active in the review process.

After *JABA*'s founding, Skinner amassed over 100 additional publications, most of them on applied topics. He addressed (a) education, for instance, contingency management in the classroom (Skinner, 1969, 1973c, 1989b); (b) cognition, creativity, and language (Skinner, 1970, 1972c; for related research, see, e.g., Epstein et al., 1980, 1981); and (c) behavior therapy and behavior modification (Skinner, 1972d, 1988a). He devised self-management systems (e.g., Skinner, 1981, 1983a; Skinner & Vaughan, 1983), one of them described in his only *JABA* article—"A Thinking Aid" (1987). And, he advanced the role of behavior analysis in the design of cultural practices (e.g., 1973b, 1973d, 1976, 1985a), among them world peace (e.g., 1971a, 1985b), freedom and dignity (1971a, 1971b, 1972b), and ethics in developmental disabilities (1972a, 1973a, 1975, 1988b).

CONCLUSION

Skinner was not only the most eminent psychologist of the 20th century but also the most eminent behavior analyst of any century. He established a science of behavior, formulated its philosophy, and founded behavior analysis. In the process, he also contributed fundamentally to advancing their application. Evidence for the latter lies in the five categories of his contributions, the breadth and depth of his extrapolations, extensions, and applications, and his inclusion of the seven dimensions of applied behavior analysis. As for the last, his science was the basis for the field's behavioral, analytic, technological, and conceptually systematic dimensions. The first two were among the field's "must be" dimensions; the first three made it an empirical science; all four made it systematic. In *Walden Two* (1948d), he brought two more dimensions into his work—the applied and effective di-

mensions. And, although he did not explicitly address generality, it was a reason for developing a technology of teaching in the first place. Generality was embedded in the very meaning that *education* and *teaching* had for him (see Skinner, 1968c).

Skinner's contributions notwithstanding, we do not conclude that he was either the originator or founder of applied behavior analysis. First, when his published research analyzed behavior in the style of his science (e.g., schedules of reinforcement), the behavior he studied was not socially important or changes in it socially significant (e.g., rates of bar pressing). That is, when his publications were behavioral, analytic, technological, and conceptually systematic, they were not also applied and effective. Second, when his applications concerned socially important behavior and its significant change (e.g., education), the style of his science was not readily apparent in his publications. That is, unlike Ayllon and Wolf, when his research was applied and effective, it was not obviously also behavioral, analytic, or technological. In other words, although Skinner addressed all seven dimensions of applied behavior analysis over the course of his career, he did not address both the scientific and the social dimensions in any one published program of research such that he could be called the field's originator. Nor, as we have seen, did he systematically integrate, advance, or promote these dimensions in the context of application so as to be called the field's founder.

This conclusion is not, of course, definitive. By focusing on Skinner's publications, we have left gaps in the historical record. These need to be filled through archival research, for instance, on his correspondence with and about the first applied behavior analysts (see Elliott, 1996). The gaps might also be filled through oral histories about Skinner's influence on the first applied behavior analysts, which might have occurred through his encouragement of their work during his service on association boards and committees or at re-

search meetings and professional conferences (e.g., Laties, 2003; Mischel, 2001). These influences notwithstanding, Skinner's publications remain a standard basis for assessing his contributions and thus defensible as a basis for our conclusion.

If Skinner did not originate or found applied behavior analysis, then we need to characterize his role differently. For this, we draw on the distinction made by his colleague, the historian of psychology E. G. Boring (1886–1968), between *founders* and *fathers* in science (Boring, 1929). As Boring (1950) wrote of Wilhelm Wundt (1832–1920), “When we call him the ‘founder’ of experimental psychology, we mean both that he promoted the idea of psychology as an independent science and that he is the senior among ‘psychologists’” (p. 316; see also Boring, 1927). This was Skinner's role in behavior analysis, generally. He promoted the field (or discipline) and was senior among behavior analysts, except in age to Keller (1899–1996).

In applied behavior analysis, though, his role was different (see Vargas, 2001). By Boring's criteria, he was not its founder. First, although he promoted application in general, he did not advance or promote applied behavior analysis as it emerged in the early work of Ayllon or Wolf or in *JABA*. Second, he was not among those known as the first applied behavior analysts, such that he could be senior among them. Skinner's role is best characterized as that of the field's father.¹ Without his having founded be-

havior analysis, applied behavior analysis would not have emerged when it did, in the form that it did, or perhaps be known by that name. What Skinner provided was a style and content of a science of behavior and its philosophy, some urging that they be applied, and likely the first applications. Through these contributions, his work was seminal to the field's founding.²

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¹ Although the “founder–father” distinction has sexist implications, we have used it for two reasons. The first is simply that the distinction has precedence in the historiography of psychology for an era in which the field's founders and parents were men (e.g., Fechner, Mueller, Wundt; see Boring, 1927, 1929, 1951). Women were generally excluded (Bryan & Boring, 1947; Scarborough & Furumoto, 1987). The second reason is that, in the 1950s and 1960s, the likely founders and parents of applied behavior analysis—if there were any—were also men (Laties, 1987; see Goodall, 1972; Kazdin, 1978). An analysis of the role women played in the founding of applied behavior analysis, or behavior analysis in general, awaits to be written.

² If Skinner was the father of applied behavior analysis, we might ask who was its mother. She was, we think, his partner in science: the behavior of organisms. Their union begot a style and content of science, technological inventions, behavioral interpretations of atypical behavior, implications for application, descriptions of applications, and actual applications that became basis of applied behavior analysis.

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